Special Economic Zones: A Welfare Analysis of Labor Market Spillover Effect

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Abstract

This paper identifies a negative horizontal spillover of Special Economic Zones (SEZs) built in China and analyzes their localized effects on firm productivity, wages, and labor market competition. The study shows both empirically and theoretically that labor market competition is responsible for the negative spillover effect. With positive assortative matching between workers' skill and firms' technology, SEZs shift the zone firm's productivity upwards, increase wages. This results in a negative effect on non-zone firms. Consequently, there is an overall positive welfare gain from SEZs, with welfare gain for zone firms and welfare loss for non-zone firms. The analysis provides caveats in analyzing the SEZ policy in terms of welfare distribution and firm performance in many developing countries.

Keywords: Special Economic Zone, Firm Productivity, Spillover, Matching, Labor Market Competition

JEL Codes: F1, J2, O3, R1

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1 Introduction

Over the past few decades, there are a few topics in international economics focusing extensively on spillover effects. The question related to labor mobility and capital flow has received an increasing amount of attention, especially in developing countries, as leading research has focused considerably on the topic of productivity spillovers. A large body of theoretical and empirical works have focused on the extent to which international products, imported intermediate goods, and how foreign investment can serve as important channels of spillover and competition. Developing countries around the world have policies that encourage, subsidize, or remove restrictions on international trade, in the belief that domestic firms can benefit from the presence of international products and gain from the positive spillover effect.

More recently, the agglomeration economies have been rigorously identified, which explain many advantages for firms located in spatially target areas. Especially in developing countries, a good example is Special Economic Zones (SEZs). A SEZ is an area in which the business and trade laws are different from the rest of the country, aiming to increase trade balance, employment, and investment. SEZs contain geographic regions within a country with more liberal trade laws and policies to encourage investment, trading, and labor regulations. The benefits of zone firms include producing and trading intermediate goods at a lower price with lower taxes collected. The efficiency gain from mobile workers and firms relocating across the boundaries of these zone areas generates interesting spillover questions as well. Despite the increasing comprehensive work on foreign direct investment knowledge spillover and the agglomeration effect, there is a lack of evidence for evaluating SEZ programs which are heavily conducted in developing countries. Few empirical studies using firm-level panel data from developing countries discover the labor and productivity spillover across the border of the targeted districts, Special Economic Zones. Lu et al. (2017) mentioned that the FDI spillover may capture the zone effects if industries are differentially distributed in SEZs. However, they do not exactly examine the spillover effect directly from the data.

The lack of evidence in the academic literature on the spillover effect of SEZs encourages a reexamination of this important research question.

The question of whether SEZs have a meaningful effect on the local economy has great policy relevance. Wang (2013) has stated that SEZ programs increase FDI and domestic investment, as well as achieve agglomeration economies. According to the world bank data, there were approximately 3000 SEZs in 135 countries in 2008, accounting for over 68 million direct jobs and over US$500 billion of direct trade related value added within the zone (World bank, 2018). The main objective in this paper is to confirm the productivity of firms in SEZs by comparing them with firms outside zones. Additionally, this paper quantifies the horizontal spillover effect of SEZ programs by exploring the local labor market mechanism.

This paper mainly discusses the labor market adjustment according to the SEZ policy by incorporating labor assignment into a trade model. New literature has emerged to address the links between trade and labor market assignment in the context of firm selection. This paper proceeds by using the labor and firm matching model to analyze the equilibrium assignment of workers to firms, the firms' productivity and workers' wage, and consequently, the total welfare under the effects of SEZs. The following are the main conclusions. First, using an instrumental variable to proxy the spillover effect of zones, the empirical estimation implies that there is a negative horizontal spillover effect on local non-zone firms in the same industry and year. Second, the decrease of non-zone firms' productivity can be explained by the change of labor assignment. Because zone firms experience an increase in productivity and are matched with a higher quality of labor force, leaving the firms outside with lower labor quality. The non-zone firms around would, therefore, illustrate a decrease in productivity. Third, while there is a negative spillover effect on the non-zone firm's wage and productivity, the overall welfare gain is positive under the Policy. The major gains are distributed unevenly to the firms and workers in the zone, with a welfare loss mainly from non-zone firms and workers, given a small open economy assumption.

This paper is related to the literature studying the effect of SEZ policy conducted in developing countries. Though many papers, both theory and empirical, have studied the effect of SEZs on firm level and district level (Wang (2013); Defever et al. (2018); Davies et al. (2018); Davies, Ronald B. and Mazhikeyev, Arman (2019); Amirahmadi and Wu (1995); Brutigam and Tang (2014); Chaudhuri and Yabuuchi (2010); Farole and Akinci (2011)), none of these papers have investigated the spillover effect of SEZs empirically. This paper also builds on the research estimating localized productivity spillover effects by focusing on the local labor market mechanism. There are much existing literature studying the spillover effect of foreign direct investment (Lu et al. (2017); Javorcik and Spatareanu (2011)), and agglomeration and linkage effect (Javorcik (2004); Kugler (2006), Zheng et al. (2017)). Compared with a positive significant influence of the localized agglomeration, this paper suggests that the labor market competition can explain the negative spillover effect. Moreover, there is emerging literature documenting the interaction between labor market and firm competition under the context of trade. Recent studies have revealed interesting patterns of how labor matching and wage inequality evolve in international markets or when trade is present (Costinot and Vogel (2010); Costinot, Arnaud and Vogel, Jonathan (2015); Sampson (2014)). This study contributes to the empirical evidence explaining the change of labor quality in coordination with the market.

This paper contributes to the literature from three perspectives. First, the empirical estimation improves the identification strategy used for foreign direct investment spillover and applies to the spillover of SEZs, taking advantage of the relaxation of trade regulation on Chinas World Trade Organization accession at the end of 2001. Since zone firms experience a positive effect through the relaxation of foreign direct investment, lower imported tariffs, and open international markets, it is able to design an exogenous instrument for the spillover term of SEZs by comparing the treatment with the control group. Using old year district export data, this paper could construct an instrumental variable by combining Chinas WTO accession and the district variable to identify the spillover term referring to the economic zones. The result shows that there is a negative spillover effect of SEZ firms to other firms outside the zones in the same district, industry, and year.

Second, compared with other datasets studying SEZs, most of which use limited firm level database and a small set of firm time-varying variables, this paper takes advantage of the detailed dataset from Chinese manufacturing firms and merges with SEZ data and the zone setup time. Tthis paper combines the public SEZ information from Wang (2013) with the firm level dataset to assess the impact of the zone policy. Besides Zheng et al. (2017) which uses firms level panel in 8 major Chinese cities studying the effects of industrial parks policy, this is the first paper to use rich nationwide manufacturing firm panels tracking the development of SEZs. By exploring comprehensive firm time-varying variables including export decisions, export intensity, wage rate, firm types, revenue, sales and capital labor ratio, we are able to control potential endogenous identity problems in the estimation. By investigating the revenue and sales of non-zone firms under this question, we also find a negative spillover effect, therefore concluding a limited effect of SEZs on firms outside the target districts, especially in developing countries.

Third, to further investigate the causes of negative spillover effect, this paper examines the labor market effect mechanism. This study builds a matching model between workers and firms based on a continuous spectrum of workers' quality and discrete levels of firms' productivity. When labor productivity is log-supermodular in productivity and skill, and the labor market is competitive, similar reasoning to Costinot and Vogel (2010) and Costinot, Arnaud and Vogel, Jonathan (2015), it implies that there is a positive assortative matching between high skill workers and high productivity firms. The matching assignment model is also sufficient to analyze the welfare effect and welfare distribution of SEZs. Consequently, non-zone firms are matched with lower quality of labors after the introduction of SEZ in the district, and they experience welfare loss. By contrast, zone firms gain major welfare improvement, resulting in an overall positive welfare gain but uneven distribution among the two types of firms. Though many papers with log supermodularity imply positive assortative matching when workers sort across tasks or sectors (Sattinger (1975), Ohnsorge and Trefler

(2007), and Costinot and Vogel (2010)), this is the first paper to examine the SEZs welfare effect and its distribution among different types of firms by incorporating and solving the matching problems.

The next section starts with the historical background of SEZ policies. Section 3 discusses the data used. Section 4 explains the estimation strategy of the spillover effect of SEZs on local non-zone firm's productivity and offers possible interpretations in terms of labor market competition. Section 5 develops and solves the theoretical model in partial equilibrium and characterizes how SEZs shift the labor firm matching and firms' productivity. Section 6 presents the calibration of the model and section 7 considers the welfare analysis. The last section gives concluding remarks.

2 Background of Special Economic Zones

In this section, we will first introduce the features of SEZs in general and then discuss in detail the conduction of SEZ policy in China. After the founding of Silicon Valley in 1951, more and more regions have developed booming economic zones with rapid development of science and technology. According to the World Bank definition (Farole and Akinci (2011)), SEZs include the Export Processing Zones, Technical Innovation Parks, Industrial Parks, Enterprise Zones, and Bank-Free Zones. SEZs have a long-established role in international trade. They are normally established with the aim of achieving one or more of these policy objectives: 1. To attract foreign direct investment (FDI). 2. To serve as pressure valves to alleviate large scale unemployment. 3. To support of a wider economic reform strategy. 4. To apply new policies and approaches. In achieving these objectives, SEZs have achieved a mixed record of success. Therefore, it is particularly important to establish a scientific and effective evaluation of SEZs. Targeting at the effect of economic zones on local non-zone plants and firms, this paper is able to explain the partial effect of economic zones in China, especially from the perspective of firm growth and labor market employment. These results could also be extended to explain similar examples in other developing countries.

Chinas experience with SEZs has developed over time. It began in the early 1980s when market-oriented reform was introduced in selected SEZ areas such as Shenzhen, next to Hongkong. The earliest established SEZ is the Dalian Economic Zone which started construction at the end of 1984, with many other SEZs approved in the same year. These were followed by a large expansion of open coastal city SEZ establishments, which are designed to stimulate economic growth, improve technology, and accelerate capitalization. According to Chinese government official documents and Wang (2013), the Peoples Congress passed the first regulation for the Dalian SEZ and started its construction in October of 1984, explicitly providing several policy packages for potential investors: 1. The SEZ encourages foreign investors to set up enterprises and other establishments on their own or in joint ventures with Chinese partners. 2. Potential investors are promised a reduced corporate income tax rate at 15-24% on the basis of the technological content of their product, compared with 33% paid by domestic firms. The SEZ firms also have no customs duties and receives duty free allowances for production materials. 3. SEZ enterprises can lawfully obtain the rights for land development and business use. As SEZs expand to other provinces and locations, there are also other associate benefits received by zone firms, especially the benefits from the labor market. Employees of SEZ enterprises are given extra personal income tax reduction, house allowance, and Hukou registration preferential policy [1].

According to one of the SEZs' investment guides, Lisha Island Fine Chemicals Industrial Park, an industrial cluster in Guandong Province, there are criteria to select companies to move into the zone. To own land, the SEZs require that the investment is no less than 5 million RMB/ mu, tax intensity no less than 0.5 million RMB/mu and land buying price no less than 0.5 million RMB/mu. To lease land, the total investment should not be less than 3 million RMB/mu and the first land leasehold is 20 years, with priority for renewal.

[1] A household registration record officially identifies a person as a resident of an area and includes identifying information such as name, parents, spouse, and date of birth. Urban and rural residents receive benefits that ranged from retirement pension to education to health care

Enterprises with higher capability and investment amount is selected into SEZ with higher priority. In order to receive the extra tax reduction incentive and attract high skilled workers, SEZ enterprises shall pay high initial investment and fixed cost. SEZ firms also contribute to the infrastructure construction and socially integrated service systems in the zones such as business, taxation, finance, and insurance.

Many researchers have studied regional development in recent decades and some mainly focus on the quantitative evaluation of SEZs. Wang (2013) assesses the impact of SEZs on the local economy using Chinese municipal datasets. With dense investment in the target municipalities, SEZs achieve agglomeration of economies and generate higher FDI and higher wage increases for workers in the district. Defever et al. (2018) explore the effect of imposing the removal of export share requirement in the SEZs. Khandelwal and Teachout (2016) study the trade patterns, foreign direct investment and success of the SEZ design in Myanmar. However, they neither establish a thorough mechanism comparing zone firms and non-zone firms, nor identify the effect of SEZ enterprises on local non-zone individual enterprises. Though Zheng et al. (2017) measure the effects of industrial parks localized spillover from the perspective of firm productivity, wages and local consumption, they mainly focus on 8 major cities in China. Through the expansion of SEZ policy across China, evaluating zones in districts far from the center of the city would be more valuable. One reason is that industrial parks and economic zones are usually located in undeveloped areas in order to stimulate local economy. The other argument is that manufacturing enterprises are consistently located at small districts around major cities. This paper provides a good justification on the spillover effect of SEZs in terms of identification and explaining the potential causes. In addition, it also provides empirical and theoretical evidence analyzing the effect of SEZs from the point of view of local labor market competition.

