



How did rising labor costs erode China's global advantage?☆

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ABSTRACT

Labor costs in China have been increasing dramatically in recent years, spurring worries that the country may lose its comparative advantage in manufacturing and its role as the “World’s Factory”. This paper aims to evaluate the effects of rising labor costs on China’s attractiveness to multinationals and its competitiveness in exports, by using regional variations in minimum wage distortion as possibly exogenous shocks to unskilled-labor costs. We first develop a two-sector model by introducing the minimum wage into a general equilibrium model which integrates production and trade in a multi-regional setting. Consistent with model predictions, we find that rising minimum wage distortion reduces more of the exports in unskilled-labor intensive industries. Moreover, exports by foreign invested firms are more sensitive to changes in minimum wage distortion than exports by domestic firms, and both intensive and extensive margins matter for this distinction.

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1. Introduction

The large and seemingly unlimited supply of unskilled labor has been considered the key factor for China to attract large inflows of foreign direct investment and become the largest exporter in the world. However, labor costs in China have been rising rapidly in recent years, spurring worries that it might erode China’s comparative advantage in the global market. As shown in Fig. 1, the monthly average real wage of China’s manufacturing workers was the lowest among Asian economies in the early 1990s, but it had increased more than five-fold between 1993 and 2015, surpassing the wage level in many neighboring countries in Asia including Vietnam, Indonesia, India, and the Philippines.

Rising labor costs may make China less attractive to multinational companies. For example, China has been the main sourcing country for Nike’s footwear production since 1997, contributing more than 40% of Nike’s total footwear production at the peak year of 2001, but it has been surpassed by Vietnam since 2009 (Khandelwal and Teachout, 2016). Nike is not alone. In fact, the share of foreign-invested firms in Chinese total exports had declined gradually to about 44 percent in 2016 since its peak at 58 percent in 2006. The shortage of cheap labor may also erode China’s comparative advantage

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Fig. 1. International comparison of manufacturing labor costs

Notes: The original nominal wage data is from UNIDO annual wage data of INDSTAT4 ISIC3 and ISIC4. We use country-specific CPI with 2007 as the base year to obtain real wages in local currency over time, and use exchange rates in 2007 to convert them into US dollars for cross-country comparison.

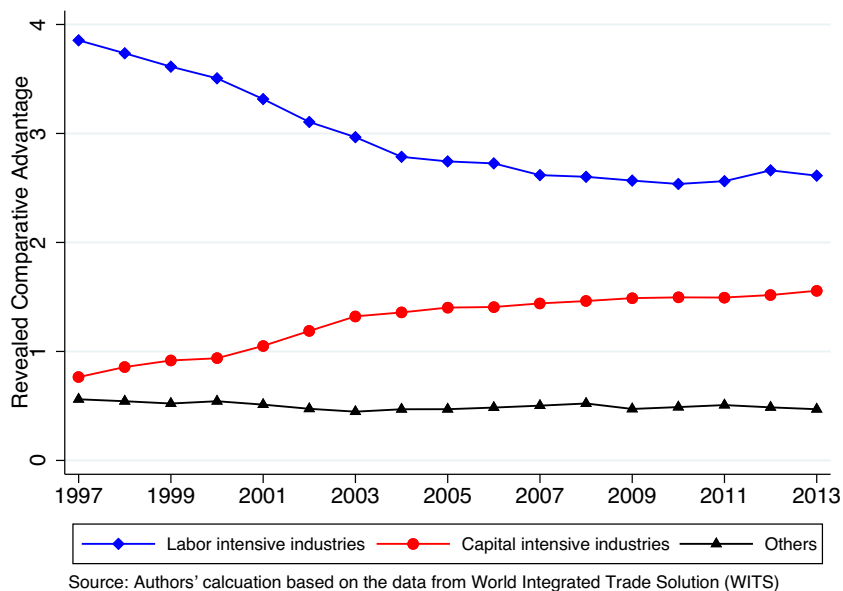


Fig. 2. China's sectoral revealed comparative advantage

Notes: We choose several important labor- and capital-intensive industries to show graphically the dynamic pattern of the comparative advantage of Chinese exports. The selected labor-intensive industries in Fig. 2 include ISIC Rev.3 two digits industries 17, 18, 19, 36, covering textile, cloth, footwear, apparel, luggage, and furniture. The selected capital-intensive industries include ISIC Rev.3 two digits industries 29–33, covering machinery, equipment and instruments.

in exports of labor-intensive products. Fig. 2 presents the revealed comparative advantages (RCA) for labor- and capital-intensive industries, where an industry's RCA is defined as the ratio of the industry's share in China's total exports to its share in world exports. We observe a gradually declining trend in RCA for labor-intensive industries, including textile, cloth, footwear, apparel, luggage, and furniture. By contrast, the comparative advantages of capital-intensive industries such as machinery, equipment, and instruments have been improving over the years.¹

This paper aims to evaluate the impact of rising labor costs on China's attractiveness to multinationals and its competitiveness in exports, by using the regional and time-varying variations in minimum wage distortion as exogenous shocks to

¹ Similar results are also obtained by using value-added exports from the OECD-WTO Trade in Value-Added database.

unskilled-labor costs and the variations in skill intensity across industries. We first develop a two-sector model by introducing the minimum wage into a general equilibrium trade model which integrates production and trade in a multi-regional setting (Eaton and Kortum, 2002; Ramondo and Rodríguez-Clare, 2013). Minimum wages set by local governments distort labor allocation between the agricultural and the manufacturing sector, and thus reduce regional exports of manufacturing goods relatively more in unskilled-labor intensive industries. Our model delivers the classic (log) gravity equation for manufacturing exports, which can be further decomposed into exports by domestic firms and exports by foreign firms. Therefore, we can adopt the empirical gravity equations to test model predictions and examine which type of exports or firms are more sensitive to labor cost shocks such as changes in minimum wage distortions.

We construct two comprehensive data sets for empirical analysis. First, we use the firm-level Chinese customs trade data for the period 2000–11 to construct a panel of Chinese manufacturing exports at the city-industry (two digits ISIC)-importer (country) level. The trade data also contains the ownership information of firms, and thus we can break down total exports into exports by domestic firms and exports by foreign-invested firms (named as domestic exports and foreign exports respectively). Moreover, the firm-level trade data also allows us to decompose exports into the extensive margin measured by the number of varieties (i.e., firm-HS code pairs) and the intensive margin measured by average exports per variety. Thus, we can explore which margin is more important for the adjustment in exports in response to labor cost shocks. Second, we collect an administrative data set of minimum wages across 337 prefectural level divisions in China from the Ministry of Labor and Social Security for the period 1995–2012.² Based on this data set, we construct a theory-based measure of minimum wage distortion (MWD) on unskilled-labor allocation, i.e., the minimum wage premium divided by rural disposable income. We use cross-city and cross-time variations in minimum wage distortions and cross-industry differences in unskilled-labor intensities to identify the effects of unskilled-labor cost shocks on regional manufacturing exports.

Our empirical analysis presents three novel findings. First, we find that minimum wage distortion reduces manufacturing exports in unskilled-labor intensive industries more than in other industries. This result holds for both domestic and foreign exports, supporting our theoretical predictions. Second, the elasticity of foreign exports to minimum wage distortion is more sensitive to the unskilled-labor intensity across industries than the elasticity of domestic exports. In other words, the negative effects of minimum wage distortions on foreign exports increase faster with industrial unskilled-labor intensity than domestic exports. Third, both intensive and extensive margins matter for the larger effect of minimum wage distortion on foreign exports. More interestingly, we find that the effects of minimum wage distortion on entry and survival are insignificant for domestic exports but are economically and statistically significant for foreign exports. Thus, rising labor costs reduces the incentive of foreign firms more than Chinese domestic firms to choose a city in China as its exporting platform to produce and export to other countries.

The empirical analysis also shows the robustness of our main results and substantial heterogeneity in the effects of the minimum wage distortion on exports. First, minimum wage distortion reduces both ordinary and processing exports in unskilled-labor intensive industries more than in other industries, but the effect is relatively stronger in ordinary exports. Second, exports to high-income countries are more sensitive to the rising cost of unskilled labor than exports to low-income destinations, partly because China may have an apparent comparative advantage in unskilled-labor intensive industries over high-income countries and partly because foreign-invested firms in China are mainly from advanced economies; they produce in China and then re-export to their home countries. Our main results are robust to excluding the sample after the global financial crisis in 2008 and also robust to including total factor productivity (TFP) as the city-industrial technology measure. Breaking down foreign-invested firms further into joint ventures and wholly foreign-owned firms not only confirms our baseline results but also shows that joint ventures are more vulnerable to rising unskilled-labor costs in China than wholly foreign-owned firms.

Our contribution is twofold. First, this paper develops a general equilibrium model of trade and multi-regional production with minimum wage distortions. The model also delivers an analytical gravity equation that demonstrates a formula determining the effect of minimum wage distortions on bilateral and foreign exports. This contributes to the literature on trade and minimum wage, such as the seminal papers by Brecher (1974) and Davis (1998), which are based on the classic Heckscher-Ohlin model, and the recent paper by Bai et al. (2018) which is based on the heterogeneous firm model of Melitz (2003). However, none of these models consider multi-regional production and foreign exports.

Second, this paper resonates among the conjecturing arguments on the adverse effect of rising labor costs on China's comparative advantage. The threat of rising labor costs on China's industrialization and exports has long been the subject of heated debates in the circle of policymakers and public media. The Institute of Population and Labor Economics at the Chinese Academy of Social Sciences predicted in 2007 that China would soon reach a “Lewisian turning point”, a situation when the cost of unskilled labor will eventually rise after the depletion of surplus labor from the rural area (Cai, 2007). The rise in wages in China also has been well documented in the literature (Yang et al., 2010; Ge and Yang, 2014). However, only several studies have been conducted on this topic, including Gan et al. (2016) and Bai et al. (2018), both of which study the effect of minimum wages on firm exporting behaviors. Our study is complementary to these studies by providing industry-level evidence. We focus on an industry-level rather than firm-level analysis because although firm responses to

² The prefectural level division is the second layer of the administrative structure of China, which is between the province and county level division. Because prefectural cities are the main components of the prefectural level division, we also follow the convention to refer prefectural cities to prefectural level divisions.

labor cost shocks are certainly interesting, the implications are less clear for China's aggregate industrial comparative advantage. Moreover, our novel findings that foreign exports are more sensitive to labor cost shocks than domestic exporters have important policy implications for developing countries.

Our study is also closely related to the literature that focuses on the effects of factor market frictions and other institutional distortions on international trade and investment in developing countries. For example, [Chen et al. \(2019\)](#) find that discriminations against domestic private firms incentivize them to produce abroad. Other studies have shown that the prevalence of institutional distortions such as political barriers to entry and differential access to credit may limit the gains from trade liberalization ([Baccini et al., 2019](#); [Bai et al., 2019](#)). Our study shows that the minimum wage distortion can jeopardize China's attractiveness to multinationals and the comparative advantage of its exports.

One caveat of our analysis is that minimum wage variations may not fully reflect changes in the overall labor cost as it is only associated with unskilled labor. This concern is legitimate but we are more interested in the rising cost of unskilled labor than skilled labor. The abundant and cheap unskilled labor has been the source of comparative advantage for China, and thus a more relevant question is whether China has lost its advantage of those industries in the global market because of the rising wages of unskilled workers.³ By using variations in the minimum wage distortion, our analysis can shed light on the general question of how rising costs of unskilled labor may affect China's competitiveness.

This paper is structured as follows. [Section 2](#) develops a two-sector theoretical model to show the effect of minimum wage distortion on the exports of manufacturing goods by taking into account multi-regional production. [Section 3](#) introduces Chinese customs trade data and the institutional background of minimum wage policy in China, and then presents the empirical strategy to test our model. [Section 4](#) shows our baseline empirical findings on exports and related sensitivity discussions. [Section 5](#) further conducts an anatomy of the effects of minimum wage distortion on exports including from the perspectives of intensive and extensive margins, domestic and foreign exports, and exit and survival, together with several interesting extensions and robustness checks. [Section 6](#) concludes with policy remarks.