3 Data

This section describes the data used. This paper mainly adopts the dataset from the Annual Survey of Industrial Firms in China that includes information about the production, employment, revenues, expenses, fixed assets, total wage bills and trade patterns of firms. Combining with the public available SEZ information, we identify the spillover effect of SEZ firms and analyze the performance of firms outside the zone under such effect.

We obtain the plant-level data from the Annual Survey of Industrial Firms (ASIF) conducted by the National Bureau of Statistics (NBS) of China from 1998 to 2007. The sample of these firms constitutes approximately 95% of total Chinese industrial outputs and 98% of Chinese industrial exports (Upward et al. (2013)). The survey data sample covers firm-level basic information and financial data, including both state-owned enterprises (SOE) and non-SOE with sales revenue larger than 5 million Chinese yuan. The industries comprise mining, production and supply of electricity, gas and water, and manufacturing, which account for over 90% of all firms in China. Following the study of Brandt et al. (2012), we match the firms over time as an unbalanced panel data, and process the data according to the industry concordances replacement in 2003 (Lu et al. (2017)) in order to achieve consistency in the industry codes over the entire sample period.

To obtain detailed information of the SEZ dummy variable, we apply the data of SEZ public information following the construction of Wang (2013) and merge it with the ASIF data by the 6-digit zip codes [2]. The firm is classified as a zone firm if the firm's zip code is matched with one SEZs zip code. Otherwise, the firm is classified as a non-zone firm, which is out of the SEZ district. The categorized zone firms have zone setup years [3].

Table 1 reports the summary statistics of firms' characteristics in SEZs and non-SEZs for the entire, pre-WTO, and post-WTO periods. This paper considers three estimations of total factor productivity (TFP), as Cobb-Douglas production function estimation (OLS),

[2]6-digit zip code is the smallest district code available in China detailed at street level
[3] The official year of zone establishment

Olley and Pakes (1996) (OP) and Levinsohn and Petrin (2003) (LP). OP is used as the benchmark TFP estimation in the analysis and the main results associated with OLS and LP are shown in the robustness tests. With regard to TFP calculated by OP and OLS, the simple average TFP of zone firms is smaller than that by LP. Nevertheless, the TFP estimated by LP for zone firms is larger than that of non-zone firms for the entire period. Descriptive facts in Appendix B show that SEZ firms are more productive than non-zone firms, controlling for other relevant variables and fixed effects.

Before the 2001 WTO accession, the TFP of non-zone firms surpasses that of other firms in the SEZ, while after 2001, the TFP of zone firms exceeds that of the non-zone firms. The output, revenue, wage, and employment of zone firms are larger than those of non-zone firms, which indicates that firms in the SEZs behave better in terms of production and wage. The capital-labor ratio and new product intensity of zone firms are higher, signifying that SEZs obviously improves the quality of labor force, firm performance, and innovation ability. Moreover, the percentage of foreign-owned firms, the ratio of SOE, the ratio of exporting firms, and export intensity in SEZs are higher as well. Zone firms are capable of absorbing more foreign investment and exporting a greater amount of goods, which are consistent with other literature (Lu et al. (2017); Davies et al. (2018)). Furthermore, the average levels of SEZ firms' production, innovation, and labor employment are higher both in the pre-WTO and post-WTO periods. Before WTO accession, the percentage of foreign-owned firm was close to zero, while the ratio grows to 0.055 and 0.031 for zone and non-zone firms respectively. Additionally, the proportion of SOE in SEZ decreases from 0.257 to 0.089. At last, the ratio of SEZ firms output to the total industrial output within an industry increases from 0.158 to 0.202 upon Chinas WTO accession at the end of 2001.

In summary, regardless of the pre-WTO and post-WTO section, zone firms have relatively higher productivity, sales, revenues, FDI ratio, SOE ratio, extensive and intensive trade margins. China's accession to the WTO shows an increase in all firms' productivity, industrial output, and other performances significantly according to the summary statistics.

4 Estimation Specification

4.1 SEZ firms and non-SEZ firms comparison

This paper first shows the TFP difference between SEZ firms and non-zone firms before discussing the spillover effect. Similar to exporting firms, SEZ firms paying higher initial fixed cost and investment shall have higher productivity according to Melitz (2003) model based on the background introduced previously. Empirically, this evidence is proven by tables in Appendix B that zone firms have statistically significant higher productivity compared with non-zone firms, controlling for other time varying variables and fixed effects. Based on this fact, it's able to continue with the future estimation of spillover effect since zone firms are superior in terms of TFP and other advantages and may have positive spillover effects to surrounding firms, which are the expected consequences that government would achieve with SEZ Policy.

4.2 Definition of the spillover

Before it comes to the estimation specification, this study starts by defining the regressor of interest, the spillover effect of SEZs. The SEZ horizontal spillover effect captures the extent of zone firms in industry i, district d, and year t. The measurement of spillover factor follows the standard estimation of the FDI horizontal spillover effect (Lu et al. (2017)), i.e,

$$SEZsp_{idt} = \frac{\sum_{f \in \Omega_{idt}} Output_{fidt}}{\sum_{f \in \Delta_{idt}} Output_{fidt}},$$

where $Output_{fidt}$ measures the industrial output of firm f of industry i at district d in year t. The spillover effect is the ratio of firms' output in the SEZ over that of all firms in the same district, same industry and same year. Ω_{idt} is the set of SEZ firms in industry i, district t, and year t. Δ_{idt} is the set of all firms in industry i, district t, and year t.

The spillover factor can also be understood as the effect of a SEZ's existence in a particular district and industry. Therefore this paper also examines the dummy variable that explains the existence of a SEZ in the same district and industry. The difference between these two definitions is that the first one takes the ratio reflecting the relative size of the effect of zone firms compared to non-zone firms, and the second one only takes binary values such that it equals to 1 if SEZ exists.

4.3 Estimation specification

To examine the change of productivity with respect to the existence of SEZ, this paper estimates the spillover effect of zone firms on non-zone firms' performance y_{fidt}.

$$y_{fidt} = \beta_1 SEZsp_{idt} + X'_{fit}\phi + \lambda_f + \lambda_t + \lambda_d + \lambda_i + \epsilon_{fidt} \, , \tag{1}$$

where f, i, d, t denote the firm, four-digit CIC industry [4], district and year respectively. The district variable d is city based district categorization. y_{it} is the productivity of each firm. $SEZsp_{idt}$ is the regressor of interest, using two different definitions above. X_{fit} are firm level control variables used to isolate the SEZ spillover effect. In addition, the estimation also controls a full set of 4 digit CIC industry dummies λ_i, district dummies λ_d, year dummies λ_t, and firm fixed effect λ_f. Then the regressor of interest examines the within- firm change of productivity due to the adjustment of the relative size of SEZs in the same industry and district. It will rule out the mechanism hypothesis that increasing one group's output ratio is automatically correlated with decreasing of the other group's output ratio.

As this study concerns the spillover effect of zones to their neighborhood, we only test on samples of all non-zone firms in the period 1998-2007. In addition, the regression is verified on the subsample of firms that do not change their plant locations and industrial products when a new local SEZ is set up in the period.

The rest of the estimation focuses on the first measurement of the spillover effect, which

[4] The China Industry Classification system

is more precise than the second dummy variable measurement. The first standard measure of the SEZ spillover effect may encounter identification concerns. Firstly, it does not rule out the effect of a sudden decrease of non-zone firms' productivity. To the extent that the shock of productivity is either for zone firms or non-zone firms, the use of total output ratio in the district would overestimate the spillover effect in the area. There could be more SEZ policy benefits to China's comparatively disadvantageous industries, where non-zone firms already have lower productivity levels; this would cause a bias toward a negative effect of SEZ spillover on non-zone firms. Secondly, some zones may be unsuccessful and experience larger decrease of output production. If zone firms' output decreases more proportionally than non-zone firms', only using the industrial output ratio as the sign of spillover effect may underestimate the true effect.

To approach above issues, we initially include many time-varying firm-level control variables and industry characteristics to isolate the SEZ spillover effect. The control variables include capital-labor ratio, firm' export decision, state-owned firm, foreign capital owned firm and material cost. To further deal with the identification problem, we use an instrument to identify the SEZ spillover effect on non-zone firms. The instrument uses variations across industries in the changes upon China's WTO accession, compares the firm performance in the SEZ encouraged industries (treatment group) with the no-change industries (control group) before and after China's WTO accession at the end of 2001 [5] , and then is adjusted by district varied variables. Using an adjusted difference in differences based-on instrumental variable, the identification problem is well defined and shows unbiased estimation. The instrument variable is an adjusted IV used by Lu et al. (2017) on the FDI spillover. The IV for SEZ spillover effect adds district variation to capture the difference of SEZ spillover on different

[5] We ranked the industries according to their share of special economic firms in the beginning year of the panel. We then picked the top 75% percentile industry as the special economic zones concentrated industries and the rest as unconcentrated industries.

locations. The first stage of the IV estimation is

$$SEZsp_{idt} = \gamma Treatment_i * After_t * \ln(export_d) + X'_{idt}\phi + \lambda_t + \lambda_i + \lambda_d + \epsilon_{idt}\,, \qquad (2)$$

where $Treatment_i$ indicates whether industry i belongs to the treatment group and $After_t$ is a dummy variable indicating the post-WTO period with $After = 1$ if $t > 2002$, $After = 3/4$ if $t = 2002$, $After = 0$ if $t < 2002$. The district variation $\ln(export_d)$ employs the log of export amount in each district in the year of 1997, which is the earliest available data of city level export volume. One concern with the district variable is that the export amount in 1997 may be affected by the set up of SEZs before 1997 in some areas. To address this concern, there are also robustness checks utilizing predicted export amount back to 1984 when no SEZ was implemented in China, and checking the main result using the sample of firms after 1997. Then, the fitted value is applied as the instrument for SEZ spillover effect in the standard linear IV estimation.

4.4 Identifying assumption of the instrument

According to the standard instrument variable estimation method, the IV is valid when the following two conditions are satisfied. 1) the relevance condition: the share of SEZ firms' output increases more in the treatment group (SEZ encouraged industries) than in the control group (industries not significantly affected by SEZs) upon China's accession to the WTO. 2) the exclusion restriction condition: variations across industries in the changes upon China's accession to WTO only affect the firm-level productivity through the channel of SEZ spillover and are not correlated with any other omitted variables or error terms. For the first relevance condition, according to China's WTO accession protocol (2001), WTO accession benefits SEZs by attracting more foreign capital investment with open trade policies. "Those special economic areas enjoyed greater flexibility in utilizing foreign capital, introducing foreign technology and conducting economic cooperation overseas. At present, foreign investors were entitled to certain preferential treatment"(Farole and Akinci (2011)). Moreover, since SEZs have a relatively higher proportion of foreign direct investment shown in the summary statistics and other literature (Lu et al. (2017)) , the relevance condition is true. In addition, the significance of the first stage in the IV estimation can also reflect the relevance condition.

To further discuss the exclusion restriction, as it is mentioned above, adding year-varying variables correlated with the productivity into the regression would help with the identification. Moreover, the mechanism of the difference-in-difference adjusted instrument can eliminate the endogeneity problem once the assumption of difference-in-difference is valid. Therefore, the next step is to validate the exclusion restriction on the difference-in-difference variation. This is to say, conditional on all the firm-level controls, the instrument variable is uncorrelated with the error term in Equation 1. We examine these possible estimation bias in the following ways. First, we use the pre-trend data in order to test the pre-treatment parallel condition between treatment group and control group. In order to validate the parallel condition of the DID method, we show the pre-trend data are parallel according to Table 3. Treatment dummy is not statistically significant with the SEZ spillover effect. Second, once the DID set up is approved, the district variation uses 1997 city level export volume and 1984 predicted city level export volume to eliminate the district variation bias.

4.5 Main results

Table 2 reports the instrumental variable estimation, with both first stage and second stage results. Controlling firm, year, industry and district fixed effects, the estimation also includes other firm's time-varying variables to isolate the effect of SEZ spillovers from other confounding factors.

According to the first stage regression, the instrument constructed has a positive statistically significant effect on the spillover effect, which casts a negative and statistically significant effect on firm productivity. These results confirm that, within firms, SEZ firms has a negative horizontal spillover effect on the productivity of other firms outside the zones.