2. The model

2.1. Endowments and households

Consider a world of total N regions with N_1 cities in China and $N - N_1$ countries in the rest of the world.⁴ We denote the source region by i and the destination region by n . Each region i is endowed with H_i units of skilled labor and L_i units of unskilled labor. There are two sectors in the economy indexed by $j \in \{A, M\}$, where A represents agriculture and M stands for manufacturing. The production for agricultural goods only uses unskilled labor, while the manufacturing sector uses both types of labor. We assume that agricultural goods are non-tradable while manufacturing goods are tradable but bear iceberg trade costs. The households in region i have a Cobb-Douglas preference with expenditure share on agricultural goods α :

$$U_i = (C_i^A)^\alpha (C_i^M)^{(1-\alpha)}. \quad (1)$$

Households provide two types of labor inputs inelastically and maximize their utility subject to the income constraint:

$$P_i^A C_i^A + P_i^M C_i^M = I_i, \quad (2)$$

where $I_i = w_i^A L_i^A + w_i^M L_i^M + s_i H_i^M$. In Appendix A we discuss the determination of household income in general equilibrium.

2.2. Production

The production for agricultural goods only uses unskilled labor with constant return to scale, and thus the production function is given by

$$Y_i^A = A_i L_i^A. \quad (3)$$

The final goods in the manufacturing sector Y_i^M is a CES composite of a continuum of tradable varieties,

$$Y_i^M = \left(\int_0^1 y_i(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}, \quad (4)$$

where σ is the elasticity of substitution. A firm uses two types of labor to produce variety ω with the following production function,

$$y_i(\omega) = \varphi_i(\omega) L_i^M(\omega)^\beta H_i^M(\omega)^{1-\beta}. \quad (5)$$

³ Although the skill premium in China had increased in the 2000s, it remains lower than the premium in advanced economies ([Sheng and Yang, 2016](#)). Moreover, college enrollment has expanded significantly since the late 1990s, with about seven million college graduates joining the labor force every year. Therefore, the skill premium has declined in recent years and the supply of skilled labor in China is less of a concern ([Bai et al., 2020](#)).

⁴ Our model is general enough to consider inter-city trade and production within China, as well as international trade and multinational production in the world, while in the empirical analysis we focus on exports from Chinese cities to foreign countries.

Given the production technology, the cost of the composite labor input bundle is $c_i = (\frac{w_i^M}{\beta})^\beta (\frac{s_i^M}{1-\beta})^{1-\beta}$, where w_i^M and s_i^M are the wages for unskilled and skilled workers.

Notice that unskilled labor can work either in the agricultural or manufacturing sector, but skilled workers can only work in the manufacturing sector. For regions out of China no minimum wage policy is imposed, and unskilled labor is assumed to move frictionlessly between the two sectors within a region, and thus, the wages for unskilled workers are equal in the two sectors, i.e., $w_i^M = w_i^A$. However, the local governments in each city in China can set a minimum wage for unskilled workers in the manufacturing sector but not in the agricultural sector. Thus, $w_i^M = \max\{w_i^M, w_i^A\}$, and unless the minimum wage meets the condition $w_i^M > w_i^A$, the policy of minimum wage is ineffective and has no effect on the allocation of unskilled labor between the two sectors.⁵

2.3. Multi-Regional production and trade

To produce manufacturing goods, region j has technologies described by the vector $\varphi_j(\omega) = \{\varphi_{1j}(\omega), \varphi_{2j}(\omega), \dots, \varphi_{Nj}(\omega)\}$. When region j produces in another region $i \neq j$, we say that a multi-regional production (MP) by region j operates in region i . We denote the destination region by n , the region of production by i , and the region where the technology originates by j . MP also incurs an iceberg-type efficiency loss of $\mu_{ij} \geq 1$, which is associated with production using an idea from j to produce in i , and $\mu_{jj} = 1$ for all j . Inter-regional trade is subject to iceberg trade cost: $\tau_{ni} \geq 1$ units of any good must be shipped from region i to n for one unit to arrive in country n . We also assume $\tau_{ii} = 1$ for all i and the triangle inequality holds: $\tau_{ni} \leq \tau_{nk}\tau_{ki}$ for all n, k, i .

Following Ramondo and Rodríguez-Clare (2013), we assume that productivity $\varphi_j(\omega)$ are drawn independently across goods and regions from a multivariate Fréchet distribution with parameters $(T_{1i}^j, T_{2i}^j, \dots, T_{Ni}^j)$ and $\theta > \max\{1, \sigma - 1\}$:

$$F_j(\varphi_j) = \exp\left(-\sum_i T_{ij}(\varphi_{ij})^{-\theta}\right), \quad (6)$$

where the parameter θ governs the productivity variation and T_{ij} governs average productivity of MP by region j in region i . We also assume $T_{ij} = T_i^{1-\nu} T_j^\nu$ and $0 \leq \nu \leq 1$, that is, the technology level of multinational production depends on both the host region and its source regions.

All varieties in the manufacturing sector are identical except for production productivity; hence, we drop the index ω . Producers that use technology from region j , produce in region i , and sell in region n charge $p_{nij}(\varphi_{ij}) = c_i \tau_{ni} \mu_{ij} / \varphi_{ij}$ for each unit. Markets are perfectly competitive for manufacturing goods. Thus, the price of a good φ in country n is simply the minimum unit cost, $p_n(\varphi) = \min_{i,j} c_i \tau_{ni} \mu_{ij} / \varphi_{ij}$. Below, we show several propositions of the model:

Proposition.

(a) The shares of goods that region n buys produced with region j 's technologies are

$$\phi_{nj} = \frac{\Phi_{nj}}{\Phi_n}, \quad (7)$$

$$\Phi_{nj} = \sum_i T_{ij} (c_i \mu_{ij} \tau_{ni})^{-\theta}, \text{ and } \Phi_n = \sum_j \Phi_{nj};$$

(b) Of the goods bought by region n produced with region j 's technologies, the share that is produced in region i is

$$\pi_{nj,i} = \frac{T_{ij} (c_i \mu_{ij} \tau_{ni})^{-\theta}}{\Phi_{nj}}; \quad (8)$$

(c) The average price of goods purchased in any market n does not depend on the source of the technology or the location of production; and

(d) The price index in region n , is given by

$$P_n = \gamma (\Phi_n)^{-1/\theta}, \quad (9)$$

where $\gamma = \Gamma(1 + (1 - \sigma)/\theta)^{1/(1-\theta)}$, and $\Gamma(\cdot)$ is the Gamma function.

Based on the proposition above, we can show that the MP by region j in region i is given by:

$$Y_{ij} = \sum_n \phi_{nj} \pi_{nj,i} (1 - \alpha) I_n = \frac{T_{ij} (\gamma c_i \mu_{ij})^{-\theta}}{P_i^{-\theta}} \Psi_i, \quad (10)$$

⁵ We assume that the demand from the urban manufacturing sector determines the employment of unskilled labor when the minimum wage is imposed by the local government, and the rest of unskilled labor remains in the rural area. This assumption can be relaxed but it is not far from China's reality because of the Hukou system, which limits labor mobility between rural and urban areas.

where $\Psi_i = \sum_n \left(\frac{\tau_{ni} P_i}{P_n} \right)^{-\theta} (1 - \alpha) I_n$ can be interpreted as region i 's market potential. The bilateral MP bears the form of a gravity equation and is determined by the adopted technology $T_{ij} \mu_{ij}^{-\theta}$, the labor cost of production c_i , and the market potential Ψ_i . The high efficiency loss in adopting foreign technology and high labor costs in the host region can lead to low MP, while regions with low trade costs can have high market potential, and thus attract more investment from foreign firms.

Taking a log transformation of Eq. (10) and substituting T_{ij} and c_i , we obtain the following linear equation:

$$\ln Y_{ij} = \text{Constant} - \theta [\beta \ln w_i^M + (1 - \beta) \ln s_i^M] + \ln(\Psi_i P_i^\theta) + (1 - \nu) \ln T_i + \nu \ln T_j - \theta \ln \mu_{ij}. \quad (11)$$

Notice that w_i^M can be replaced with w_i^A if no distortion on unskilled labor between two sectors exists. However, if the government imposes a minimum wage policy for unskilled labor in the manufacturing sector, we have $w_i^M = \underline{w}_i^M \geq w_i^A$. Define $\lambda_i \equiv \max\{\frac{w_i^M}{w_i^A}, 1\}$, which measures the distortion on the unskilled labor wage between two sectors, and thus we have $w_i^M = \lambda_i w_i^A$.⁶ The above equation can be written as

$$\begin{aligned} \ln Y_{ij} = & \text{Constant} - \beta \theta \ln \lambda_i - \theta [\beta \ln w_i^A + (1 - \beta) \ln s_i^M] \\ & + \ln(\Psi_i P_i^\theta) + (1 - \nu) \ln T_i + \nu \ln T_j - \theta \ln \mu_{ij}. \end{aligned} \quad (12)$$

Furthermore, we can show

$$\frac{\partial \ln Y_{ij}}{\partial \ln \lambda_i} = -\theta \beta < 0, \text{ and } \frac{\partial^2 \ln Y_{ij}}{\partial \ln \lambda_i \partial \beta} = -\theta < 0, \quad (13)$$

which implies that the elasticity of MP to the minimum wage distortion depends on the factor share of unskilled labor (β) in an industry: a rise in the effective minimum wage standard decreases the MP from region j in region i more for unskilled-labor intensive industries. Moreover, θ captures the sensitivity of the elasticity of MP to minimum wage distortion with respect to the unskilled-labor intensity of the industry. A higher θ implies a larger difference in the effects of minimum wage distortion on MP between two given industries with different intensities of unskilled labor.

Total imports by region n from i are given by the sum of goods produced in region i with technologies from any other regions,

$$X_{ni} = \sum_k \phi_{nk} \tau_{nk,i} (1 - \alpha) I_n = \frac{T_i' (c_i \tau_{ni})^{-\theta}}{\sum_{k=1}^N T_k' (c_k \tau_{nk})^{-\theta}} (1 - \alpha) I_n, \quad (14)$$

where $T_i' \equiv \sum_j T_{ij} \mu_{ij}^{-\theta}$ is the augmented technology parameter for region i that takes into account the possibility of using technologies from other regions discounted by efficiency loss μ_{ij} . Thus, the bilateral imports of region n from i are determined by the exporting region i 's augmented technology level T_i' , cost of composite labor input c_i , and trade cost τ_{ni} , all relative to the aggregation of these factors around the world for region n . This gravity equation differs from the one in Eaton and Kortum (2002) in the technology parameter, which allows the possibility of using technology from other regions discounted by efficiency loss μ_{ij} . This equation also demonstrates the complementarity of MP and exports.

Taking the log of Eq. (14) and substituting for c_i , we obtain the log gravity equation of bilateral exports from i to region n :

$$\ln X_{ni} = \text{Constant} + (\ln T_i' - \theta \ln w_i^A) - \beta \theta \ln \lambda_i - \theta (1 - \beta) \ln (s_i^M / w_i^A) + \ln \xi_n - \theta \ln \tau_{ni}, \quad (15)$$

where $\xi_n \equiv \frac{(1 - \alpha) I_n}{\sum_{k=1}^N T_k' (\tau_{nk} c_k)^{-\theta}}$ is the effective import demand by region n , which depends on its expenditure share of manufacturing goods divided by an index of the toughness of industry competition in this region. Moreover, the trade elasticity to iceberg trade cost in this model is still θ .