The presence of SEZ firms in the same industry and district damages the productivity levels of non-zone firms.

When it comes to the reduced-form estimation results such that the regression of outcome productivity is regressed directly on the instrumental variable with the same set of controls. The estimated coefficient is also statistically significant and negative, confirming the precondition of validating the instrument. The relevance condition is satisfied according to both the reduced-form regression and the first stage regression.

The IV estimation confirms the negative spillover effect of SEZs. Compared with the IV coefficient, the OLS result is smaller and reflects that it underestimates the result. The OLS estimator is downward biased, possibly due to measurement errors and omitted variable which is the amount of fluctuation in both firms' output. If the share of SEZ firms in the same industry and district increases by 10%, the productivity of non-zone firms drops by 0.217 or 21% of the sample mean.

4.6 Robustness checks

This section provides several robustness checks on results to address some estimation issues stated above.

4.6.1 IV using predicted export data

In order to eliminate the endogeneity problem of the districts' export amount in the instrument, we use the predicted export volume in 1984, when the SEZ Policy has not been conducted in China as one robustness check. Since there is no available district level export volume data back to 1980s, this paper takes advantages of the gravity model to predict the export amount in the past year. We conduct prediction using 1997 district level export data [6] and district demographic characteristics such as population, geographic areas, if the district is landlocked, and the east, west, central location of the district. The prediction

[6] The earliest available district level export data

details are explained in details in Appendix C. This estimation result is reported in Table 4. Compared with the instrument using 1997 export data, the 1984 export data instrument also shows a statistically significant and negative coefficient, representing a negative effect of the SEZ spillover.[7] Compared with the previous instrument, the coefficient is smaller but still significantly negative. We also test all firms that set up after 1997 in order to eliminate the correlation between SEZs and district export volume. The coefficient is smaller as well and still significantly negative.

4.6.2 Testing state-owned firms' effect

A problem with the instrument involves the timing when other policy reforms may affect the outcomes at the time of China's WTO accession. It may lead bias to the estimation of SEZ spillover effects. At the beginning of the 2000s, an important policy was the restructuring and privatization of state-owned firms. In order to eliminate the effect of this privatization progress throughout China, we add an interaction term of the state-owned dummy with year effect additional to other control variables in the baseline regression. Table 4 reflects that there is still a significant negative spillover effect even controlling for the interaction terms.

4.6.3 Alternative measurement of TFP

In the baseline analysis, the paper uses Olley and Pakes (1996) to estimate firm productivity. To check whether the results are sensitive to this method, we also use the ordinary least square regression Cobb-Douglas production function and Levinsohn and Petrin (2003), shown in Appendix A. The estimations are reported in table 4. All results are consistent, representing that the finding are not driven by a particular method of TFP estimation.

[7] Since demographic data in 1984 is the earliest available in China and the first SEZ started at the end of the year, we use 1984 as our predicted data to eliminate the potential effect of SEZs on firms.

4.6.4 Other measures of firm performance

In order to examine comprehensive effects of SEZs, we also include other variables of the firms as the measurement of firm performance. It might be the case that firms could benefit from other perspectives than the production efficiency. The second state results of the instrument variable are presented in table 4 as well. Based on the results, except capital-labor ratio, all other firms' performance including the log of revenue, the log of sales, export decisions, and new product intensity all have negative coefficients. But the revenue and sales' coefficients are smaller than the productivity of the firms, reflecting a mild negative spillover effect. New product intensity is just significant and negatively affected by the spillover with similar economic magnitude. The export decision of non-zone firms are not affected according to the non-significant coefficient but the export intensity is significantly affected and reduced with the presence of SEZ firms in the same industry.

4.7 How to explain the negative spillover effect

In general, there are many reasons to explain the spillover effect. The geographic concentration of economic activities is a crucial way to facilitate the development of economies through positive externalities of endowment clusters such as labor, technology, capital (Davis and Weinstein (2002); Kantor and Whalley (2014)). From the point of view of the labor employment, thicker labor market is associated with higher quality employers, which offers high wage and priority policy. Furthermore, skill-augmenting firms are always positively matched with actively technological innovation (Sampson (2014),Costinot and Vogel (2010),Costinot, Arnaud and Vogel, Jonathan (2015)), leading to the variation of productivity. International trade and imported intermediates improve the matching between workers and firms and induce firms to switch technologies and change productivity (Yeaple (2005); Pellandra (2013)). This section further discusses the potential channels of the negative spillover effect of SEZ share on TFP of non-zone firms mainly from the perspective of the labor market.

To the major concern of the local labor market effect, we investigate in the wage level, a proxy of labor quality, to study SEZ spillover via the labor channel, which is the potential explanation for the reduction of non-zone firms TFP. The competition of human capital between zone firms and non-zone firms could further explain the mechanism. We first test the relationship between SEZ share and average wage based on IV regressions as

$$avewage_{fidt} = \beta_1 SEZsp_{idt} + X'_{fit}\phi + \lambda_f + \lambda_t + \lambda_d + \lambda_i + \epsilon_{fidt}\,, \tag{3}$$

where the outcome variable is the log of average wage of each non-zone firm. As shown in the first column of Table 5, there is a negative and significant correlation, which indicates that SEZ spillover decreases the average wage of non-zone firms. Then, we further separate the regression into two groups as high input tariff group and low input tariff group. High input tariff group is defined as the group of non-zone firms that produce relatively high quality products and have higher imported tariffs on their inputs. They can be viewed as main competitors of firms in the zone. On the contrary, low input tariff group contains non-zone firms that produce relatively low quality products and low intermediate input tariffs, not the main competitors of firms in the zone. [8] The impact coefficient β_1 is -1.506 for the high tariff group while -1.297 for the low tariff group based on the second-stage results in columns (2) and (3). Hence, compared with the low input tariff group, competitors of firms in zones suffer from a larger significantly negative effect at 1% significance level. The level of the average wage is an approximation for the labor quality employed in each firm. Since there is no available data on the labor employment quality, the average wage is a good substitution to reveal the fact that SEZ firms absorb high quality labors from other local firms. The low quality labor left in these local non-zone firms is corresponding to the negative change of productivity, which is shown below. The following regression explores the impact of average

[8] The ASIF dataset does not have intermediate input tariffs collected, so we use China's 2002 Input-Output (or IO) table and product information of each firm to obtain an approximated intermediate input tariffs faced by each firm based on their major product produced. The industries in the ASIF data are more disaggregated than the sectors in China's IO table. Hence, we compile a concordance table to link four-digit CIC industries in the ASIF data with IO sectors, and to measure the extent of tariffs at the broad level of IO sectors. The high and low input tariff groups are defined according to the medium of firms' input tariffs.

wage changes on TFP.

$$y_{fidt} = \alpha_1 avewage_{idt} + X'_{fit}\phi + \lambda_f + \lambda_t + \lambda_d + \lambda_i + \epsilon_{fidt}\,, \tag{4}$$

where y_{fidt} represents the TFP(OP) of non-zone firms. Columns (4) in Table 5 shows that average wage exerts a positive effect on non-zone firms TFP. The increase of average wage or labor quality helps improve the productivity of firms, and vice versa. Overall, the impact channel of the labor market can be interpreted as: SEZ spillover cuts down the average wage level or labor quality of non-zone firms, especially for competitors of SEZ firms with higher input tariff. Thus, the labor effect decreases the TFP of non-zone firms. The detailed explanation is that with the share of SEZ firms increase , firms in zones experience higher productivity and offer higher wage to attract more skilled labors, resulting in the loss of high-quality workers in non-zone firms around. The non-zone firms are not competitive in the labor pooling process and experience decreasing productivity.

5 Theoretical Framework

Previous empirical evidence shows that SEZs lead to negative horizontal spillover effect for firms outside, especially from the point of view of the labor market competition. This study also presents a theoretical model of firm choice that can explain this evidence as well as other stylized facts on firms' productivity and wages. Assume there is a continuum of final good producers each of which produces a different variety. The model is built on two types of firms: high technology zone firms and low technology non-zone firms differentiated by the quality of labor usage. It allows capturing the change of labor usage before and after the implementation of SEZ policy. Firstly, the consumer problem is discussed, followed by the static profit maximization problem of producers. Then, the labor choice of different types of firms is presented to distinguish the differences between zone firms and non-zone firms.

5.1 Consumers problem

Consider a region that is small in the overall economy. Within the region, there are two types of firms, high technology (h) zone firms and low technology (l) non-zone firms. The mass of each type of firm, M^h and M^l, is fixed. Each firm produces a unique variety of differentiated product. There is a mass of available products each of which is indexed by j. The total mass of products is represented by J. Consumers have a taste for variety with the elasticity of substitution $\sigma > 1$. The consumption function is,

$$C = \left(\int_{j \in J} y(j)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}. \tag{5}$$

The demand of consumers for each variety is given by,

$$D = y(j) = C \left(\frac{p_j}{P} \right)^{-\sigma} = Bp^{-\sigma}. \tag{6}$$

B includes the overall price index P. Assuming that the mass of firms within the region is small relative to that of the broader economy and that trade in goods is free, B is treated as a constant.

5.2 Intermediate goods producers problem

In the intermediate goods sector, denote the quantity of intermediate input as $m(z)$ used by the firm type $z \in \{h, l\}$ provided from the outside market. The price of intermediate goods is exogenous given p_m, as the small economy takes the intermediate price given. When there is no SEZ policy, the price of intermediates is the same for all firms. When firms enter the zone, intermediate inputs price falls to $p_m\phi$, where $0 < \phi < 1$. Firms in the zone pay a fixed cost f in order to enjoy a lower variable cost of the intermediate inputs.

5.3 Final goods producers problem

This section solves the producer's decision problem regarding the firm's decision whether to enter the zone or not. The production of each variety requires both employment of labor and intermediate goods. Firms using intermediate inputs incur a fixed cost f in the zone. The specification of the production function follows the Cobb-Douglas production function by incorporating importing decision to the firm's optimization problem. For each type of firms, production function of each firm is,

$$y(z) = x(z)^{\alpha} m(z)^{1-\alpha}\,, \tag{7}$$

where $x(z)$ shows the composite of labor, $m(z)$ shows the unit of intermediate goods employed in the production. The labor share in the production is represented by $0 < \alpha < 1$.

The solution of the final good producer's static optimization problem is given in Appendix D. In the solution, the price of the final good expressed by labor wage and intermediate inputs price is found as

$$p = \frac{\sigma}{\sigma - 1}\frac{c(z)^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}p_m^{\alpha-1}}. \tag{8}$$

And the amount of intermediate inputs usage and the composite of labor can be written as the following

$$m(z) = \frac{c(z)}{p_m}\frac{1-\alpha}{\alpha}x(z)\,, \tag{9}$$

$$x(z) = Bb(\frac{\sigma}{\sigma-1})^{-\sigma}c(z)^{-\sigma\alpha-1+\alpha}\,, \tag{10}$$

where $b = \left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha}\left((1-\alpha)^{1-\alpha}\alpha^{\alpha}\right)^{\sigma} p_m^{(\sigma-1)(\alpha-1)}$.

5.4 Labor choice problem

Now consider the choice of labor in the production process. Firms first choose the level of labors and then decide the final good production. In this section, workers differ according to continuum of different skill levels, indexed by θ on the interval $\left[\underline{\theta}, \overline{\theta}\right]$. Let $G(\theta)$ denotes the supply of workers with skill no greater than θ. The output of a firm labor input proportion of type $z \in [l, h]$ is determined by,

$$x(z) = \int_{\underline{\theta}}^{\overline{\theta}} A\left(z, \theta\right) L\left(z, \theta\right) d\theta\,, \tag{11}$$

where $A\left(z, \theta\right)$ is the productivity of labor of skill θ operating at a type z firm and $L\left(z, \theta\right)$ is the corresponding employment level. Technology and skill are assumed to be complements. In particular, assume $A\left(h, \theta\right)/A(l, \theta)$ is strictly increasing θ. This is similar to positive assortive matching, which guarantees high technology firms will match with high quality labors. This is an important assumption in the model's setting and is consistent with many other theoretical and empirical findings (Costinot and Vogel (2010), Costinot, Arnaud and Vogel, Jonathan (2015), Sampson (2014)).