Furthermore, we can show that

$$\frac{\partial \ln X_{ni}}{\partial \ln \lambda_i} = -\theta \beta < 0, \text{ and } \frac{\partial^2 \ln X_{ni}}{\partial \ln \lambda_i \partial \beta} = -\theta < 0. \quad (16)$$

Define the elasticity of bilateral exports to minimum wage distortion as $\epsilon = -\frac{\partial \ln X_{ni}}{\partial \ln \lambda_i}$, the equation above implies that the elasticity of bilateral exports to minimum wage distortion increases with the industrial factor share of unskilled labor. A rise in the effective minimum wage standard decreases more exports from region i to region n for more unskilled-labor intensive industries. Moreover, θ captures the sensitivity of bilateral-exports elasticity to minimum wage distortion with respect to the unskilled-labor intensity of the industry. A higher θ has the same implication for the differential effect of minimum wage distortion on bilateral exports as it has on MP, which should be larger if we compare two industries with different intensities of unskilled labor.

⁶ For regions (countries) out of China, we assume that no minimum wage is imposed, and thus $\lambda_i = 1$. Our definition of λ_i is general enough to incorporate cases with and without minimum wage policy for a given region. However, our focus is on regions within China with binding minimum wage policies and the associated distortions of the labor market.

Barba Navaretti et al. (2015) and Hanson et al. (2015) define $\kappa_i \equiv \ln T_i' - \theta \ln c_i$ as source region i 's log export competitiveness, which is a function of the regional augmented efficiency in the manufacturing sector (T_i') and the region's unit composite labor cost (c_i). Thus, raising the minimum wage standard also reduces the region's export competitiveness in unskilled-labor intensive industries.

Eq. (16) shows that rising labor costs in region i not only affect domestic firms but also reduce the incentive of foreign companies to use region i as an export platform. This result is consistent with the finding on the effect of rising labor costs on the MP as indicated in Eq. (13). Moreover, we can break down the RHS of Eq. (14) into domestic exports ($X_{ni,i}$) and foreign exports ($X_{nj,i}$) from region j located in region i

$$\begin{aligned} X_{ni} &= X_{ni,i} + \sum_{j \neq i} X_{nj,i} \\ &= \frac{T_i (c_i \tau_{ni})^{-\theta}}{\sum_{k=1}^N T_k' (c_k \tau_{nk})^{-\theta}} (1 - \alpha) I_n + \frac{(\sum_{j \neq i} T_{ij} \mu_{ij}^{-\theta}) (c_i \tau_{ni})^{-\theta}}{\sum_{k=1}^N T_k' (c_k \tau_{nk})^{-\theta}} (1 - \alpha) I_n. \end{aligned} \quad (17)$$

Note each still bears the form of a gravity equation. Moreover, $\frac{\partial^2 \ln X_{ni,i}}{\partial \ln \lambda_i \partial \beta} = \frac{\partial^2 \ln X_{nj,i}}{\partial \ln \lambda_i \partial \beta} = -\theta < 0$. Hence we can test empirically whether unskilled-labor cost shocks affect domestic and foreign exports separately. From the Chinese trade data, we can use exports by Chinese-owned firms and exports by foreign-invested firms to measure the domestic and foreign exports, respectively.

The complementarity between MP and exports is also indicated by $\pi_{nj,i}$, which is region i 's share of goods bought by region n produced with region j 's technology as shown in Eq. (8). Regions with lower labor costs and trade costs can have greater export potential, making them preferable locations for multi-regional companies. In a similar vein, regions with greater export potential and lower loss of technology efficiency for MP are better places for FDI inflows, which boosts further the technology level and export competitiveness in the global market. Cheap labor has been the crucial factor for China developing into the “magnet of FDI” and the “World's Factory”, but trade liberalization and reductions in FDI barriers have also played significant roles in attracting foreign investment and promoting China's exports.

The model generates a set of hypotheses on MP and bilateral exports that we can test empirically.

Hypothesis.

- (1) A rise in minimum wage distortion decreases bilateral exports more for unskilled-labor intensive industries.
- (2) A rise in minimum wage distortion decreases domestic exports and foreign exports more for unskilled-labor intensive industries.

The model also provides guidance for our empirical analysis. First, bilateral exports follow the form of gravity equations; thus, we can use empirical data to test for it. Second, Eq. (15) provides an empirical gravity specification for us to evaluate the differential effects of minimum wage on exports across industries within the manufacturing sector. However, an upward adjustment in minimum wages may reflect an improvement in the living standard and minimum wages increase over time as the economy grows. We deflate the minimum wage level by rural income per capita and underscore the distortion due to the minimum wage requirement. This theory-based measure of distortion reflects government interventions on the labor market, and thus, is more likely to be exogenous and provide better identification for the effect of labor cost shocks on exports. Moreover, the regression of regional exports on minimum wage distortion might be subject to some unobservable regional factors. We also take the advantage of rich variations of skill intensity at the industry level to explore the heterogeneous effects of minimum wage distortion on exports. The identification assumption is that those unobservable regional factors are not correlated with industrial skill intensities. The fundamental implication of Eq. (15) for identification is that we should explore cross-region and cross-time variations in minimum wage distortions and cross-industry differences in skill intensities.

One unique contribution of the model is that it breaks down bilateral exports into domestic and foreign exports according to exporter ownership types, and each of them still follows the gravity equation. Thus, we can use the same econometric specification and identification method to study the effect of rising labor costs on two types of exports and compare which one is more sensitive to labor cost shocks. The model suggests that the effect of minimum wage distortion should have the same effects on two types of exports, given the same industrial skill intensity and the same shape parameter of the productivity distribution. In reality, firms in China might choose to locate in different cities with different levels of labor costs and the productivity distribution might also vary across cities and industries. In addition, the model also does not consider the dynamic feature of firms' entry and survival. Thus, an interesting empirical question is whether foreign exports are more sensitive to labor cost shocks than domestic exports.

Last, we only show the effects of minimum wage distortion on exports in the partial equilibrium. In a full general equilibrium model as shown in Appendix A, both unskilled and skilled wages w_i^A and s_i^M will be affected by minimum wage distortion λ_i . However, this effect may not be a serious concern for the case of China. First, given the large size of the rural labor force and the quality difference between skilled and unskilled workers, the general equilibrium effect of minimum wage distortion on w_i^A and s_i^M might be limited. Second, Eq. (15) indicates that we can still capture the effects of minimum wage distortion if we control properly for the relative wage of skilled workers in empirical regressions and if our identification assumptions hold.

Table 1
Summary Statistics of Chinese Manufacturing Exports.

Year	Total exp (bn\$) (1)	Share of foreign firms (2)	Ave exp per variety (1000\$) (3)	Num of varieties (4)	Num of firms (5)	Ave num of varieties per firm (6)
2000	134.64	0.72	465.25	289,396	39,429	7.34
2001	159.93	0.72	432.24	370,002	49,425	7.49
2002	203.61	0.72	416.49	488,869	64,550	7.57
2003	285.87	0.73	485.98	588,228	77,207	7.62
2004	398.93	0.74	541.27	737,033	94,703	7.78
2005	525.67	0.75	600.12	875,947	110,828	7.90
2006	659.92	0.74	692.81	952,521	126,539	7.53
2007	880.55	0.72	754.79	1,166,615	140,549	8.30
2008	774.35	0.68	821.92	942,129	126,337	7.46
2009	886.75	0.70	737.76	1,201,946	155,865	7.71
2010	1187.50	0.68	865.83	1,371,512	167,913	8.17
2011	1321.84	0.66	959.76	1,377,258	178,836	7.70

3. Data and empirical strategy

3.1. Trade data

We use the data set of firm-product level Chinese customs trade data for the period 2000–11, which have been widely used in the literature, for example, [Brandt et al. \(2017\)](#) and [Yu \(2015\)](#). This data set covers the universe of Chinese exporting and importing firms and records the value and quantity of imports and exports at the product level categorized by the eight-digit Harmonized System (HS) code for each firm. The data set also contains information on each firm including firm identity, name, location, destination/sourcing country, ownership category, Chinese customs regimes, and transportation methods. One unique feature of Chinese customs data is that it contains the ownership information of firms, including domestic state-owned enterprises, domestic collective-owned enterprises, domestic private-owned enterprises, joint ventures, and wholly foreign-owned enterprises. We group the latter two as foreign-invested enterprises (FIE) and the others as domestic-owned enterprises (DOE). We use exports by DOEs as domestic exports and exports by FIEs as foreign exports. For our analysis, we focus on manufacturing exports and exclude all trade intermediaries and observations with missing values in key variables such as export value, HS code, destination country, firm location, and ownership types. We also focus on ordinary exports and processing exports, which in total contribute more than 90 percent of Chinese total trade on average and exclude other customs regimes, such as foreign aid and barter trade.⁷ Moreover, as firm locations are at best known at the prefecture level with a four-digit administrative code, we choose prefecture as the geographic unit for analysis.⁸ By using the concordance between HS code and ISIC Revision 3, we aggregate export value into the two-digit ISIC industrial level, and thus, we can construct a panel of Chinese manufacturing exports at the city-ISIC-importer (country) level for different ownership types of firms, which allows us to adopt the classic gravity equation regression in the subsequent empirical analysis.

With the aid of the disaggregated firm-product trade data, we further decompose export value into intensive margins and extensive margins, and explore which margin is more important upon labor cost shocks such as minimum wage hikes. Define a variety as a firm ID-six digits HS code pair, and we have the following decomposition of exports:

$$EX_{sint} = \frac{EX_{sint}}{NFHS_{sint}} \times NFHS_{sint} = \frac{EX_{sint}}{NFHS_{sint}} \times NFIRM_{sint} \times \frac{NFHS_{sint}}{NFIRM_{sint}}. \quad (18)$$

The first equality decomposes export value EX_{sint} into the extensive margin, which is measured by the number of varieties ($NFHS_{sint}$), and the intensive margin, which is measured by the average export value per firm-HS pair ($\frac{EX_{sint}}{NFHS_{sint}}$). The second equality further decomposes the extensive margin into two parts: the number of exporting firms ($NFIRM_{sint}$) and the average number of varieties per firm ($\frac{NFHS_{sint}}{NFIRM_{sint}}$).

[Table 1](#) reports the key statistics and the decomposition of Chinese manufacturing exports over years. Chinese manufacturing exports have increased by almost ten-fold from 2000 to 2011. Joint ventures and wholly foreign-owned firms are the main players as they contributed to about 70 percent of Chinese manufacturing exports on average during the sample period. More interestingly, the export share of foreign firms increased from 72% in 2000 to the peak at 75% in 2005, and then declined to 66% in 2011. This inverted U-shape may suggest that China is losing its edge as the platform for foreign exports by multinationals. The decomposition exercise implies that the extensive margin is more important than the intensive margin for Chinese export growth, as the number of varieties has increased more than four times while the average

⁷ One practical reason is that the data during the period 2007–10 only contains observations for ordinary and processing trade.

⁸ Although the customs trade data have the information of firm address which possibly allows us to find the county or sub-district of prefectures, this variable has many missing values over the sample period. For example, 35% of observations do not have the information of firm address in 2005.

export value per variety only doubled during the sample period. The rising number of varieties can be attributed mainly to the entry of new firms as the average number of products per firm did not change significantly over time.

3.2. Minimum wage and spatial distortion

3.2.1. Institutional background of minimum wages in china

The Chinese government implemented a minimum wage system in urban areas starting in July 1994, as stated in the then Labor Law. According to Article 48 of the Labor Law, firms in formal sectors were all required to comply with local minimum wage policies. Provincial governments were authorized to set their own minimum wage standards. The minimum wages across cities within a province also differ generally due to economic disparities and negotiations between local governments and their respective authorities (Casale and Zhu, 2013).