The unit cost of labor composite for a type z firm depends on the wage schedule $w\left(\theta\right)$ as follows:

$$c(z) = \int_{\underline{\theta}}^{\overline{\theta}} w\left(\theta\right) a\left(z, \theta\right) d\theta\,, \tag{12}$$

where $a(z, \theta) \equiv \frac{L(z,\theta)}{x(z)}$. Cost minimization problem is also presented in Appendix D, which implies

$$w\left(\theta\right) = c(z) A\left(z, \theta\right). \tag{13}$$

Consider a skill level employed by both zone and non-zone firms. This would imply that,

$$\frac{c\left(l\right)}{c(h)} = \frac{A\left(h, \theta\right)}{A\left(l, \theta\right)}. \tag{14}$$

As the right hand side of (14) is strictly increasing in θ, there must be a single critical skill level θ^*, such that all $\theta \leq \theta^*$ are employed by non-zone firms l, and all $\theta \geq \theta^*$ are employed by zone firms h. This is directly related to positive assortive matching intuition.

5.5 Labor market clear

Integrating over all firms and set labor demand equal to labor supply, the labor market clearing problem for skill levels employed by non-zone and zone firms respectively is solved in Appendix D. After taking ratio,

$$\frac{c\,(l)}{c(h)} = \left[\left(\frac{M^l}{M^h} \right) \left(\frac{\int_{\theta^*}^{\overline{\theta}} A(h,\theta) dG(\theta)}{\int_{\underline{\theta}}^{\theta^*} A(l,\theta) dG(\theta)} \right) \right]^{\frac{1}{\gamma}} , \tag{15}$$

where $\gamma = -(\alpha - 1 - \sigma\alpha) > 0$. The right-hand side of (15) is decreasing in θ^*. Equating the cost-minimization condition (14) and the market-clearing condition (15) can find the equilibrium critical skill level θ^*.

Now suppose the government creates a SEZ in the region. The Zone causes a reduction in the cost of imported intermediate inputs for firms in the zone: p_m decreases to $p_m\phi$ and therefore b increases to b'. In general, the operating profit for a firm of type z is,

$$\pi(z) = Bb\sigma^{-\sigma} (\sigma - 1)^{\sigma - 1} c(z)^{\alpha(1-\sigma)}.$$

The operating profit of a firm not in the zone is,

$$\pi^N(z) = Bb\sigma^{-\sigma} (\sigma - 1)^{\sigma - 1} c(z)^{\alpha(1-\sigma)}.$$

The operating profit of a firm in the zone is,

$$\pi^Z(z) = Bb'\sigma^{-\sigma} (\sigma - 1)^{\sigma - 1} c(z)^{\alpha(1-\sigma)}.$$

It follows that a firm would enter the zone if and only if,

$$\pi^Z(z) - \pi^N(z) \geq f \,,$$

or

$$c(z) \leq \omega \equiv \left[\frac{f}{B\sigma^{-\sigma}(\sigma-1)^{\sigma-1}(b'-b)}\right]^{-\frac{1}{\sigma-1}}.$$

If $\frac{A(h,\theta)}{A(l,\theta)} > 1$ for all θ, then $c(l) > c(h)$ in equilibrium. Hence, assume $c(l) > \omega > c(h)$, so that high technology firms h enter the zone and low technology firms l do not. In this case, the creation of a zone results in

$$\frac{c(l)}{c(h)} = \frac{A(h,\theta)}{A(l,\theta)}, \tag{16}$$

or

$$\frac{c(l)}{c(h)} = \left[\left(\frac{M^l b}{M^h b'}\right)\left(\frac{\int_{\theta^*}^{\overline{\theta}} A(h,\theta)dG(\theta)}{\int_{\underline{\theta}}^{\theta^*} A(l,\theta)dG(\theta)}\right)\right]^{\frac{1}{\gamma}} \tag{17}$$

The expression in the right-hand side of (17) decreases if p_m decreases to $p_m\phi$. This implies that θ^* goes down when a zone is created. In other words, non-zone firms, which are the low technology firms in the model, switch to employ lower skilled workers on average.

The tariff loss from the reduction of intermediate input price comes from the change of revenue of intermediate inputs from both firms. The total cost of intermediate inputs before the implementation of SEZs is,

$$M^z m(z) p_m = M^z c(z)^{-\sigma\alpha+\alpha}(\frac{1-\alpha}{\alpha})B(\frac{\sigma}{\sigma-1})^{-\sigma}b. \tag{18}$$

The total cost of intermediate inputs after the implementation of SEZs changes to,

$$M^l m(l) p_m = M^l c(l)'^{-\sigma\alpha+\alpha}(\frac{1-\alpha}{\alpha})B(\frac{\sigma}{\sigma-1})^{-\sigma}b. \tag{19}$$

$$M^h m(h) p_m\phi = M^h c(h)'^{-\sigma\alpha+\alpha}(\frac{1-\alpha}{\alpha})B(\frac{\sigma}{\sigma-1})^{-\sigma}b'\phi. \tag{20}$$

The change of tariff revenue is the change of the sum of two types of firms. The Unit price of intermediate input decreases, the change of tariff is negative.

5.6 Comparative statics

To better understand the mechanism of this model and the change of direction of firm productivity and wages upon setup of SEZs, this section introduces the comparative statics by varying the cutoff θ^*. As long as the average productivity and wage of all types of firms are higher than the average that of non-zone firms, the decrease of the labor cutoff point θ^* results in decrease in the non-zone firm' productivity and wage. The conclusion of the model is consistent with previous empirical results that productivity and wage both decrease with more SEZs setup and spillovers.

6 Calibration

We parameterize the model so that it replicates the empirical observations documented in the previous section. Then, we run a counter-factual test to address the questions in the welfare analysis section later: by how much do the SEZ's reduction in intermediate inputs prices changes the welfare gain of the economy. And how is the welfare gain distributed over local zone firms and non-zone firms?

From the theoretical model section, it can be concluded that non-zone firms suffer from the SEZ policy because of the labor market effect. They are experiencing a decrease in labors' quality, resulting in a decrease in firms' productivity. This section will further analyze the change of zone firms wage and productivity. The tariff loss calculated from the reduction of intermediate input prices will also be discussed in the total welfare gain.

We match moments of the productivity and wage changes for both zone firms and non-zone firms according to the regression result in table 2. Overall, we choose 6 moments that characterize the behavior of two types of firms upon SEZ set up and their difference before the policy is conducted.

6.1 Parameterization

The parameters of model are divided into two sets. A set of parameters is determined outside of the model according to the dataset. And the other set is estimated using the general method of moments. In this section, we discuss how we choose the parameter according to the dataset and discuss the moments we used in the calibration process.

The mass of each type of firms is treated as exogenously given so we summarize the percentage of non-zone firms using the same data sample in the previous empirical section. Thus, $M^l = 0.9003$. Labors draw their quality realizations from a Pareto distribution with bound 1 and shape parameter a. This paper is going to estimate the elasticity of substitution and the labor share in the production function α. In the later part of robustness check given the elasticity of substitution σ and labor share α, we set $\sigma = 3$ (Defever, Fabrice and Riaño, Alejandro (2017)), $\sigma = 3.42$ (Broda and Weinstein (2006), Broda, Christian and Greenfield, Joshua and Weinstein, David (2006)) respectively. The labor share is set to 0.399 according to the data. [9]

There are 6 parameters to be calibrated, which are chosen so as to minimize the distance between the number of moments in the model and the regression results from the previous section. Assume the productivity function is $A(l, \theta) = \theta^{\beta_l}$ and $A(h, \theta) = \theta^{\beta_h}$. The unknown parameters to estimate include: σ, the elasticity of substitution; α, labor share in the production function; ϕ, the decrease in zone firms' imported tariff; β_l, β_h, and Pareto distribution parameter a. Table 6 presents the estimated parameters. The moments from previous empirical regression include: the change of non-zone firms' productivity before and after policy, the change of non-zone firms' wage before and after policy, the change of zone firms' productivity before and after policy, the change of zone firms' wage before and after policy, the difference between zone firms' and non-zone firms' productivity before policy, and the difference between zone firms' and non-zone firms' wage after policy.

[9] We take the share of labor cost to the value of industrial output by district, industry and year. This number is achieved after taking the average.

6.2 Calibration strategy

The set of parameters $\Gamma = \{a, \beta_l, \beta_h, \phi, \sigma, \alpha\}$ are calibrated jointly. To obtain the vector of parameters, we search the parameter space to solve the following problem:

$$M(\Gamma) = \min_{\Gamma}(M_m(\Gamma) - M_d)' W (M_m(\Gamma) - M_d)\,,$$

where Γ is the vector of parameters. M_d is the vector of moments from data. $M_m(\Gamma)$ is the vector of moments computed from the model using Pareto distribution. And W is the weighting matrix that is set to the identity matrix. The model does not admit a one-to-one mapping of each parameter to each moment, so the parameters are jointly identified given an appropriate initial guess. The paper uses a derivative-free algorithm to search parameter space starting from the local minima given the initial guess. Moments are calculated according to the data by taking a within district, industry and year average of TFP and wage of all firms in each group who do not change their product and location before and after the SEZ policy. The sample is consistent with the regression sample. For the first two moments, in order to incorporate the change of TFP after the policy, we use the regression result previously: a 1% increase in the SEZ share decreases the TFP of non-zone firms and wage by 2.171% and 1.261% respectively. For the third and fourth moments, we also use another regression only on zone firms sample with a dummy variable of zone existence. After joining the SEZ, the TFP of zone firms and wage increase by 3.255% and 1.980% respectively. The detailed regression tables and estimation are shown in Appendix E. Then for zone firms and non-zone firms, the ln of average difference in TFP is used in the calibration for the last two moments. The welfare gain of SEZ is obtained by comparing case when $\phi = 1$ and $\phi < 1$ when SEZs are present. The values of parameters determined by the joint estimation are presented in Table 6.

To do a robust check on fixed σ and labor share in the production function, we also use labor share 0.4, taken from the dataset by calculating the average ratio of employment cost over the total industrial output for each firm. This number is also consistent with other literature's statement about the labor share in China (Karabarbounis and Neiman (2013), Kamal et al. (2014), Chong-En and Zhenjie (2010)). The elasticity of substitution, σ, is set to 3 (Broda and Weinstein (2006),Defever, Fabrice and Riaño, Alejandro (2017)), and equal to 3.42, the value of China (Broda, Christian and Greenfield, Joshua and Weinstein, David (2006)). The estimation results are robust in terms of the zone firms tariff reduction parameter. The results are presented in Appendix E.

Table 6 reports the values of calibrated parameters and their interpretation. The elasticity of substitution is 3.821, consistent with other literature's estimation of σ (Broda and Weinstein (2006), Di Giovanni and Levchenko (2013), Arkolakis et al. (2008), Bernard et al. (2007)). The labor share in the production function is 0.437, in line with the estimated China's labor share in production (Karabarbounis and Neiman (2013), Kamal et al. (2014), Chong-En and Zhenjie (2010)). Based on the estimation of elasticity and labor share, the zone firms intermediate price input price reduction parameter is 0.885. Therefore, the input price of intermediates for firms in the SEZ is 0.885 lower than the price of outside firms. The Pareto distribution parameter is also in a reasonable range compared with other literature.

6.3 Estimation results

In this section, we show that the calibrated model generates moments that are consistent with the observations and regression results obtained in the previous section.

Table 7 reports the moments from the previous regression using 1997 export data, the benchmark regression result, and moments calculated from the data. The model correctly captures the facts documented in Section 4. First, non-zone firms suffer from a negative shock on their productivity and wages after the introduction of SEZs. The change in productivity is -2.54% higher than the change of wages of non-zone firms, -1.10%. Second, zone firms experience an increase in their productivity and wage, and the model matches the difference between zone firms and non-zone firms before the policy well. However, the model does not generate a high increase in the productivity change of zone firms. The estimated value is 0.12%, versus 3.26% from the regression. This implies that there may be other factors that result in an additional increase in the productivity of firms in the zone areas other than the intermediate input price reduction. The sources could be further income tax reduction, infrastructure convenience, or subsidies from the government. In order to better estimate the increase of productivity of zone firms, this study will add another productivity increase factor in the model in the next section. The average difference of firms comparison before SEZ policy is well matched according to Table 7 as well.

6.4 Adding the increase of productivity in the model

This section basically introduces an increase of productivity parameter into the original model in order to better approximate the increase in the zone firms productivity. Assume zone firms not only experience a decrease in the intermediate input price p_m, but also have an increase in the productivity ψ, where $\psi > 1$. Then,

$$\frac{c\,(l)}{c(h)} = \psi \frac{A\,(h, \theta)}{A\,(l, \theta)}\,, \tag{21}$$

or

$$\frac{c\,(l)}{c(h)} = \psi^{\frac{1}{\gamma}} \left[\left(\frac{M^l b}{M^h b'} \right) \left(\frac{\int_{\theta^*}^{\overline{\theta}} A(h, \theta) dG(\theta)}{\int_{\underline{\theta}}^{\theta^*} A(l, \theta) dG(\theta)} \right) \right]^{\frac{1}{\gamma}}. \tag{22}$$

The right shift in equation (22) is smaller than the left shift of equation (21). This would imply that θ^* goes down as well when the zone is created. In other words, non-zone firms, which are the low technology firms in the model, switch to lower skilled workers on average.

When it comes to the model estimation, there is an increase proportion of ψ for zone firms' productivity and $\psi^{\frac{\gamma-1}{\gamma}}$ for zone firms' wage. The detailed expressions are in Appendix E. Since there is an additional parameter to estimate, we used the labor share in the previous parameter and using the total 6 moments to estimate parameters including the elasticity of substitution.

Adding productivity parameter improves the estimation according to the methods of moments error term. It implies that there is an additional benefit for firms in the zone besides the lower intermediate input price. The elasticity, Pareto distribution parameters are still in line with the estimation in other literature presented before. According to Table 8 and Table 9, zone firms tariff decrease parameter does not change significantly with a value around 0.88. Zone firms now have an increase in their productivity, 1.029 higher than previous.

In Appendix E, this paper also investigates the model further with tests assuming a fixed σ and labor share value α given. The fixed σ and labor share chosen is comparable to the baseline model: $\alpha = 0.4$ and $\sigma = 3.42$ or $\sigma = 3$. The results are still robust and the moments are matched well with the given value of elasticity and labor share.

7 Welfare Gain from Special Economic Zones

In this section, the paper investigates the importance of SEZs on the welfare, including wages collected by both types of firms, firms' total profits, and total tariffs collected based on the baseline model. Using the model presented, we analyze the following questions, respectively.

- Do Special Economic Zones harm non-zone firms?
- What are the overall welfare gains from Special Economic Zone Policy in China?
- What is the distribution of welfare gains among firms?

To do so, the parameters are set to be the calibrated parameters in the previous section and set the parameter of tariff parameters for zone firms to be in the range $[0.2, 1]$, where 1 represents the cases when there is no SEZ. We then generate graphs of wage's and profits' changes in both types of firms correspondingly. Figure 1 and 2 present the findings that the total profits and wages of non-zone firms decrease when the parameter of tariff reduction ϕ

is smaller. When there is more reduction in the intermediate input price, more intensity of the zone policy, non-zone firms suffer more.

On the contrary, the total wages and profits of zone firms increase when the parameter of tariff decreases since they experience lower variable cost in the production according to the figures. Apparently, lower tariff parameter represents lower intermediate input price and lower tariff collection. The results are shown in the figure of tariff revenue. Given no change in the aggregate price level, there is an overall welfare gain from SEZs since the policy improves the productivity of zone firms and lowers the variable cost, even though non-zone firms are harmed in the meantime. The SEZ policy in fact generates an uneven distribution of gains focusing mainly on zone firms. The direct competition of zone firms and non-zone firms on the labor market brings about the welfare loss on local non-zone firms. Firms outside of the zone without high skilled labor matching eventually decrease their productivity and lose firms' profits. Although the SEZ policy generates benefits in overall, the unbalanced distribution of gains shall be marked.

In order to answer the question what is the overall welfare gain from the SEZ Policy, this paper uses the calibrated parameters in the model and compares the welfare gain for current situation and case when no SEZ policy is present. The overall welfare is 0.3487, compared with 0.3281 when there is no reduction in the intermediate input price. Therefore, there is an overall 6.28% increase in the welfare with SEZs policy. When adding an additional productivity increase parameter for zone firms, the overall welfare is 0.3437, compared with 0.3257 when no policy. There is an overall 5.53% increase in welfare and the result is still robust. The graphs when there is an increase in productivity is similar and robust to the benchmark figures.

8 Conclusion

This paper identifies a negative horizontal spillover effect of SEZs and analyzes the effects of local labor market competition on non-zone firms' productivity and workers' quality. It also further evaluates the welfare gain of the SEZ policy and its distribution among zone firms and non-zone firms, using a trade model with workers firms matching mechanism.

Empirically, the paper uses the Chinese firm-level data to document empirical evidence about the horizontal spillover effect of SEZs. Then, it identifies the spillover effect by using a difference in difference inspired instruments variable and confirms that SEZs decrease the productivity of non-zone firms around in the same district and industry. This paper also shows the effect of spillover factor on the labor wages of non-zone firms to reveal the fact that non-zone firms are suffering from decreasing labor quality and therefore lower productivity.

To account for these empirical findings, this paper develops a trade model with positive assortative matching between labors and firms in order to quantify the welfare gain and loss of different types of firms. The equilibrium cutoff of the labor quality decreases implies that non-zone firms are matched with lower quality of labor in production with the introduction of SEZs. Though there is an overall welfare gain of SEZs policy, zone firms receive all the welfare gain and non-zone firms obtain a welfare loss. The uneven distribution of welfare is reflected based on the calibrated model. This study also runs a counter-factual experiment to demonstrate the advantages of intermediate inputs price reduction received by zone firms. The overall welfare is positive with a larger gap in the distribution among zone firms and non-zone firms. Future work with precise matched employer-employee datasets would offer an opportunity to identify the channel better than using wages as the proxy. In general, maintaining considerable high quality labor supply in the area of SEZs would help alleviate labor market competition pressures and promote a balanced development of all firms.

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Tables

Table 1: Summary Statistics

	[1998-2007]		[1998-2001]		[2002-2007]	
	Zone	Non-Zone	Zone	Non-Zone	Zone	Non-Zone
SEZ share	.0997		.0583		.1117	
	(.2996)		(.2343)		(.3150)	
Log firm TFP OP	3.419	3.436	3.144	3.213	3.504	3.512
	(1.200)	(1.191)	(1.212)	(1.220)	(1.184)	(1.171)
Log firm TFP OLS	2.378	2.458	2.132	2.265	2.454	2.525
	(1.218)	(1.200)	(1.231)	(1.229)	(1.203)	(1.183)
Log firm TFP LP	5.288	5.257	4.998	5.004	5.378	5.330
	(1.314)	(1.282)	(1.295)	(1.275)	(1.307)	(1.274)
Log output	10.168	10.073	9.997	9.915	10.222	10.127
	(1.253)	(1.184)	(1.160)	(1.110)	(1.276)	(1.204)
Log revenue	10.192	10.086	9.976	9.887	10.259	10.155
	(1.280)	(1.201)	(1.146)	(1.089)	(1.311)	(1.230)
Log wage	7.423	7.303	7.177	7.031	7.500	7.397
	(1.286)	(1.289)	(1.263)	(1.298)	(1.283)	(1.272)
Log employment	5.332	5.260	5.210	5.105	5.371	5.313
	(1.477)	(1.467)	(1.158)	(1.173)	(1.561)	(1.552)
Log total assets	10.112	9.868	10.004	9.741	10.146	9.911
	(1.501)	(1.446)	(1.458)	(1.460)	(1.513)	(1.438)
Capital-labor ratio	311.4	255.8	265.0	215.1	326.0	269.9
	(2298.1)	(4344.4)	(1559.1)	(869.2)	(2485.0)	(5016.4)
Foreign owned firm rate	0.042	0.023	0.000	0.000	0.055	0.031
	(0.200)	(0.150)	(0.000)	(0.000)	(0.228)	(0.174)
SOE	0.129	0.111	0.257	0.204	0.089	0.079
	(0.335)	(0.314)	(0.437)	(0.403)	(0.285)	(0.269)
Export status	0.291	0.269	0.305	0.270	0.287	0.269
	(0.454)	(0.444)	(0.460)	(0.444)	(0.453)	(0.443)
Log export intensity	9.509	9.433	9.295	9.284	9.580	9.486
	(1.752)	(1.673)	(1.671)	(1.614)	(1.773)	(1.689)
Log new product intensity	9.359	9.100	9.065	9.032	9.475	9.126
	(2.105)	(2.065)	(2.005)	(1.993)	(2.132)	(2.092)

Table 2: Main Result: regression result for SEZs spillover

	(1)	(2)	(3)	(4)	(5)
	IV_{1997}	IV_{1997}	OLS	OLS	Reduced_Form
Second Stage: Log TFP					
SEZs spillover	-3.126***	-2.171***			
	(0.199)	(0.179)			
First stage: SEZs spillover					
SEZs spillover	0.315***	0.316***			
	(0.0546)	(0.0546)			
OLS and reduced form: Log TFP					
Dummy: existence of SEZ			0.159***		
			(0.0105)		
SEZs spillover				-0.0310***	
				(0.0105)	
Treatment*Post02*ln(export)					-1.412***
					(0.476)
Firm fixed effect	YES	YES	YES	YES	YES
District fixed effect	YES	YES	YES	YES	YES
Industry fixed effect	YES	YES	YES	YES	YES
Year fixed effect	YES	YES	YES	YES	YES
Time varying firm controls	NO	YES	YES	YES	YES
N	645712	644300	658461	658458	644311
adj. R^2	0.696	0.728	0.729	0.729	0.728

Firm level clustered standard errors in parentheses

IV_{1997} refers the usage of export by district data in 1997. Robustness check using earlier export is table 4

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

Table 3: Preparallel condition test

	(1) SEZs spillover growth	(2) TFP growth
SEZs spillover	7.85E-06	0.106*
	(.0002428)	(0.040)
Firm fixed effect	NO	YES
District fixed effect	YES	YES
Industry fixed effect	YES	YES
Year fixed effect	YES	YES
Time varying controls	YES	YES
N	441,670	129,566
adj. R^2	0.0079	0.4816

Clustered standard errors in parentheses

The sample only contains firms before 2012

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

Tables

Table 4: Robustness check regression result for SEZs spillover (IV regression)

	(1)	(2)	(3)	(4)	(5)	(6)
	TFP_{OLS}	TFP_{LP}	Revenue	Sales	Export dummy	$\text{IV}_{1997}(SOE)$
SEZs spillover	-2.285***	-2.063**	-0.399***	-0.767***	-0.0746	-2.391***
	(0.183)	(0.174)	(0.113)	(0.082)	(0.068)	(0.182)
N	644300	644300	704834	704438	704834	645170
adj. R^2	0.745	0.774	0.881	0.946	0.74	0.61
	(7)	(8)	(9)	(10)	(11)	(12)
	$\text{IV}_{1984}(SOE)$	Export intensity	K/L ratio	New product intensity	$\text{IV}_{1997}after$	IV_{1984}
SEZs spillover	-1.43***	-0.680**	0.851***	-3.344***	-1.998*	-1.262***
	(0.148)	(0.336)	(0.260)	(0.966)	(1.093)	(0.146)
N	557052	704834	704834	31527	49816	556257
adj. R^2	0.599	0.769	0.781	0.796	0.742	0.730
Firm fixed effect	YES	YES	YES	YES	YES	YES
District fixed effect	YES	YES	YES	YES	YES	YES
Industry fixed effect	YES	YES	YES	YES	YES	YES
Year fixed effect	YES	YES	YES	YES	YES	YES
Time varying firm controls	YES	YES	YES	YES	YES	YES

Firm level clustered standard errors in parentheses

IV_{1997} refers the usage of export by district in 1997

IV_{1984} refers the usage of export by district in 1984

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

Table 5: IV regression explaining the spillover effect of SEZs through labor market

	(1) Ave Wage	(2) Ave Wage (High Tariff)	(3) Ave Wage (Low Tariff)	(4) TFP_{OP}
SEZs spillover	-1.261***	-1.506***	-1.297**	
	(0.276)	(0.348)	(0.425)	
Average wage				0.117***
				(0.00159)
N	704834	392228	304951	658461
adj. R^2	0.664	0.646	0.69	0.735
Firm fixed effect	YES	YES	YES	YES
District fixed effect	YES	YES	YES	YES
Industry fixed effect	YES	YES	YES	YES
Year fixed effect	YES	YES	YES	YES
Time varying firm controls	YES	YES	YES	YES

Clustered standard errors in parentheses

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

Table 6: Values of parameters determined by the estimation

Parameters	Value	Interpretation
α	10.7645	Pareto distribution shape parameter
β_l	3.2571	Non-zone firms productivity function parameter (low tech firms)
β_h	3.2900	Zone firms productivity function parameter (high tech firms)
ϕ	0.8845	Zone firms tariff decrease parameter
σ	3.8208	Elasticity of substitution
a	0.4373	Labor share in the production function