The implementation of the minimum wage requirement moved ahead quickly and widely and our data indicate that the majority of prefectural cities had implemented their minimum wage standards by 1997. After then, the adjustment of minimum wages became even more frequent than the past. Because China was advancing its market reforms when it joined the WTO in 2001, the Ministry of Labor issued a new policy that established a more comprehensive coverage of minimum wage standards and increased non-compliance penalties. This new phase of minimum wage policy reform starting in 2004 made the administrative procedure of minimum wage adjustment more formal and more regular. Since then, governments have strengthened supervision and enforcement has been more effective (Su and Wang, 2014). In particular, this reform emphasized the following major changes: (1) extension of coverage to town-village enterprises and self-employed businesses; (2) a new type of wage standard for hourly minimum wages; (3) an increase in the penalty for violators from 20%–100% to 100%–500% of the wage owed; and (4) more frequent minimum-wage adjustment (at least once every two years).⁹ The new policy states that local labor departments exercise supervision within the scope of each hierarchical administration. The new Labor Contract Law enacted later in 2008 emphasized once more the importance of minimum wage policies, and thereafter, the minimum wage became one of the key components of China's labor market policies.

3.2.2. Minimum wage data

From the Ministry of Labor and Social Security, we collect an administrative data set of minimum wages across 337 prefectural cities in all provinces of China for the period 1995–2012. China's minimum wages are specified in terms of several levels, including monthly wages, part-time hourly wages, and full-time hourly wages. Hourly minimum wages are set by local governments based on monthly minimum wages and an estimate of monthly working hours of about 170. We use full-time monthly minimum wages to compute annual minimum wages in our estimation due to their relevance to the manufacturing sector. The prefectural city is the geographic unit of our data. Our data shows that 22 percent of cities have uniform levels of minimum wages for their counties and sub-districts. For a city with different minimum wages across its counties, we use the simple average as the city level minimum wage.

One concern is the compliance in China with minimum wage regulations because the formal legal institutions in developing countries are relatively weak. Huang et al. (2015) show that the shares of manufacturing firms in China that paid an average wage below the county minimum wage was about 7% during the period 2002–03 and dropped to about 2% during the period 2004–06. They also use the Urban Household Survey data to calculate the share of the full-time employees with wages below their county minimum wages, and find that this non-compliance share was about 7% over the period 2002–06, thereby indicating that the issue of non-compliance in China may not be worse than that in other developed economies.¹⁰

Next, we use minimum wage data to construct our key measure of the minimum wage distortion on unskilled labor $\lambda_i \equiv \max\{\frac{w_i^M}{w_i^A}, 1\}$ where i denotes city i . Empirically, we use the (one-year-lagged) provincial agricultural household disposable income per capita as a proxy for w_i^A , partly because the wage data in the agricultural sector at the city level are not available and partly because the cross-city variation of this index is largely from the minimum wage rather than agricultural income.¹¹

Note that the measure of minimum wage distortions should be no less than one, but to show the fraction of cities with minimum wages below their provincial agricultural incomes, we plot the distributions of $\log(w_i^M/w_i^A)$ for 2000, 2005, and 2011 in Fig. 3. A further look at the data shows that the fraction of cities that have minimum wages below lagged

⁹ When the global financial crisis hit China in 2008, the Ministry of Labor provided policy guidelines that asked for a freeze in minimum wage adjustment in that year. This kind of national interruption of minimum wage adjustment only happened once so far.

¹⁰ US Bureau of Labor Statistics (2020) shows that the non-compliance rate in the U.S. is about 1.5%, defined as the proportion of hourly-paid workers earning below the federal minimum wage, but the rate becomes much larger for teenagers. For 16–19 year old, it is estimated to be 3.2%.

¹¹ At the national level, we find that rural household disposable income per capita is very close to the bottom 10% urban household disposable income per capita during 2002–2012, based on the data from the National Bureau of Statistics of China. This fact further justifies the use of rural income as the opportunity cost of urban manufacturing employment for unskilled workers. In contrast to the national average, We prefer provincial rural incomes as they better capture the spatial variations in rural income. However, our results continue to hold when we alternatively use the national agricultural household disposable income per capita to deflate the city level minimum wage, or the log value of minimum wage itself as we will show later.

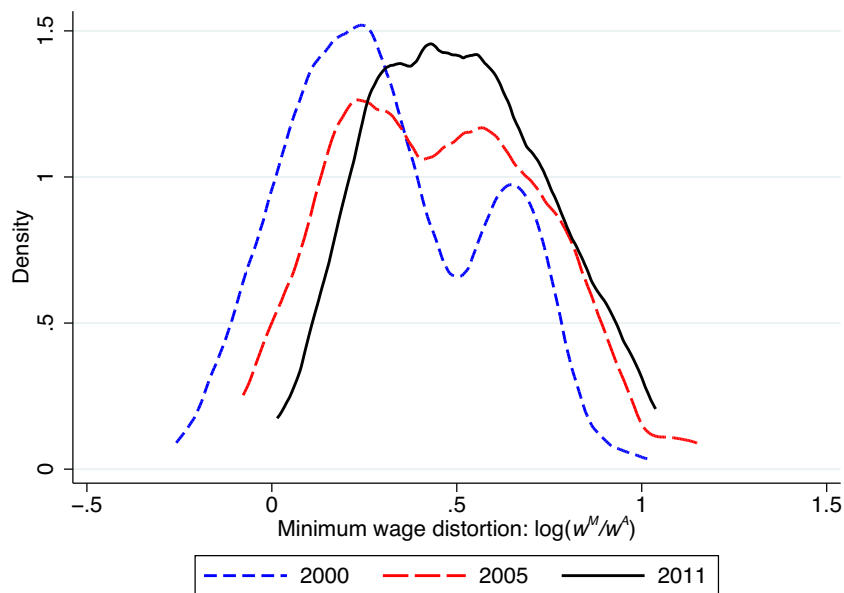


Fig. 3. The Distribution of Minimum wage distortion without lower bound.

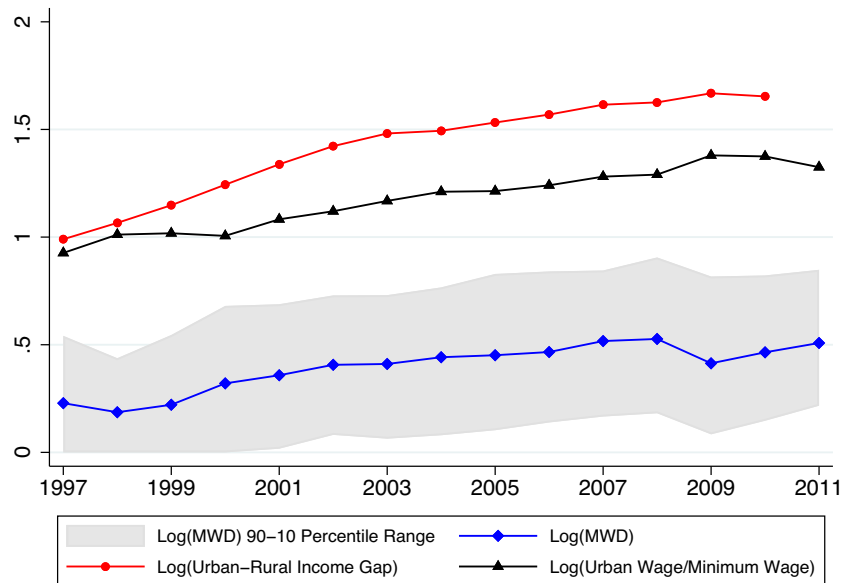


Fig. 4. Minimum wage distortion and Urban-Rural income gap

Notes: MWD denotes minimum wage distortion at the prefectural city level. Urban wages at the city level are average employee wages from the formal sector surveyed by the NBS of China. The urban-rural income gap is measured by the ratio of urban wages to provincial rural household disposable income. Three lines are plotted with national means for each year. The shaded band denotes the 90-10 percentile range for the distribution of $\log(\text{MWD})$.

agricultural incomes per capita dropped significantly and only fewer than twenty cities after 2001 set minimum wages below lagged agricultural incomes per capita. The fraction continued to decline during the sample period, and all cities in 2011 set minimum wage standards above their lagged rural household incomes per capita.

Fig. 4 shows that the mean of (\log) minimum wage distortions across cities had been increasing steadily during the period 2000–11 except in 2009 when a significant drop occurred because minimum wage adjustment was frozen temporarily due to the global financial crisis. The 90-10 percentile interval also grew before 2008 but shrank later on. Fig. 4 also presents the (\log) urban-rural income gap measured by the (\log) ratio of urban average wages to rural income. The urban average wage was about two times higher than rural income in 1997, but the gap more than doubled after 2006. Clearly, the urban-rural income gap is larger and also grew faster than the minimum wage distortion. Moreover, Fig. 4 plots the (\log) ratio of urban average wage to minimum wage. A rising trend in this ratio indicates that urban average wages grew

much faster than minimum wages, and thus it is unlikely that local governments adjust minimum wages mainly according to their local average wages.¹²

We also plot the spatial distributions of minimum wages and (log) minimum wage distortions across cities for 2000, 2005, and 2011, as shown in Fig. 5. One striking observation is that regions with higher minimum wages are not necessarily the places with higher distortions. For example, regions with higher minimum wages such as cities in the eastern coast have less severe distortions than cities in the western and middle areas of China. In fact, the correlation between the minimum wage level and its distortion is relatively low, i.e., the correlation coefficient is about 0.28. This feature has important implications for the competitiveness of regional exports as the provinces in the eastern coast are key contributors to the remarkable growth of Chinese exports. Low distortions of minimum wages there might alleviate the negative effect of this policy on China's overall export competitiveness.

3.3. The econometric specification

Now we turn to study how rising labor costs affect China's exports by exploring the cross-city and cross-time variations in minimum wage distortions and cross-industry differences in skill intensities. Our theory shows that the classic gravity equation can be applied for both multi-regional production and trade. It also suggests that we can adopt the gravity regression not only for total exports, but also separately for domestic exports and foreign exports. This consistency of econometric specifications allows us to study comparatively whether foreign exports are more sensitive than domestic exports.

Following the theoretical gravity Eq. (15), the empirical specification of gravity can be written as

$$\ln(EX_{sint}) = \delta_0 + \delta_1 \times Unskint_s \times \ln \lambda_{it} + \delta_2 Bilvar_{in} + \delta_3 X + D_{it} + D_{nt} + D_{st} + \epsilon_{sint}, \quad (19)$$

where the dependent variable $\ln(EX_{sint})$ is the log value of exports in industry s shipped from city i to destination country n in year t . Eq. (15) indicates that the export elasticity of minimum wage distortion depends on the unskilled-labor intensity of the industry. Thus, we interact $\ln \lambda_{it}$ with the industry-specific unskilled-labor intensity $Unskint_s$ in regression, which is proxied by the employment share of workers with an education level of junior high school or below based on the Economic Census in 2004. We do not include $\ln \lambda_{it}$ and $Unskint_s$ themselves explicitly in the regression because they will be captured by the city-year and industry-year fixed effects. Our primary interest lies in the parameter δ_1 , which measures the sensitivity of export elasticities to the minimum wage distortion when unskilled-labor intensities vary across industries. Consider two industries with a difference in the unskilled-labor intensity $\Delta Unskint_s$ and their difference in the elasticities of exports to minimum wage distortions are given by $\delta_1 \Delta Unskint_s$. Our model suggests that δ_1 is negative, thereby implying that the higher unskilled-labor intensities of an industry, the stronger the (negative) effect of the minimum wage distortion on its exports.

$Bilvar_{in}$ denotes either a set of time-invariant bilateral variables such as distance, border, and colonial ties between Chinese cities and importer countries, or bilateral fixed effects to control for other unobservable bilateral trade costs.¹³ D_{it} and D_{nt} are city-year and importer-year paired fixed effects, which are used to control for the augmented technology and unskilled-labor costs in city i , and the importer demand in country n in Eq. (15). These two fixed effects are also used to capture the multilateral resistance in the gravity literature, suggested by Anderson and van Wincoop (2003). In addition, the city-year fixed effect also captures unobserved city time-varying factors such as local economic development. We also include the industry-year fixed effect, i.e., D_{st} to control for unobserved industry time-varying factors, such as country-wide industrial technological progress. Lastly, as a more robust alternative to the set of importer-year and industry-year fixed effects, we also adopt the triple importer-industry-year fixed effects D_{snt} , which can further control for industry-destination specific and time-varying demand factors.

X denotes the control variables suggested by our model and some other variables commonly used in the literature of the gravity equation. Our model, through the channel indicated by the third term in Eq. (15), suggests that the relative wage of skilled workers is important for exports of skill-intensive industries. Thus, we include skill endowments, measured by the yearly population share of high-school graduates (including dropouts) at the province level interacted with industry-specific skill intensities.

Following Romalis (2004) and Nunn (2007), we also include industrial capital intensities interacted with yearly city-level capital endowments (capital-output ratios) and industrial contract dependence interacted with provincial contract environment to capture local comparative advantages.¹⁴ Specifically, the data of industrial contract dependence are obtained from Nunn (2007). To proxy contract environment we use the World Bank's index of court cost in the survey of *Doing Business* for 30 provincial capitals in China (World Bank, 2008). For the convenience of quantitative interpretations, we construct an effi-

¹² Note that our measure of minimum wage distortions is likely to be inflated when the price index is higher in the urban than in the rural area. We repeat all of our empirical regressions by using a measure of minimum wage distortion adjusted further by the difference between urban and rural price indices. The results are very similar.

¹³ All cities in China use Chinese as the official language, and a dummy variable indicating common language between Chinese cities and other countries is captured by importer fixed effects, and thus is not included. The colonial ties between Chinese cities and other countries are from Long et al. (2019).

¹⁴ We are grateful to Yang Du in University of Chinese Academy of Social Sciences for sharing his estimate of China's capital stocks at the prefectural level.

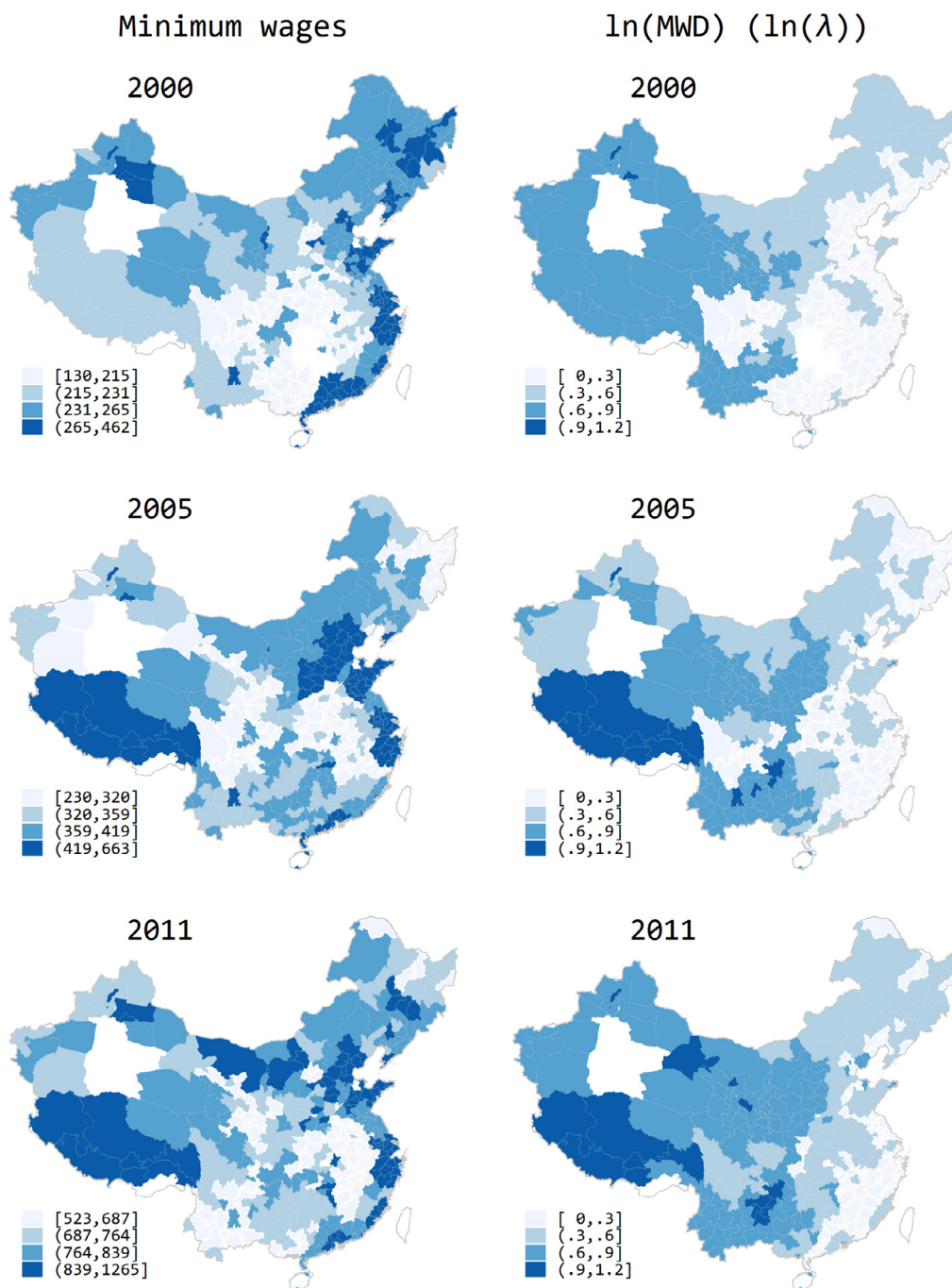


Fig. 5. The spatial distribution of minimum wage and its distortion
 Notes: Missing data in white-colored areas.

ciency measure of contract environment that equals 0.5 minus the ratio of the court cost of going through court procedures to debt claims.¹⁵

¹⁵ We select the threshold of 0.5 because the highest court cost ratio observed in the data is 0.42. See more discussion in Feenstra et al. (2013) and Sheng and Yang (2016).

One important concern may be the endogeneity of the minimum wage standard and the constructed minimum wage distortion.¹⁶ In particular, our estimation would be biased if minimum wage standards are associated with city industry structure or characteristics. For example, if cities with a greater share of unskilled-labor intensive industries increase the minimum wage standard at a slower speed, then our estimate of the key variable will be biased. Moreover, industry concentration and the presence of state-owned enterprises and foreign invested firms might affect local governments' decision on minimum wage standard through bargaining and lobbying. To test this possibility, in Appendix B, we conduct a panel regression of minimum wage growth at the city level on a set of local economic conditions. We find that a city's minimum wage growth does not respond to the output shares of unskilled-labor intensive industries in the city and its neighboring cities, nor to the industry concentration measured by the Herfindahl index and the shares of SOEs and FIEs in the manufacturing sector. In contrast, minimum wage growth would be slower in a city where the minimum wage was already high or the minimum wage growth rate two years before was higher relative to its neighboring cities. This is consistent with the fact that local governments set minimum wages as part of the social security system, rather than as a policy instrument for industrial development. In addition, we already include in *X* the interaction term of the industrial skill intensity multiplied by the provincial relative skill endowment. Thus, the potential correlation between minimum wages and the provincial concentration of skill intensive industries is already controlled for.

To further ease the concern of endogeneity from unobserved contemporaneous confounding factors, we construct an instrumental variable for the key variable of minimum wage distortion. Local governments are usually required by the central government to raise minimum wage standards (at least once) every two years except 2008, the year when the global financial crisis broke out, and they are also under pressure to keep the pace of minimum wage adjustment along with its neighboring cities. Following these policy considerations, we construct the predicted minimum wage in year *t* for a city by multiplying its minimum wage in year *t* – 2 with the average growth rate of minimum wage levels between year *t* – 4 and year *t* – 2 in its neighboring cities.¹⁷ Using this predicted minimum wage, we further construct an instrumental variable for the minimum wage distortion and its interaction term with the industry-specific unskilled-labor intensity.¹⁸

One additional challenge is to deal with the zeros of export value, which is a common issue in the empirical trade literature when disaggregated exports are recorded according to industrial and spatial classifications (Baldwin and Harrigan, 2011). Excluding zero exports because of log transformation may leave out useful information contained in the data and possibly lead to biased estimates. To address this issue, we adopt the Poisson pseudo-maximum likelihood (PPML) estimation method proposed by Silva and Tenreyro (2006), which uses the level of trade flow as the dependent variable so that it can include zeros.

In the empirical analysis, we drop four municipalities, including Beijing, Shanghai, Tianjin, and Chongqing, because those four mega cities enjoy a higher degree of autonomy than other prefectural cities and the decision process for minimum wage adjustment might be different from other cities.¹⁹

4. Baseline empirical results

4.1. Baseline results

Table 2 shows the baseline results for the log value of exports as the dependent variable.²⁰ Each observation is a unit for the tuple of city (exporter), importer, industry, and year. We cluster the standard errors at the city level as the minimum wage is at the city level. In OLS and IV regressions, only observation units with positive exports are included, while the PPML estimation in the last column includes zero export values.

The specification for Column (1) follows the gravity Eq. (15) closely by including the common bilateral variables relevant to trade, such as distance and dummy indicators for border sharing and colonial ties. Column (2) replaces the bilateral variables with importer-by-exporter fixed effects so as to control for other unobserved time-invariant bilateral factors that might also affect trade. To capture the effects of local comparative advantages on exports, both columns include the interaction terms of industrial skill intensity multiplied by provincial relative skill endowments, industrial capital intensity multiplied by city capital endowments, and industrial contract dependence multiplied by provincial contract environment.

¹⁶ Hau et al. (2020) have shown that the minimum wage growth at the city level does not correlate with macroeconomic variables including GDP per capita growth, city average wage growth, TFP growth, and local stocks returns.

¹⁷ We use two-period lagged minimum wages as the city might not adjust its minimum wage every year.

¹⁸ Our IV based on the lagged value of minimum wage can mitigate the possible bias from unobserved contemporaneous confounding factors. For example, an unexpected local government revenue windfall may lead to an increase in the minimum wage standard and subsidies (or in terms of value added tax rebates) to the exports of high tech and skill-intensive industries. In this case, omitting the government revenue windfall may lead to bias in our estimate of the key variable. Other unobserved contemporaneous factors that affect firm performance may also have effects on their abilities to hiring minimum wage workers and on their performance of exports, such as tax policy changes or natural disasters (i.e., flood). The endogeneity issue arising from those omitted variables can be addressed by our IV approach.

¹⁹ However, our results are robust if we include these four mega cities.

²⁰ Due to the zero value in trade data and missing values in other control variables such as the capital-output ratio, the sample for regressions in Table 2 covers about 274–275 prefectures. As the cities that are not covered in the regression contribute less than 0.3% of total exports (except the four mega cities), we believe that they may not change our results substantially.

Table 2
Baseline results.

	OLS		IV			PPML
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(MWD) × Unsk int	-3.013*** (0.921)	-3.016*** (0.941)	-2.983*** (1.012)	-2.989*** (1.020)	-3.755*** (1.379)	-5.588*** (1.332)
Sk endow × Sk int	0.129*** (0.042)	0.139*** (0.043)	0.137*** (0.044)	0.143*** (0.046)	0.120** (0.054)	0.290*** (0.089)
Contr envir × Contr int	0.053*** (0.012)	0.050*** (0.012)	0.050*** (0.011)	0.053*** (0.012)	0.067*** (0.015)	0.130*** (0.019)
Capit endow × Capit int	0.005** (0.002)	0.006*** (0.002)	0.006*** (0.002)	0.008*** (0.003)	0.008** (0.003)	0.010*** (0.003)
TFP					0.385*** (0.048)	
Ln(dist)	-0.601*** (0.037)					-0.339*** (0.028)
Border	0.524 (0.358)					0.059 (0.088)
Colony	0.125*** (0.035)					0.010 (0.046)
N	1,687,420	1,694,326	1,682,662	1,678,698	1,022,873	14,264,524
R ²	0.410	0.468	0.470	0.520	0.463	0.83
City-Year FE	+	+	+	+	+	+
Importer-Year/Ind-Year FE	+	+	+		+	+
Importer-Ind-Year FE				+		
Importer-City FE		+	+	+	+	
First stage F-stat			1031	1043	635	
# Cities	275	275	274	274	272	275
# Industries	22	22	22	22	22	22

Notes: The dependent variable is the log value of exports, and constants are included in the regressions while not shown in the table. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

The OLS estimation results in Columns (1) and (2) show that our key estimate of δ_1 is significantly negative at the 1 percent level, indicating that minimum wage distortions have much stronger (negative) effects on Chinese exports for unskilled-labor intensive industries than skill-intensive industries. In other words, the export elasticity to minimum wage distortion is higher for industries with higher shares of unskilled labor. This result supports our theory and is also robust to controlling for common bilateral variables or importer-exporter fixed effects as well as local comparative advantages from the skilled labor force, capital endowment, and contract environment.