Table 7: Model Calibration

Moments(Log)	Data	Model
Productivity change of non-SEZ firms	-2.17%	-2.54%
Wage change of non-SEZ firms	-1.26%	-1.10%
Productivity change of SEZ firms	3.26%	0.12%
Wage change of SEZ firms	1.98%	1.73%
Productivity difference of SEZ and non-SEZ firms before policy	0.0498	0.0660
Wage difference of SEZ and non-SEZ firms before policy	0.0781	0.0560

Table 8: Model Calibration with Productivity Increase Parameter

Moments(Log)	Data	Model
Productivity change of non-SEZ firms	-2.17%	-1.65%
Wage change of non-SEZ firms	-1.26%	-0.38%
Productivity change of SEZ firms	3.26%	2.85%
Wage change of SEZ-firms	1.98%	2.89%
Productivity difference of SEZ and non-SEZ firms before policy	0.0498	0.0646
Wage difference of SEZ and non-SEZ firms before policy	0.0781	0.0563

Table 9: Values of parameters with Productivity Increase Parameter

Parameters	Value	Interpretation
α	8.1497	Pareto distribution shape parameter
β_l	2.1446	Non-zone firms productivity function parameter (low tech firms)
β_h	2.1663	Zone firms price decrease parameter (high tech firms)
ϕ	0.8888	Zone firms tariff decrease parameter
ψ	1.0289	Zone firms productivity increase parameter
σ	5.9835	Elasticity of substitution
a	0.4373	Labor share in the production function

Figures

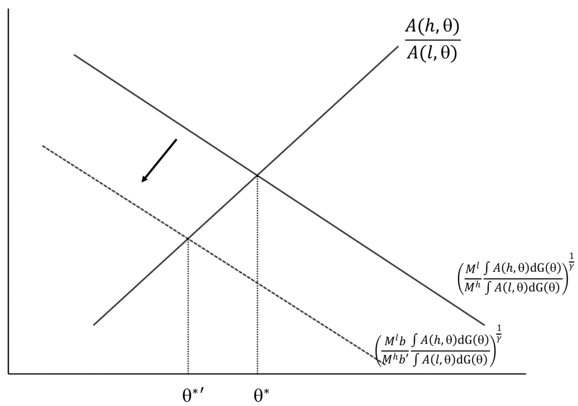

Figure 1: Change of θ^* with no productivity increase

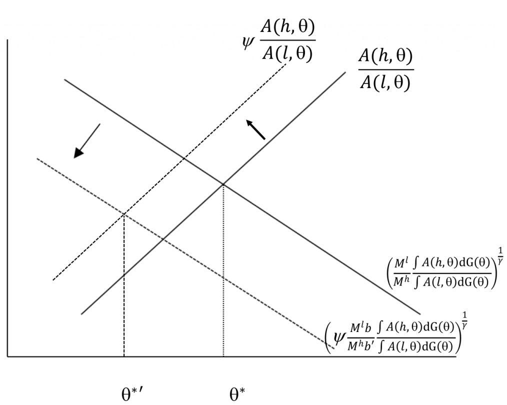

Figure 2: Change of θ^* with productivity increase

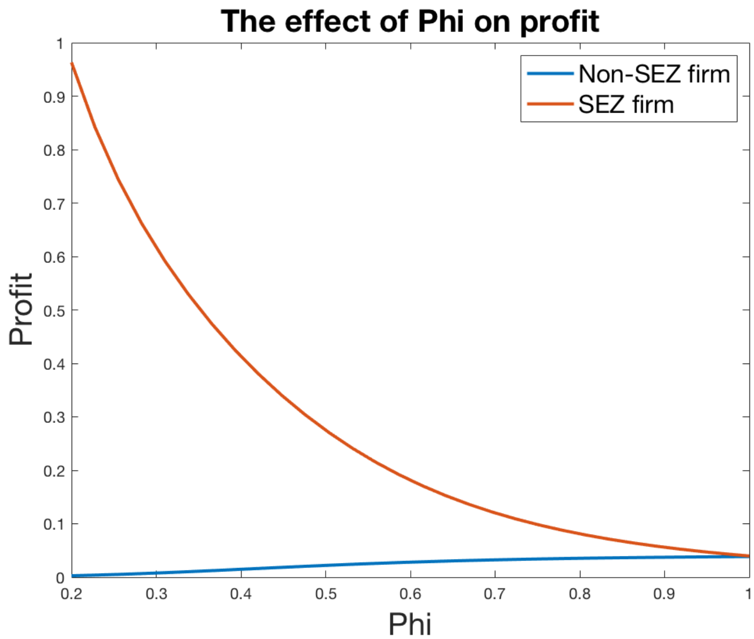

Figure 3: The effect of Phi on profit distribution

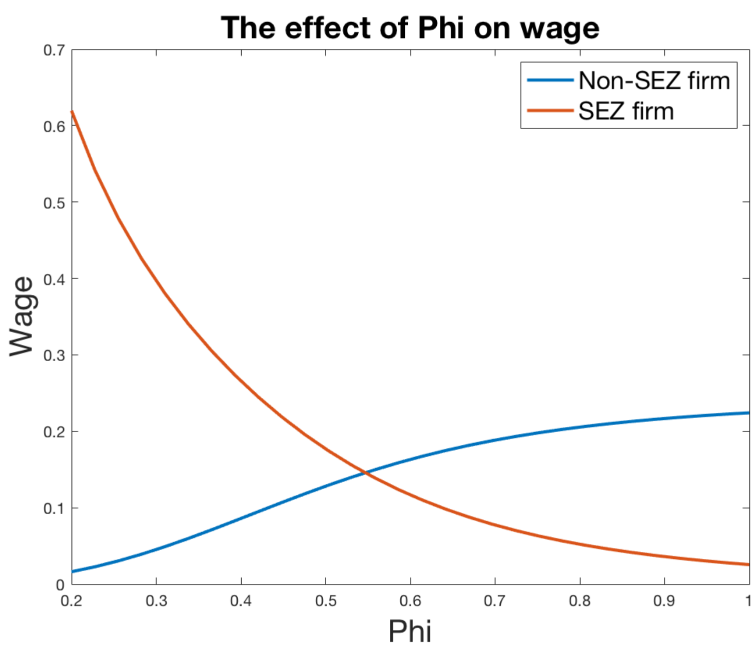

Figure 4: The effect of Phi on wage distribution

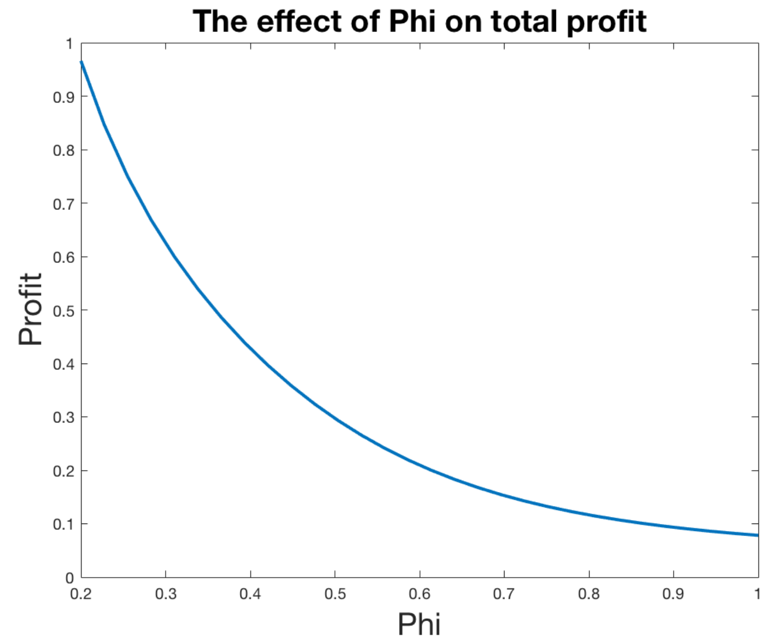

Figure 5: The effect of Phi on total profit

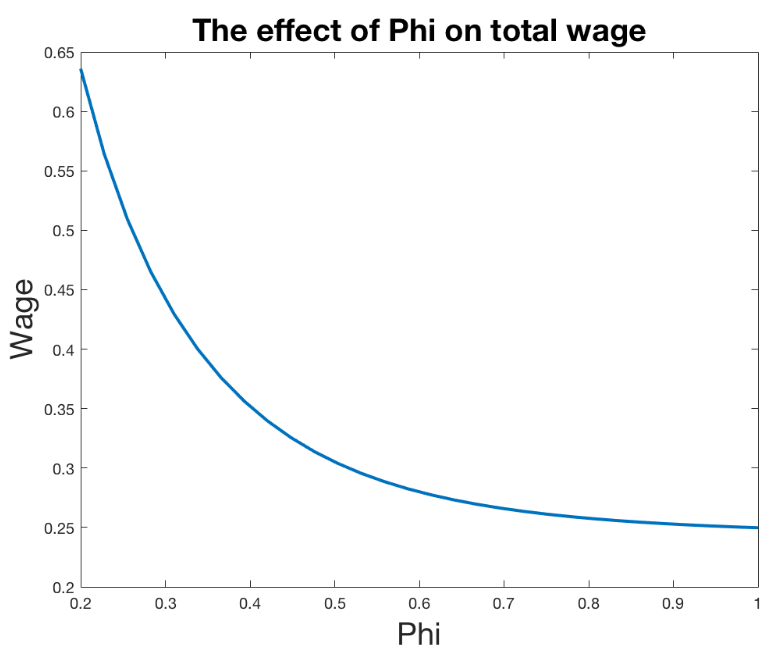

Figure 6: The effect of Phi on total wage

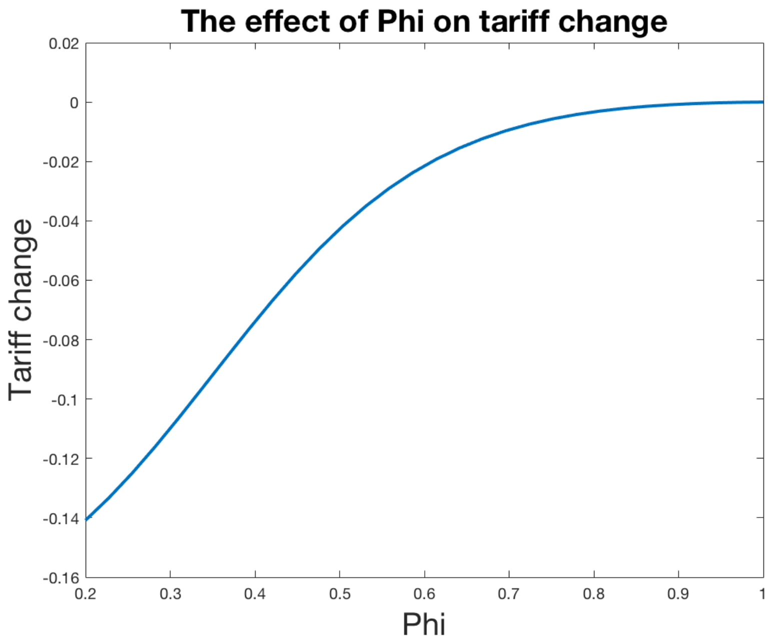

Figure 7: The effect of Phi on tarrif collection

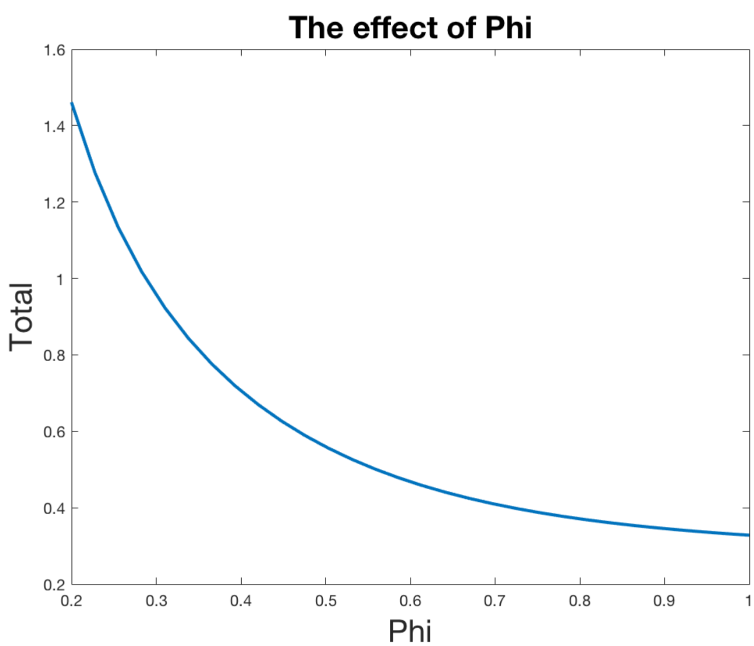

Figure 8: The effect of Phi on total welfare

A Estimation of firm TFP

Consider the following Cobb-Douglas production function in logs:

$$y_{ft} = \beta_l l_{ft} + \beta_k k_{ft} + \omega_{ft} + \epsilon_{ft}\,, \tag{23}$$

where y_{ft} is the log of firm value added that is calculated by the firm output minus the material cost. ω_{ft} is the firm productivity, and ϵ_{ft} is measurement error and/or unanticipated shocks to output. We estimate the firm productivity according to this OLS regression for each 4-digit CIC industry level, allowing technology to vary industry-by-industry. To obtain a consistent production function estimation, we then follow the control function approach initiated by Olley and Pakes (1996) and extended by Levinsohn and Petrin (2003). The Olley-Pakes approach estimating firms' TFP follows the construction of TFP in Dai et al. (2016). Applying the same Cobb-Douglas production function above, we also add export status as an extra argument in the investment function.

$$inv_{ft} = I(k_{ft}, \omega_{ft}, FX_{ft})\,, \tag{24}$$

where FX_{ft} is a dummy variable to measure whether the firm f exports in year t. Inverting inv_{ft}, the unobserved productivity is a function of capital and export status:

$$\omega_{ft} = I^{-1}(k_{ft}, inv_{ft}, FX_{ft})\,, \tag{25}$$

Then the estimation specification can be written as,

$$y_{ft} = \beta_l l_{ft} + \beta_k k_{ft} + g(k_{ft}, inv_{ft}, FX_{ft}) + \epsilon_{ft}. \tag{26}$$

Following Olley and Pakes (1996), the selection bias due to firm exit is also corrected in order to get a consisent estimation of coefficients. Finally, the OP type of TFP of firm f in industry i is achieved once the estimated coefficients are obtained:

$$\ln TFP^{OP}_{ift} = y_i t - \beta_k k_{ft} - \beta_l l_{ft}\,, \tag{27}$$

The production function is also estimated separately for each industry level. The Levinsohn and Petrin (2003) type of TFP also follows the standard way of estimation, using material cost as the proxy in obtaining the productivity of firms based on different industry levels.

B Stylized facts comparing Special economic Zone firms and non-Zone firms

Table B1: Compare SEZ and non-SEZ firms TFP

	(1) ln_OP	(2) ln_OLS	(3) ln_LP	(4) ln_OP	(5) ln_OLS	(6) ln_LP
SEZ dummy	0.0347***	0.0381***	0.0261***	0.0365***	0.0396***	0.0271***
	(0.00437)	(0.00462)	(0.00400)	(0.00470)	(0.00499)	(0.00429)
Export dummy	-0.0221***	-0.0223***	-0.0183***	-0.0208***	-0.0212***	-0.0175***
	(0.00311)	(0.00322)	(0.00294)	(0.00331)	(0.00343)	(0.00313)
foreign_owned	-0.0289***	-0.0247***	-0.0350***	-0.0287***	-0.0245***	-0.0349***
	(0.00509)	(0.00530)	(0.00479)	(0.00510)	(0.00531)	(0.00480)
soe	-0.0151**	-0.0155**	-0.0115*	-0.0151**	-0.0154**	-0.0115*
	(0.00740)	(0.00782)	(0.00694)	(0.00740)	(0.00782)	(0.00694)
Firm fixed effect	NO	NO	NO	YES	YES	YES
District fixed effect	YES	YES	YES	YES	YES	YES
Industry fixed effect	YES	YES	YES	YES	YES	YES
Year fixed effect	YES	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES	YES
N	834002	834002	834002	834002	834002	834002
adj. R^2	0.825	0.830	0.866	0.825	0.830	0.866

Clustered standard errors in parentheses

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

In order to illustrate the TFP comparison between SEZ firms and non-zone firms, this paper estimates three different types of TFP based on the following equation,

$$y_{ft} = \beta_1 FX_{ft} + \beta_2 SEZ_{ft} + \beta_3 SEZ_{ft} * FX_{ft} + X_{ft} + FE + \epsilon_{ft}\,, \tag{28}$$

where y_{ft} is the TFP of each firm; SEZ_{ft} is the dummy variable if the firm is located inside a SEZ; FX_{ft} is the export dummy in year t if the firm exports. The OLS regression also contains firm, industry, district, year fixed effects, and other control variables including age of the firm, capital-labor ratio, wage, material cost, foreign-owned-firm dummy and state-owned-firm dummy.

C Gravity model predicting 1984 district export data

Since the earliest available district level (city level) export data in China is in 1997, we incorporate a predicted 1984 district varied export data following the gravity model to further eliminate the bias from the district export. The demographic data used in the following equation is in the year of 1984, the earliest possible demographic data available. The prediction follows the equation below,

$$\ln X_d = \beta_p \ln POP_d + \beta_g \ln GDP_d + \beta_o \ln GEOarea_d + \beta_e East_d + \beta_c Central_d + \beta_l Landlock_d + \epsilon_d \,, \tag{29}$$

where X_d is the export quantity, POP_d is the amount of total population in the district, GDP_d represents the gross domestic product and $GEOarea_d$ is the geographic area of each district. We also include the dummy variables whether the district is located in the east, central or west region of China, and whether the district or city is landlocked compared to seashore.

The regression estimation is conducted over the sample in 1997 and then the coefficients are used to predict the city level export data in 1984, using demographic data in 1984.

Table C1: Gravity regression estimating 1984 district level export data

	ln_exp97
ln_gdp97	1.790***
	(0.208)
ln_pop97	-0.689**
	(0.261)
ln_geo97	-0.213*
	(0.0986)
East	0.405
	(0.248)
Central	-0.0112
	(0.221)
Landlock	-0.733**
	(0.262)
N	235
adj. R^2	0.659

Robust standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

D Solving firm's optimization problem

D.1 Firm's profit maximization problem

The maximization of a final good producer can be formalized as

$$\max_{m,x(z)} PC^{1/\sigma}y^{\frac{\sigma-1}{\sigma}} - m(z)p_m - c(z)x(z) \tag{30}$$

such that

$$y(z) = x(z)^{\alpha}m^{1-\alpha}$$

Taking the FOC with respect to $n(z)$ and $m(z)$:

$$p_m = PC^{1/\sigma}\frac{\sigma-1}{\sigma}y^{-1/\sigma}x(z)^{\alpha}(1-\alpha)m^{-\alpha} \tag{31}$$

$$c(z) = PC^{1/\sigma}\frac{\sigma-1}{\sigma}y^{-1/\sigma}x(z)^{\alpha-1}\alpha m^{1-\alpha} \tag{32}$$

From equation (32) and (33),

$$m = \frac{c(z)}{p_m}\frac{1-\alpha}{\alpha}x(z) \tag{33}$$

By $p = (y/c)^{-1/\sigma}P$, equation (32) and (33),

$$p = \frac{\sigma}{\sigma-1}\frac{c(z)^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}p_m^{\alpha-1}} \tag{34}$$

The labor value can be found using equation (32),(33), and (35),

$$x(z) = B\left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha}\left((1-\alpha)^{1-\alpha}\alpha^{\alpha}\right)^{\sigma}p_m^{(\sigma-1)(\alpha-1)}(\frac{\sigma}{\sigma-1})^{-\sigma}c(z)^{-\sigma\alpha-1+\alpha} \tag{35}$$

$$x(z) = Bb(\frac{\sigma}{\sigma-1})^{-\sigma}c(z)^{-\sigma\alpha-1+\alpha} \tag{36}$$

where $b = \left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha}\left((1-\alpha)^{1-\alpha}\alpha^{\alpha}\right)^{\sigma}p_m^{(\sigma-1)(\alpha-1)}$

D.2 Firm's labor cost minimization problem

The labor cost minimization problem can be solved by

$$c(z) + \lambda\left(1 - \int_{\underline{\theta}}^{\overline{\theta}} A(z,\theta)\, a(z,\theta)\, d\theta\right)$$

which implies $w(\theta) = \lambda A(z,\theta)$ for all $a(z,\theta) > 0$. Multiplying both sides of this expression by $a(z,\theta)$ and integrating over all θ with positive $a(z,\theta)$ give $c(z) = \lambda$, or

$$w(\theta) = c(z)A(z,\theta) \tag{37}$$

D.3 Labor market clear

$$\int_{\underline{\theta}}^{\theta^*} A(l,\theta)L(l,\theta)d\theta = M^l Bb \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} c(l)^{\alpha-1-\alpha\sigma}$$
$$\int_{\theta^*}^{\bar{\theta}} A(h,\theta)L(h,\theta)d\theta = M^h Bb \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} c(h)^{\alpha-1-\alpha\sigma}$$

Solving gives,

$$c(l) = \left(M^l Bb\right)^{\frac{1}{\gamma}} \left(\frac{\sigma}{\sigma-1}\right)^{-\frac{\sigma}{\gamma}} \left[\int_{\underline{\theta}}^{\theta^*} A(l,\theta)dG(\theta)\right]^{-\frac{1}{\gamma}}$$
$$c(h) = \left(M^h Bb\right)^{\frac{1}{\gamma}} \left(\frac{\sigma}{\sigma-1}\right)^{-\frac{\sigma}{\gamma}} \left[\int_{\theta^*}^{\bar{\theta}} A(h,\theta)dG(\theta)\right]^{-\frac{1}{\gamma}}$$

where $\gamma = -(\alpha - 1 - \sigma\alpha) > 0$. Note that the right-hand side of the ratio equation is decreasing in θ^*. To verify this,

$$\frac{d\left(\frac{c(l)}{c(h)}\right)}{d\theta^*} = \frac{1}{\gamma}\frac{M^l}{M^h}\left(\frac{c(l)}{c(h)}\right)^{\frac{1-\gamma}{\gamma}} \frac{\frac{d}{d\theta^*}D}{\left(\int_{\underline{\theta}}^{\theta^*} A(l,\theta)dG(\theta)\right)^2} \tag{38}$$

where

$$\frac{d}{d\theta^*}D = \frac{d}{d\theta^*}\left[\int_{\theta^*}^{\bar{\theta}} A(h,\theta)dG(\theta)\right]\int_{\underline{\theta}}^{\theta^*} A(l,\theta)dG(\theta) - \frac{d}{d\theta^*}\left[\int_{\underline{\theta}}^{\theta^*} A(l,\theta)dG(\theta)\right]\int_{\theta^*}^{\bar{\theta}} A(h,\theta)dG(\theta) < 0 \tag{39}$$

From (39), we can conclude

$$\frac{d\left(\frac{c(l)}{c(h)}\right)}{d\theta^*} < 0$$

D.4 Comparative Statics

The average productivity of firms not in the zone (low technology firms) refers to the productivity of non-zone firms summing over all labors divided by the total labor employed,

$$log(Prod(l)) = \alpha \log \left(\frac{\int_{\underline{\theta}}^{\theta^*} A(l,\theta) dG(\theta)}{G(\theta^*)} \right) = \alpha \log \left(\frac{M^l Bb(\frac{\sigma}{\sigma-1})^{-\sigma/\gamma} c(l)^{-\gamma}}{G(\theta^*)} \right) \tag{40}$$

$$\frac{d \log(Prod(l))}{d\theta^*} = M^l Bb(\frac{\sigma}{\sigma-1})^{-\sigma/\gamma} \frac{d}{d\theta^*} \frac{c(l)^{-\gamma}}{G(\theta^*)} \tag{41}$$

In order to have the productivity decreases with the cutoff, $\frac{d}{d\theta^*}\frac{c(l)^{-\gamma}}{G(\theta^*)} > 0$.

$$\frac{d}{d\theta^*} \frac{c(l)^{-\gamma}}{G(\theta^*)} = A(l,\theta^*) g(\theta^*) G(\theta^*) - g(\theta^*) \int_{\underline{\theta}}^{\theta^*} A(l,\theta) dG(\theta) > 0 \tag{42}$$

The previous equation implies that whenever the productivity at θ^* is larger than the average productivity of non-zone firms, then productivity is increasing in θ^*. When θ^* is lower, then the productivity of non-zone firms is lower.