Moreover, our results on other control variables are largely consistent with empirical gravity regressions in the literature. Trade barriers proxied by distance have significantly negative effects on Chinese exports. The export elasticity of distance is estimated to be around -0.6 , comparable to typical gravity equation estimates (Head and Mayer, 2014). The effect of sharing borders between Chinese cities and other countries is positive but statistically insignificant at the 10 percent level, possibly because only 0.1 percent of our sample share borders with other countries. The coefficient of the colony dummy variable is statistically significant, consistent with the literature that shows that historical colonial ties increase current bilateral trade (Head et al., 2010). Moreover, consistent with our theory, a city located in provinces with high skill endowment also exports more skill-intensive products. In addition, contract environment and capital stock are important sources of local comparative advantages. Cities with better contract environment and abundant capital export more in contract- or capital-intensive industries. These findings are broadly consistent with those in the existing literature (Romalis, 2004; Nunn, 2007).

To deal with the endogeneity issue we adopt an instrumental variable approach as discussed above. The results of IV estimation in Column (3) are close to OLS estimation in Column (2). In the regression of the first stage, the estimated coefficient of the IV is 0.78 and statistically significant at the 1 percent level. We also conduct the F-test for weak instruments in the first-stage regression. The statistics are all above the Stock-Yogo criteria of 10, and thus, the notion of weak instruments is rejected.²¹

Moreover, one may be concerned that the estimation of the effect of minimum wage distortions on exports would be biased without controlling for external demand specific to industry-by-destination. For example, the key estimate will be biased upwards if cities with higher growth in minimum wages happen to export unskilled-labor intensive products to countries with low GDP growth. To control for unobserved industry-destination specific and time-varying demand factors,

²¹ Note that the high F-stat is partly because we construct the predicted minimum wage by using a city's 2-year lagged minimum wage, and partly because we interact the predicted minimum wage with the industrial unskilled-labor intensity. The increase in sample dimensionality from city-year in minimum wage regressions to city-industry-destination-year in export regressions together with much more fixed effects may inflate the F-stat in the first stage regression. With the sample of the city-year panel, the F-stat of a test for weak instruments falls to 104 from the first stage regression of minimum wages on the instrumental variable and other controls including skill endowment, capital endowment, and city and year fixed effects.

we include importer-industry-year fixed effects in Column (4), and the estimates are similar to those in Column (3), suggesting that industry-year and destination-year fixed effects may be sufficient to capture unobserved industry or destination demand factors.

In addition, we also include city-industry time-varying TFP in Column (5) as one additional control variable for the subsample of 2000–08 since the measure of TFP is not available after 2008 from the data of Annual Survey of Industrial Firms. We compute the productivity at the city-industry-year level by averaging firm level TFP estimates (Hau et al., 2020). As the TFP measure is the Solow residual from the estimation of production function using firm level data, it captures all the remaining observed or unobserved factors for firms' production and exports. Thus, including TFP could significantly mitigate the concern of omitted variable bias. Consistent with our model, we find that the TFP effect is significantly positive for exports. The estimates of δ_1 s remain largely consistent with our baseline results, although the magnitudes decline slightly when controlling for TFP for the same subsample.²²

Column (6) presents the PPML estimation that deals with zero values in the dependent variable. Note the sample size increases dramatically from 1,687,420 in Column (1) to 14,264,524 in Column (6).²³ The PPML estimates for distance and colonial ties become smaller and the colony dummy is no longer significant. However, the PPML estimates for our key coefficient δ_1 and other three control variables of local comparative advantages become larger than the corresponding OLS estimates in Column (1) indicating that our OLS and IV estimates may be rather conservative. Thus, we use the IV specification in Column (3) for quantitative interpretations and the subsequent analysis.

We compute the quantitative effects of minimum wage distortion and other variables based on the IV estimation in Column (3). For example, given two industries with a difference in unskilled-labor intensity equal to 0.1, i.e., $\Delta Unskint_s = 0.1$, our key estimate of $\delta_1 \approx 3$ implies that a one percent increase in the minimum wage distortion will lead to a 0.3 percent decline in the exports of the more unskilled-labor intensive industry compared with its effect on the export of the other industry. Based on the 2004 Economic Census data, the largest gap in unskilled-labor intensity across industries is about 0.3. Thus, a one percent increase in the minimum wage distortion will lead to an extra decline of 0.9 percent in the exports of the most unskilled-labor intensive industry compared with its effect on the exports of the least unskilled-labor intensive industry.

Our baseline estimate of $\delta_1 \approx 3$ is in the range of the dispersion-of-productivity estimates in the literature based on Eaton and Kortum (2002).²⁴ The estimated dispersion parameters for two-digit ISIC-Rev. 3 manufacturing sectors by Caliendo and Parro (2015) range from 0.39 to 64.85, with the median value of 4. In their robust sample by dropping the observations with small trade values, the median value of their estimates drop to 2.2. Using various disaggregated international price and trade flow data, Simonovska and Waugh (2014) find dispersion parameters between 2.79 and 4.46, and their preferable estimate is roughly four.

4.2. Further discussions on baseline estimation

In this subsection we address several additional concerns on our identification strategy and econometric specification. The first is related to the source of identification—whether it is truly from the minimum wage or the provincial rural income. The second concern is whether our results are robust to unobserved region-industry specific factors. The third considers that the variations in the minimum wage are across cities and years but not across destination countries, and thus it could be more transparent to aggregate the sample over importers. The last one is about the correlations of error terms within industries or regions, so we should experiment with different clustering options to allow for potential correlations in different dimensions and check the robustness of our benchmark results.

Our identification crucially relies on the exogenous variation in minimum wages across cities and years. Specifically, we construct a measure of minimum wage distortion by deflating the minimum wage with the lagged provincial rural disposable income to control for the difference in living standards for unskilled workers across China over years. However, this may introduce additional variations from the rural income into minimum wage distortions.

To address this concern, we first include province-industry-year fixed effects, which not only absorbs the provincial rural disposable income, the denominator in the constructed log value of minimum wage distortion, but also helps to capture any unobserved province-industry time-varying factors such as provincial industrial structure and industrial spatial correlations within the province, and yet at the cost of removing cross-province variations in the minimum wage. Column (2) of Table B.2 in Appendix B shows that our results still hold. However, the magnitude of our key estimate increases significantly after controlling for province-industry-year fixed effects, compared with the baseline results in Column (1). This is possible due to the fact that the estimated effects of the minimum wage distortion capture the cross-city effect within narrowly defined province-industry groups.

²² The IV estimates of δ_1 is -4.455 for the subsample 2000–08 with the same set of fixed effects and control variables except TFP.

²³ Estimating the non-linear PPML model with high dimensional fixed effects is challenging due to the incidental parameter problem. We use the Stata command `ppmlhdfc` for estimation and it converges when we include bilateral variables with fixed effects of city-year, importer-year and industry-year, but it does not when we further include the bilateral fixed effects. Thus, we report the results for the regression with bilateral variables, which also allows us to compare them with the results of the log-linear model.

²⁴ In the context of Eaton and Kortum (2002), the parameter of productivity dispersion is also the elasticity of bilateral trade to trade cost.

Moreover, to ensure that the identification source is from the minimum wage itself, we also use the log value of minimum wage deflated by the lagged national rural income and the log value of minimum wage as two alternative measures, with the same specifications in Columns (1)–(2) of Table B.2. We find that the estimates of the key variable using alternative measures in Column (3) and (5) are larger than the baseline estimate in Column (1), consistent with our conjecture that using minimum wage distortions is more conservative as it removes the differences in living standards across provinces over years. Thus, the source of our identification is largely from minimum wages varying across cities rather than provincial rural incomes.

The second concern is whether our results are robust to unobserved city-industry specific factors. First of all, as we discussed in Section 3.3 and in Appendix B, city minimum wage growth is not correlated with various measures of city-industry structure, which helps to mitigate the concern over the omitted variable bias due to unobserved city-industry specific factors. A more robust approach to deal with this issue is to include city-industry fixed effects in our baseline regression, however, this approach suffers efficiency loss of useful city-industry variations and the inclusion of multi-dimensional fixed effects may also lead to sensitive results.²⁵

We experiment with three alternative fixed effect specifications to capture unobserved region-industry specific factors. First, we include city-industry fixed effects, and use the TFP measure rather than industry-year fixed effects to capture the technological level so as to avoid the curse of multi-dimensional fixed effects. Second, rather than city-industry fixed effects, we include province-industry fixed effects in the baseline regression which captures cross province-industry variations but involves fewer dummies than city-industry fixed effects in regression. Third, we include province-industry-year triple fixed effects to capture unobserved province-industry time-varying factors. These specifications are very demanding as region-industry fixed effects absorb useful variations. However, as shown in Table B.3 the coefficients of our key variable $Unskint_s \times \ln \lambda_{it}$ are negative and significant in all specifications with OLS and IV estimations, though the estimated coefficients except column (1) are higher than our baseline estimates in Table 2. Thus, these results suggest that our key finding of the negative effects of minimum wage distortion on the exports of unskilled-labor intensive industries is robust to unobserved region-industry factors.²⁶

The third concern is with our sample aggregation. As the variations in the minimum wage are not across destination countries, a more parsimonious specification is to aggregate the sample over importers and to use unilateral exports as the dependent variable. In Appendix B, Table B.4 presents the results for this alternative specification using three different measures of minimum wage shocks with city-year and industry-year fixed effects. Our key estimates of the interaction term between minimum wage distortion and industrial unskilled-labor intensity are still significant, but the magnitudes are smaller, possibly due to the fact that the aggregation over importers loses useful information of external demand.

Although this alternative specification is more transparent and parsimonious, it bears the risk of biased estimation without controlling for external demand. For example, if cities with higher growth in minimum wages happen to export unskilled-labor intensive products to countries with higher GDP growth, without controlling for destination-industry-year fixed effects, the estimation of the negative effect of minimum wage distortion on exports is likely to be biased toward zero. Thus, we prefer our baseline specification which follows the bilateral gravity equation derived from the model and explicitly controls for external demand and bilateral trade costs.

Lastly, we also adopt various clustering options to check the robustness of our results. First, we use two-way clustering by city and industry to control for error correlations within cities and industries, and we also explore alternative clustering by city-year and industry as minimum wages vary across cities and years. Second, to control for possible spatial correlations within the province, we also use two-way clustering by province and industry, or by province-year and industry. Table B.5 in Appendix B shows that our baseline estimates of the interaction between minimum wage distortion and industrial unskilled-labor intensity remain significant and thus robust to these clustering options.

5. The anatomy of the effects of minimum wage distortion on exports

In this section we conduct a thorough investigation on the effects of minimum wage distortion on exports, including from the perspectives of intensive and extensive margins, domestic and foreign exports, and exit and survival. We also conduct an array of sensitivity checks and interesting extensions.

²⁵ We regress our key independent variable $Unskint_s \times \ln \lambda_{it}$ on various combinations of city-year, city-industry, and industry-year fixed effects, in order to explore the source of variations. We find that the city-industry variation is an important source of variations in our key independent variable, however, they are almost entirely from the city-specific or industry-specific variations, rather than from the city-industry pair variations, which suggests that including city (-year) and industry (-year) fixed effects may be sufficient. Moreover, the inclusion of three paired fixed effects, city-industry, city-year, and industry-year, significantly reduces the residual sum of squared (RSS) by about 90% compared with the RSS when two paired fixed effects of city-year and industry-year are specified. The R^2 for the regression with three paired fixed effects is as high as 0.998, and thus few variations are left in the key independent variable to identify the effects of minimum wage distortion on exports across industries with various skill intensities. However, we find that industry-year fixed effects contribute little to the total variation once we have already controlled for city-year and city-industry fixed effects. This suggests that we may include city-industry fixed effects and use the TFP measure rather than industry-year fixed effects to capture the technological level, so as to avoid the curse of multi-dimensional fixed effects. We thank one referee for providing this insight.

²⁶ Admittedly, the inclusion of region-specific fixed effects affects estimates for other coefficients. The coefficients of the interaction term of capital endowment multiplied by industrial capital intensity are still positive but less robust, and the coefficients of the interaction term of provincial skill endowment multiplied by industrial skill intensity become insignificant or negative. In addition, the results are similar if we also include TFP in Columns (3)–(6).

Table 3
Decomposition.

	Ln(exp) (1)	Ln(exp per variety) (2)	Ln(num of varieties) (3)	Ln(num of firms) (4)	Ln(num of varieties per firm) (5)
Ln(MWD) × Unsk int	-2.983*** (1.012)	-1.663** (0.643)	-1.320** (0.524)	-1.293*** (0.470)	-0.027 (0.103)
Sk endow × Sk int	0.137*** (0.044)	0.116*** (0.031)	0.021 (0.020)	0.022 (0.018)	-0.001 (0.004)
Contr envir × Contr int	0.050*** (0.011)	0.031*** (0.007)	0.019*** (0.006)	0.016*** (0.005)	0.003** (0.001)
Capit endow × Capit int	0.006*** (0.002)	0.000 (0.001)	0.006*** (0.002)	0.005*** (0.002)	0.001 (0.000)
N	1,682,662	1,682,662	1,682,662	1,682,662	1,682,662
R ²	0.470	0.277	0.684	0.720	0.258
First stage F-stat	1031	1031	1031	1031	1031

Notes: IV estimates are reported. Constants and fixed effects of city-year, importer-year, industry-year, and importer-city are included in the regressions while not shown in the table. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

5.1. Intensive margin and extensive margin

As we show in Eq. (18), we can decompose exports into the intensive and extensive margin and study which margin matters for the export adjustment in response to unskilled-labor cost shocks due to changes in minimum wage. We adopt the same specifications as in regression (19) for the log values of average export per variety, number of varieties, number of firms, and average number of varieties per firm.

Table 3 presents the IV estimation results for total export value and its components. Column (1) is copied from Table 2 for easy comparison. Columns (2) and (3) show that intensive margins measured by the exports per variety and extensive margins measured by the number of varieties both matter for the negative effect of rising minimum wage distortions on total exports. Given two industries with $\Delta Unskint_s = 0.1$, the difference in their export elasticities to minimum wage distortion is $\hat{\delta}_1 * 0.1 \approx 0.3$, among which the intensive margin accounts for about 56% ($=1.663/2.983$) and the extensive margin accounts for about 44%. More interestingly, Columns (4) and (5) imply that the response in the extensive margin arises completely from the adjustment in the number of exporting firms, rather than the number of varieties that the average exporting firm produces. It suggests that upon shocks of unskilled-labor cost, firms tend to export less for each variety and fewer firms become exporters, whereas the product scope for exporters remains unaffected.

5.2. Domestic and foreign exports

Our model illustrates that rising labor costs in a particular region can reduce foreign exports through the channel of MP because the increase in labor costs dwarfs the benefit of creating an export platform in this region for multinational firms. To explore the differential effects of labor cost shocks on domestic and foreign exports, we estimate the specification (19) for two types of exports. We also use the same decomposition method proposed above (Eq. (18)) for domestic and foreign exports to study their differential responses in different export margins. Note our measurement of unskilled-labor intensities is specific to firm ownership types. On average, foreign-invested firms are relatively more skill-intensive than domestic Chinese-owned firms.²⁷

Table 4 presents the IV estimation results for domestic and foreign exports, as well as the estimates for their corresponding intensive and extensive margins in panel A and B, respectively. Several interesting results emerge. First, compared with domestic exports, the elasticity of foreign exports to minimum wage distortion is more sensitive to the unskilled-labor intensity of the industry. More specifically, given the same $\Delta Unskint_s$ for two industries, minimum wage distortions have much stronger effects in reducing foreign exports than domestic exports for the less skill-intensive industry relative to the other more skill-intensive industry. This finding indicates that multinational firms in China are more sensitive to unskilled-labor costs than domestic firms in less skill-intensive industries.

Second, intensive margins play a more important role than extensive margins for domestic exports in response to minimum wage distortions. The estimated coefficient $\hat{\delta}_1$ is significant for the log number of firms but not for the log number of varieties, indicating an ambiguous differential effect of minimum wage distortion on the extensive margins of domestic exports across industries. By contrast, both intensive and extensive margins contribute to the high sensitivity of the foreign exports elasticity to minimum wage distortion with respect to the unskilled-labor intensity of industries. Quantitatively, the intensive and extensive margin account for 54% and 46% of the estimated $\hat{\delta}_1 = -3.405$ in Column (1) of Panel B.

²⁷ Our results hold if we use the same unskilled-labor intensity measures for both domestic and foreign exports.

Table 4

Domestic Exports and Foreign Exports.

Panel A. Domestic-Owned Enterprises					
	Ln(exp) (1)	Ln(exp per variety) (2)	Ln(num of varieties) (3)	Ln(num of firms) (4)	Ln(num of varieties per firm) (5)
Ln(MWD) × Unsk int	-2.050** (0.944)	-1.236* (0.659)	-0.815 (0.497)	-0.762* (0.432)	-0.053 (0.118)
Sk endow × Sk int	0.086* (0.044)	0.077** (0.034)	0.009 (0.018)	0.006 (0.016)	0.003 (0.005)
Contr envir × Contr int	0.045*** (0.013)	0.031*** (0.009)	0.013** (0.005)	0.010** (0.005)	0.004** (0.002)
Capit endow × Capit int	0.008*** (0.003)	0.002 (0.001)	0.006*** (0.002)	0.005*** (0.001)	0.001*** (0.000)
<i>N</i>	1,385,535	1,385,535	1,385,535	1,385,535	1,385,535
<i>R</i> ²	0.431	0.273	0.643	0.686	0.265
First stage <i>F</i> -stat	879	879	879	879	879
Panel B. Foreign-Invested Enterprises					
	Ln(exp) (1)	Ln(exp per variety) (2)	Ln(num of varieties) (3)	Ln(num of firms) (4)	Ln(num of varieties per firm) (5)
Ln(MWD) × Unsk int	-3.405*** (0.785)	-1.850*** (0.519)	-1.555*** (0.412)	-1.523*** (0.379)	-0.032 (0.096)
Sk endow × Sk int	0.169*** (0.043)	0.131*** (0.027)	0.039* (0.021)	0.048** (0.020)	-0.009 (0.006)
Contr envir × Contr int	0.034*** (0.012)	0.016** (0.008)	0.019*** (0.006)	0.015*** (0.005)	0.004** (0.001)
Capit endow × Capit int	0.003 (0.003)	-0.003* (0.002)	0.006*** (0.002)	0.005*** (0.002)	0.000 (0.000)
<i>N</i>	962,898	962,898	962,898	962,898	962,898
<i>R</i> ²	0.434	0.261	0.668	0.700	0.245
First stage <i>F</i> -stat	1238	1238	1238	1238	1238

Notes: IV estimates are reported. Constants and fixed effects of city-year, importer-year, industry-year, and importer-city are included in the regressions while not shown in the table. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

Third, we also confirm our previous finding that the responses in the extensive margins for the two types of exports are driven mainly by the adjustments in the number of exporting firms rather than the product scope of the average exporting firm. Thus, below we look into the effects of minimum wage distortions on entry and survival of varieties for the two types of exports.

5.3. Entry and survival

We define “entry of a variety” as the case when the variety (firm-HS6 pair) does not exist in year $t - 1$, but exists in year t , and “survival of a variety” as the case when a variety exists in both year $t - 1$ and t . We count the number of entries and survivals and take log values of these numbers as the dependent variables in the regression (19). Table 5 reports the IV estimation results of entry and survival for exports, domestic exports, and foreign exports. Our primary interest is still the parameter δ_1 , which measures the sensitivity of the elasticity of entry/survival to minimum wage distortions with respect to the industry unskilled-labor intensity.

Our key estimates of δ_1 in Columns (1) and (4) imply that one percent increase in the minimum wage distortion will lead to extra declines of about 0.11 percent and 0.28 percent respectively for entries and survivals in the foreign market if one industry is 10 percentage point less skill-intensive than the other industry. More strikingly, by comparing the results in Columns (2) and (5) with Columns (3) and (6), we find that the effects of minimum wage distortions on entry and survival are insignificant for domestic exports but both economically and statistically significant for exports by foreign firms. This finding is consistent with the conjecture that foreign-invested firms in the unskilled-labor intensive industries reallocate their production out of China upon the hike of unskilled-labor costs, which can undermine China's position as the “World's Factory” in the global supply chain. This result also explains to some extent our previous finding that foreign exports are more sensitive to the minimum wage distortion than domestic exports.

5.4. Extensions and sensitivity analysis

In this subsection, we conduct an array of sensitivity checks and interesting extensions. First, we consider different customs regimes of exports and heterogeneous effects across destination countries with different income levels. Next, we check whether our baseline results are robust to the exclusion of the period of the global financial crisis and afterwards. Finally,

Table 5
Entry and Survival.

	Ln(num of entrants)			Ln(num of survivors)		
	All (1)	DOE (2)	FIE (3)	All (4)	DOE (5)	FIE (6)
Ln(MWD) × Unsk int	-1.147** (0.480)	-0.694 (0.457)	-1.320*** (0.363)	-2.750** (1.284)	-1.711 (1.249)	-2.208** (0.899)
Sk endow × Sk int	0.018 (0.017)	0.006 (0.016)	0.034* (0.017)	0.069 (0.046)	0.054 (0.048)	0.075 (0.050)
Contr envir × Contr int	0.015*** (0.005)	0.009* (0.005)	0.016*** (0.005)	0.047*** (0.013)	0.030** (0.012)	0.046*** (0.015)
Capit endow × Capit int	0.006*** (0.002)	0.006*** (0.002)	0.006*** (0.002)	0.008** (0.004)	0.008** (0.004)	0.009* (0.005)
<i>N</i>	1,539,470	1,276,274	858,078	415,105	294,161	261,561
<i>R</i> ²	0.694	0.656	0.676	0.579	0.502	0.584
First stage <i>F</i> -stat	1018	880	1219	443	317	719

Notes: Entry is defined as the variety (firm-hs6 pair) that does not exist in year $t - 1$, but exists in year t . Survival is defined as the variety that exists in both year $t - 1$ and t . IV estimates are reported. Constants and fixed effects of city-year, importer-year, industry-year, and importer-city are included in the regressions while not shown in the table. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

Table 6
Customs Regime.