The wage paid by low tech firm (non-zone firms) is the wage function summing over all types of worker below θ^* divided by $G(\theta^*)$,

$$wage = \frac{\int_{\underline{\theta}}^{\theta^*} c(l) A(l,\theta) dG(\theta)}{G(\theta^*)} \tag{43}$$

$$\frac{dWage}{d\theta^*} = \frac{d}{d\theta^*} \frac{\int_{\underline{\theta}}^{\theta^*} c(l) A(l,\theta) dG(\theta)}{G(\theta^*)} \tag{44}$$

$$\frac{d}{d\theta^*} \frac{\int_{\underline{\theta}}^{\theta^*} c(l) A(l,\theta) dG(\theta)}{G(\theta^*)} = c(l) A(l,\theta^*) g(\theta^*) G(\theta^*) - g(\theta^*) \int_{\underline{\theta}}^{\theta^*} c(l) A(l,\theta) dG(\theta) \tag{45}$$

Whenever

$$c(l) A(l,\theta^*) > \frac{\int_{\underline{\theta}}^{\theta^*} c(l) A(l,\theta) dG(\theta)}{G(\theta^*)} \tag{46}$$

The wage at θ^* is larger than the average wage of the low productivity firms, then wage is increasing in θ^*.When $\theta*$ is smaller, wage paid is less.

E Model calibration and structural estimation

E.1 Moments

- Before policy:
  The productivity,

$$\log(prod(l)) = \alpha \log\left(\frac{\int_{\underline{\theta}}^{\theta^*} A(l,\theta)dG(\theta)}{G(\theta^*)}\right) = \alpha \log\left(\frac{a\underline{\theta}^a}{1-\underline{\theta}^a\theta^{*-a}}\frac{1}{\beta_l - a}\left[\theta^{*\beta_l - a} - \underline{\theta}^{\beta_l - a}\right]\right) \tag{47}$$

$$\log(prod(h)) = \alpha \log\left(\frac{\int_{\theta^*}^{\bar{\theta}} A(h,\theta)dG(\theta)}{1-G(\theta^*)}\right) = \alpha \log\left(\frac{a\underline{\theta}^a}{(\frac{\underline{\theta}}{\theta^*})^a}\frac{1}{\beta_h - a}\left[-\theta^{*\beta_h - a}\right]\right) \tag{48}$$

  The wage,

$$w(l) = \frac{\int_{\underline{\theta}}^{\theta^*} c(l)A(l,\theta)dG(\theta)}{G(\theta^*)} = n^l(\frac{a\underline{\theta}^a}{\beta_l - a})^{\frac{\gamma-1}{\gamma}}\left[\theta^{*\beta_l - a} - \underline{\theta}^{\beta_l - a}\right]^{\frac{\gamma-1}{\gamma}}\frac{1}{1-\underline{\theta}^a\theta^{*-a}} \tag{49}$$

  where $n^l = (M^l Bb)^{1/\gamma}(\frac{\sigma}{\sigma-1})^{-\sigma/\gamma}$

$$w(h) = \frac{\int_{\theta^*}^{\bar{\theta}} c(h)A(h,\theta)dG(\theta)}{1-G(\theta^*)} = n^h(\frac{a\underline{\theta}^a}{\beta_l - a})^{\frac{\gamma-1}{\gamma}}\left[-\theta^{*\beta_h - a}\right]^{\frac{\gamma-1}{\gamma}}\frac{1}{(\frac{\underline{\theta}}{\theta^*})^a} \tag{50}$$

  where $n^h = (M^h Bb)^{1/\gamma}(\frac{\sigma}{\sigma-1})^{-\sigma/\gamma}$

- After policy:
  The productivity expression is the same for every firm except with a new cutoff point $\theta^{*'}$. The wage for non-zone firm is also with new cutoff in the same function. The wage for zone firm is with the new parameter $p_m\phi$,

$$w(h) = \frac{\int_{\theta^{*\prime}}^{\bar{\theta}} c(h)A(h,\theta)dG(\theta)}{1-G(\theta^{*\prime})} = n^{h'}(\frac{a\underline{\theta}^a}{\beta_l - a})^{\frac{\gamma-1}{\gamma}}\left[-\theta^{*'\beta_h - a}\right]^{\frac{\gamma-1}{\gamma}}\frac{1}{(\frac{\underline{\theta}}{\theta^{*\prime}})^a} \tag{51}$$

  where $n^{h'} = (M^h Bb')^{1/\gamma}(\frac{\sigma}{\sigma-1})^{-\sigma/\gamma}$

When do the estimation, the following are the moments equations after taking log:

$$mm_1 = \Delta prod_l = \ln\left[(\frac{1-\underline{\theta}^a\theta^{*a}}{1-\underline{\theta}^a\theta^{*'-a}})\left[\frac{\theta^{*'\beta_l - a} - \underline{\theta}^{\beta_l - a}}{\theta^{*\beta_l - a} - \underline{\theta}^{\beta_l - a}}\right]\right] \tag{52}$$

$$mm_2 = \Delta wage_l = \ln\left[\left[\frac{\theta^{*'\beta_l - a} - \underline{\theta}^{\beta_l - a}}{\theta^{*\beta_l - a} - \underline{\theta}^{\beta_l - a}}\right]^{\frac{\gamma-1}{\gamma}} \left(\frac{1 - \underline{\theta}^a \theta^{*-a}}{1 - \underline{\theta}^a \theta^{*'-a}}\right)\right] \tag{53}$$

$$mm_3 = \Delta prod_h = \ln\left[\left(\frac{\underline{\theta}^a \theta^{*-a}}{\underline{\theta}^a \theta^{*'-a}}\right)\left(\frac{\theta^{*'\beta_h - a}}{\theta^{*\beta_h - a}}\right)\right] \tag{54}$$

$$mm_4 = \Delta wage_h = \ln\left[(\phi^{(\alpha-1)(\sigma-1)})^{\frac{1}{\gamma}}\left(\frac{\underline{\theta}^a \theta^{*-a}}{\underline{\theta}^a \theta^{*'-a}}\right)\left(\frac{\theta^{*'\beta_h - a}}{\theta^{*\beta_h - a}}\right)^{\frac{\gamma-1}{\gamma}}\right] \tag{55}$$

The last two moments are the log of difference between equation (48) and (49) and log of difference between equation (50) and (51).

$$mm_5 = prod(h) - prod(l) \tag{56}$$

$$mm_6 = wage(h) - wage(l) \tag{57}$$

E.2 Zone firms productivity regression

The following regression illustrates the increase of firms productivity if a firm enters the zone. β for productivity and wages are the parameters used in the calibration section.

$$y_{fidt} = \beta SEZ_{fidt} + X_{fidt}\alpha + \lambda_f + \lambda_i + \lambda_d + \lambda_t + \epsilon_{fidt}\,, \tag{58}$$

where y_{fidt} represents the TFP or average wage of the firm and SEZ_{fidt} is the dummy variable if the firm is in SEZ in year t. Control variables include the export decision of firms, if the firm is foreign owned, if the firm is state owned, material cost, capital labor ratio and industrial output. In order to test the increase parameter of zone firm' productivity, the regression is tested on SEZ firms only who move into the zone over the sample period and does not change their location and output produced. In order to calibrate the model, this is the best way to test the parameter increase.

Table E1: Productivity increase of zone firms

	(1)	(2)	(3)	(4)
	ln_OP	ln_LP	ln_OLS	ln_avewage
sez_vary	0.0326***	0.0272***	0.0353***	0.0198**
	(0.00566)	(0.00527)	(0.00592)	(0.00619)
export_dummy	-0.0397***	-0.0279**	-0.0437***	0.0180
	(0.0108)	(0.00999)	(0.0112)	(0.0119)
foreign_owned	-0.0374**	-0.0333*	-0.0344*	0.0555***
	(0.0145)	(0.0136)	(0.0151)	(0.0155)
soe	0.0156	0.0221	0.0158	0.0692**
	(0.0196)	(0.0180)	(0.0212)	(0.0216)
N	83828	83828	83828	88367
adj. R^2	0.791	0.851	0.808	0.800

Robust standard errors in parentheses

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

E.3 Calibration with fixed elasticity of substitution and labor share

E.3.1 Baseline model

- $a = 0.4$ Labor share in production
- $\sigma = 3.42$ Elasticity of substitution between varieties

Table E2: Model Calibration

Moments(Log)	Data	Model
Productivity change of non-SEZ firms	-2.17%	-1.82%
Wage change of non-SEZ firms	-1.26%	-0.84%
Productivity change of SEZ firms	3.26%	3.01%
Wage change of SEZ firms	1.98%	2.65%
Productivity difference of SEZ and non-SEZ firms before policy	0.0498	0.0501

Table E3: Values of parameters determined by the estimation

Parameters	Value	Interpretation
α	9.6955	Pareto distribution shape parameter
β_l	6.1004	Non-zone firms productivity function parameter (low tech firms)
β_h	6.1620	Zone firms price decrease parameter (high tech firms)
ϕ	0.8887	Zone firms tariff decrease parameter
ψ	1.0255	Zone firms productivity increase parameter
σ	3.42	Elasticity of substitution
a	0.40	Labor share in the production function

- $a = 0.4$ Labor share in production
- $\sigma = 3$ Elasticity of substitution between varieties

Table E4: Model Calibration

Moments(Log)	Data	Model
Productivity change of non-SEZ firms	-2.17%	-1.81%
Wage change of non-SEZ firms	-1.26%	-0.75%
Productivity change of SEZ firms	3.26%	3.05%
Wage change of SEZ firms	1.98%	2.63%
Productivity difference of SEZ and non-SEZ firms before policy	0.0498	0.0501

Table E5: Values of parameters determined by the estimation

Parameters	Value	Interpretation
α	8.7431	Pareto distribution shape parameter
β_l	5.5866	Non-zone firms productivity function parameter (low tech firms)
β_h	5.6430	Zone firms price decrease parameter (high tech firms)
ϕ	0.8678	Zone firms tariff decrease parameter
ψ	1.0259	Zone firms productivity increase parameter
σ	3	Elasticity of substitution
a	0.40	Labor share in the production function

E.3.2 Adding productivity increase

The changes of moments:

$$mm_3 = \Delta prod_h = \ln\left[\psi\left(\frac{\underline{\theta}^a \theta^{*-a}}{\underline{\theta}^a \theta^{*\prime -a}}\right)\left(\frac{\theta^{*\prime \beta_h - a}}{\theta^{*\beta_h - a}}\right)\right] \tag{59}$$

$$mm_4 = \Delta wage_h = \ln \left[\psi^{\frac{\gamma-1}{\gamma}} (\phi^{(\alpha-1)(\sigma-1)})^{\frac{1}{\gamma}} (\frac{\underline{\theta}^a \theta^{*-a}}{\underline{\theta}^a \theta^{*'-a}}) \left(\frac{\theta^{*'\beta_h - a}}{\theta^{*\beta_h - a}} \right)^{\frac{\gamma-1}{\gamma}} \right] \tag{60}$$

- $a = 0.4$ Labor share in production
- $\sigma = 3.42$ Elasticity of substitution between varieties

Table E6: Model Calibration

Moments(Log)	Data	Model
Productivity change of non-SEZ firms	-2.17%	-1.82%
Wage change of non-SEZ firms	-1.26%	-0.84%
Productivity change of SEZ firms	3.26%	3.01%
Wage change of SEZ firms	1.98%	2.65%
Productivity difference of SEZ and non-SEZ firms before policy	0.0498	0.0501

Table E7: Values of parameters determined by the estimation

Parameters	Value	Interpretation
α	9.6955	Pareto distribution shape parameter
β_l	6.1004	Non-zone firms productivity function parameter (low tech firms)
β_h	6.1620	Zone firms price decrease parameter (high tech firms)
ϕ	0.8887	Zone firms tariff decrease parameter
ψ	1.0255	Zone firms productivity increase parameter
σ	3.42	Elasticity of substitution
a	0.40	Labor share in the production function

- $a = 0.4$ Labor share in production
- $\sigma = 3$ Elasticity of substitution between varieties

Table E8: Model Calibration

Moments(Log)	Data	Model
Productivity change of non-SEZ firms	-2.17%	-1.81%
Wage change of non-SEZ firms	-1.26%	-0.75%
Productivity change of SEZ firms	3.26%	3.05%
Wage change of SEZ firms	1.98%	2.63%
Productivity difference of SEZ and non-SEZ firms before policy	0.0498	0.0501

Table E9: Values of parameters determined by the estimation

Parameters	Value	Interpretation
α	8.7431	Pareto distribution shape parameter
β_l	5.5866	Non-zone firms productivity function parameter (low tech firms)
β_h	5.6430	Zone firms price decrease parameter (high tech firms)
ϕ	0.8678	Zone firms tariff decrease parameter
ψ	1.0259	Zone firms productivity increase parameter
σ	3	Elasticity of substitution
a	0.40	Labor share in the production function