	Ordinary Exports			Processing Exports		
	All (1)	DOE (2)	FIE (3)	All (4)	DOE (5)	FIE (6)
Ln(MWD) × Unsk int	-2.714*** (1.019)	-1.902* (0.993)	-3.546*** (0.792)	-1.992** (0.937)	-1.367 (0.857)	-1.626* (0.939)
Sk endow × Sk int	0.111** (0.045)	0.075* (0.045)	0.153*** (0.046)	0.151*** (0.042)	0.106** (0.046)	0.190*** (0.049)
Contr envir × Contr int	0.045*** (0.012)	0.045*** (0.013)	0.026* (0.013)	0.035*** (0.010)	0.023** (0.011)	0.046*** (0.014)
Capit endow × Capit int	0.006*** (0.002)	0.008*** (0.003)	0.004 (0.003)	0.007** (0.003)	0.010*** (0.003)	0.004 (0.003)
<i>N</i>	1,504,911	1,267,267	801,162	782,239	491,128	517,765
<i>R</i> ²	0.453	0.422	0.409	0.444	0.404	0.416
First stage <i>F</i> -stat	941	831	1153	900	592	1100

Notes: The dependent variable is the log value of exports. IV estimates are reported. Constants and fixed effects of city-year, importer-year, industry-year, and importer-city are included in the regressions while not shown in the table. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

we separate foreign-invested firms into joint ventures and wholly foreign-owned firms to examine the heterogeneous effects of minimum wage distortions.

First, we examine whether minimum wage distortions have different effects on ordinary and processing exports. China has a special arrangement on customs regimes by separating ordinary from processing exports. Processing exports entail a foreign firm either working with its own affiliates or contracting with local firms to assemble imported inputs with local factors and then selling the products to foreign markets. Thus, processing trade is more involved in the global value chain and foreign firms have a higher share in processing exports than in ordinary exports. Moreover, processing trade is also subject to a very different set of regulation policies in China. For example, imported inputs for processing are duty free if the processed goods are exported.

Table 6 presents the estimation results for total exports, domestic exports, and foreign exports for two customs regimes. First, our main result that the negative effects of minimum wage distortions increase with industrial unskilled-labor intensity hold for both ordinary and processing exports. Interestingly, we find that ordinary exports are more sensitive to the rise in unskilled-labor costs than processing exports, based on the estimated δ_1 in Columns (1) and (4). Processing exports contain less domestic value added (DVA) than ordinary exports and thus may be affected less adversely by the rising cost of unskilled labor.²⁸ Another possible reason is that processing exporters increasingly use domestic inputs to substitute imported materials when those inputs become available at lower price in China, which helps to offset rising labor costs

²⁸ Koopman et al. (2012) find that the domestic value added ratio (DVAR) for ordinary exports is 84%, much higher than that of processing exports whose DVAR is only 37% in 2007. Using firm level data, Kee and Tang (2016) find that DVARs in Chinese exports are relatively higher, with 90% and 60% for ordinary exports and processing exports, respectively.

Table 7
Destination Countries by Income Group.

	Low-income destinations			High-income destinations		
	All (1)	DOE (2)	FIE (3)	All (4)	DOE (5)	FIE (6)
Ln(MWD) × Unsk int	-2.600** (1.064)	-2.015** (1.019)	-2.619*** (0.787)	-3.439*** (1.048)	-1.940** (0.933)	-4.251*** (0.915)
Sk endow × Sk int	0.153*** (0.046)	0.130*** (0.048)	0.169*** (0.048)	0.115** (0.047)	0.011 (0.042)	0.172*** (0.049)
Contr envir × Contr int	0.041*** (0.011)	0.038*** (0.013)	0.028** (0.013)	0.067*** (0.014)	0.055*** (0.015)	0.050*** (0.014)
Capit endow × Capit int	0.008*** (0.002)	0.010*** (0.003)	0.006* (0.003)	0.005* (0.003)	0.007** (0.003)	0.003 (0.003)
N	928,309	777,732	464,231	754,589	607,892	498,566
R ²	0.427	0.403	0.377	0.511	0.469	0.478
First stage F-stat	933	804	1100	1114	945	1327

Notes: The dependent variable is the log value of exports. IV estimates are reported. Constants and fixed effects of city-year, importer-year, industry-year, and importer-city are included in the regressions while not shown in the table. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

Table 8
Sample before the Global Financial Crisis.

	Ln(exp)			Intensive/Extensive Margins	
	All (1)	DOE (2)	FIE (3)	Ln(exp per variety) (4)	Ln(num of varieties) (5)
Ln(MWD) × Unsk int	-4.455*** (1.375)	-3.362** (1.310)	-4.122*** (1.110)	-2.410*** (0.815)	-2.045*** (0.764)
Sk endow × Sk int	0.120** (0.053)	0.077 (0.052)	0.154*** (0.056)	0.105*** (0.035)	0.015 (0.027)
Contr envir × Contr int	0.068*** (0.015)	0.064*** (0.018)	0.045*** (0.015)	0.039*** (0.009)	0.029*** (0.008)
Capit endow × Capit int	0.007** (0.003)	0.010** (0.004)	0.003 (0.004)	0.000 (0.002)	0.007** (0.003)
N	1,061,973	855,635	624,271	1,061,973	1,061,973
R ²	0.454	0.411	0.432	0.283	0.655
First stage F-stat	670	575	871	670	670

Notes: IV estimates are reported. Constants and fixed effects of city-year, importer-year, industry-year, and importer-city are included in the regressions while not shown in the table. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

(Kee and Tang, 2016).²⁹ Moreover, the estimated δ_1 for ordinary and processing exports from domestic-owned firms are both smaller than those from foreign-invested firms (Columns (2) and (5), and Columns (3) and (6)), confirming our aforementioned findings that foreign exports are relatively more sensitive to the rising cost of unskilled labor.

Second, China has a clearly comparative advantage in unskilled-labor intensive industries over high-income countries, comparing with its advantages over low-income destination countries. Thus, it is interesting to detect whether minimum wage distortions have stronger negative effects for exports to high-income countries than to other markets. To do so, we run regressions separately for high- or low-income destinations, according to the World Bank's standard classification.³⁰ Table 7 shows that the negative effects of minimum wage distortions on exports to high-income destinations increase to a larger extent with industrial unskilled-labor intensity than that on exports to low-income countries, confirming our conjecture. Meanwhile, this differentiated effect between destinations with different income levels is mainly from the exports by

²⁹ People may suspect that processing exports have a higher share of labor costs in domestic value added (DVA) than ordinary exports even though processing exports have lower DVAR. However, China's comparative advantage in ordinary exports is labor intensive goods and thus ordinary exports also have a high labor share compared with Chinese domestic productions. To the best of our knowledge, no systematic research has been conducted on the difference of labor shares between processing and ordinary exports. However, anecdotal evidence suggests that processing exports may not have a higher share of labor costs in DVA than ordinary exports, particularly in recent years. Using the similar Input-Output methodology, Chen et al. (2012) find that the employment generated from ordinary exports is much higher than that of processing exports in 2007. For one million dollar gross exports, ordinary exports are associated with 138 jobs, while processing exports are only associated with 45 jobs. This is reasonable as ordinary exports have higher DVA than processing exports. However, even if we use the DVAR from Koopman et al. (2012), for one million dollar DVA exports, ordinary exports are associated with 164 jobs, but processing exports are only associated with 122 jobs. Although this piece of anecdotal evidence is not sufficient to prove that the labor cost shares in DVA are higher in ordinary exports than in processing exports, at least it indicates that the labor shares in DVA for processing exports are unlikely to outweigh ordinary exports by more than the difference in their DVARs.

³⁰ The World Bank does not include Taiwan in the data set, although it qualifies for a high-income region. We add Taiwan to our sample because it is an important trade partner of China.

Table 9
Joint Ventures and Wholly Foreign-Owned Enterprises.

Panel A. Joint Ventures					
	Ln(exp) (1)	Ln(exp per variety) (2)	Ln(num of varieties) (3)	Ln(num of firms) (4)	Ln(num of varieties per firm) (5)
Ln(MWD) × Unsk int	-3.995*** (0.786)	-2.602*** (0.619)	-1.393*** (0.310)	-1.293*** (0.243)	-0.100 (0.125)
Sk endow × Sk int	0.233*** (0.058)	0.194*** (0.043)	0.039* (0.021)	0.046** (0.019)	-0.007 (0.008)
Contr envir × Contr int	0.030* (0.017)	0.014 (0.011)	0.016** (0.008)	0.010 (0.007)	0.006*** (0.002)
Capit endow × Capit int	0.005* (0.003)	0.001 (0.002)	0.005*** (0.002)	0.003** (0.002)	0.001** (0.001)
<i>N</i>	658,944	658,944	658,944	658,944	658,944
<i>R</i> ²	0.353	0.237	0.565	0.600	0.235
First stage <i>F</i> -stat	972	972	972	972	972
Panel B. Wholly Foreign-Owned Enterprises					
	Ln(exports) (1)	Ln(export per var) (2)	Ln(num of var) (3)	Ln(num of firms) (4)	Ln(num of var per firm) (5)
Ln(MWD) × Unsk int	-2.318** (1.028)	-1.405** (0.619)	-0.913* (0.550)	-1.001* (0.551)	0.088 (0.098)
Sk endow × Sk int	0.121*** (0.047)	0.086*** (0.031)	0.035 (0.022)	0.051** (0.021)	-0.016*** (0.005)
Contr envir × Contr int	0.027*** (0.009)	0.008 (0.008)	0.019*** (0.005)	0.016*** (0.004)	0.003* (0.002)
Capit endow × Capit int	0.001 (0.003)	-0.005** (0.002)	0.007*** (0.002)	0.007*** (0.002)	-0.000 (0.001)
<i>N</i>	652,229	652,229	652,229	652,229	652,229
<i>R</i> ²	0.442	0.274	0.678	0.712	0.265
First stage <i>F</i> -stat	1228	1228	1228	1228	1228

Notes: IV estimates are reported. Constants and fixed effects of city-year, importer-year, industry-year, and importer-city are included in the regressions while not shown in the table. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

foreign-invested firms, in accordance with the fact that foreign-invested firms in China are mainly from advanced economies, produce in China, and then re-export to their home countries.

Third, Chinese exports have slumped during the Great Depression and rebounded quickly afterwards. To avoid the confounding effects of the global financial crisis, we exclude the sample since the onset of the Great Recession, namely 2008. Table 8 shows that our baseline results on total exports, domestic and foreign exports, intensive and extensive margins still hold.

Last, multinationals that invest in China can choose to set up wholly-foreign owned firms or joint ventures with Chinese partners. Thus, we break down exports by joint ventures and wholly foreign-owned firms to explore whether two types of foreign-invested firms respond differently to minimum wage distortions. Table 9 shows that exports by joint ventures in less skill-intensive industries are more sensitive to minimum wage distortions, compared with wholly foreign-owned firms. Moreover, for intensive and extensive margins, estimates of δ_1 for exports from joint ventures always dominate the estimates from exports by wholly foreign-owned firms. This result indicates that joint ventures are more vulnerable to rising labor costs in China. It is possible that wholly foreign-owned firms have better technology or management practice than joint ventures and thus, are more resilient to labor cost shocks.

6. Conclusion

Rising labor costs have profound impacts on China's comparative advantage, and thus this topic has received intense discussions in academia, public media and the policy circle. By exploring the variations in minimum wage distortions across cities and years, and the variations in skill intensities across industries for the period 2000–11, we show that in response to rising minimum wage distortions, exports in less skill-intensive industries decrease more than other industries. More importantly, foreign exports are more sensitive to changes in unskilled-labor costs than domestic exports. These findings confirm public concerns that multinational firms in China are relocating their productions to other countries at a fast pace due to rising labor costs.

Our study has important policy implications for China's export competitiveness. To cope with rising labor costs, China needs to upgrade its industrial structure and enhance its comparative advantage in more skill-/capital-intensive industries. Our results show that human capital and contract environment play important roles in promoting exports in skill-intensive and contract-dependent industries. Thus, more efforts in the future should also be devoted to improving the business environment and cultivating innovative activities.

Declaration of Competing Interest

Authors wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.jebo.2021.01.019](https://doi.org/10.1016/j.jebo.2021.01.019).

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