Regional Divergence and Import Competition

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Abstract

During the last decades, regions in the United States are diverging, with more skill-intensive regions having higher wage and skill premium growth and becoming even more skill-intensive. In this paper, I show that this may be driven in part by trade with China. I show that the effects of rising exposure to import competition are heterogeneous among regions depending on the prior level of skill-intensity. Indeed, among more skill-intensive regions, greater exposure to Chinese imports increases skilled-wages and skill premium, and it attracts skilled workers to those regions. Besides, I show that changes might be caused by differential sectoral reallocations.

Introduction

Since 1980, regions in the United States are diverging, with more skill-intensive regions having higher wage and skill premium growth and becoming even more skill-intensive. In this paper, I show that this may be driven in part by trade with China. Indeed, I show that, among more skill-intensive regions, greater exposure to import competition increases skill intensity and the skill premium, whereas it has the opposite effect among less skill-intensive regions.

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The mechanism through which growing import competition contributes to increasing differences and skill premium and the skill sorting is not a depression of conditions in those regions specialized in manufacturing industries versus less manufacturing-intensive areas. Instead, the effect of the negative shock to the manufacturing sector amplifies or reverses depending on the overall characteristics of the local labor market.

In this article, I discuss that critical role of the way in which local labor markets reallocate resources previously used in the manufacturing sector. While highly educated regions employ slack factors from manufacturing in STEM-intensive sectors and they become attractive for highly-educated workers, less educated areas fall into the vicious circle of low skill-intensity specialization. Therefore, this article highlights the relevance of previous characteristics of local labor markets to determine the effect of increasing import competition.

First, I develop a simple model of regional economies to illustrate how the same shock in exposure to import competition may have differential effects depending on prior regional characteristics. The model incorporates two productive sectors; manufactures and an advanced sector. Also, it includes three production factors: skilled and unskilled labor, and local office space. Factors have perfect mobility among sectors but different degrees of mobility among regions. In the model, exposure to a negative competition shock in the manufacturing sector displaces resources from the latter to the more skill-intensive advanced sector in a first step. However, even if every region faces the same shock, this reallocation is larger in skill-intensive regions. Hence, due to factor mobility and the nation-wide spatial equilibrium for skilled workers, the initial factors displacement is magnified in previously skill-intensive regions, while it is reversed in areas with a prior low skill intensity level.

The model delivers three testable implications. Even facing the same adverse shock to the manufacturing sector, consequences are significantly different depending on the level of skill intensity. More skill-intensive regions leverage out the negative shock in manufacturing and (1) attract more skilled workers, (2) offer them higher wages and (3) specialize in skill-intensive sectors. The opposite happens in regions with lower skill intensity. These areas lose skilled workers, skill wage premium decreases, and innovative industries decline.

Empirically, I study the effect of growth in exposure to Chinese import competition in urban commuting zones in the US between 1990 and 2007. I interact the measure of exposure to trade with the share of the workforce with a college degree in 1990 to capture the heterogeneity in effects of higher import competition. Also, I control for other confounding interactions such as population or proportion of employment in routine-task intensive jobs.

I show that neglecting the overall characteristics of regions exposed to trade competition, focusing only on the size or composition of those directly exposed industries, misses a relevant part of the total effect of import competition. Analyzing the heterogeneous impact of import competition on regions, I find significant effects on variables like college wage premium, migration of college-educated workers or the number of patents per capita. These effects are not significant with a standard analysis as in Autor, Dorn, and Hanson 2013.

In particular, conditional on the level of exposure to Chinese imports, the effects on local labor markets largely depends on the level of college education prior to the arrival of the competition shock. Adverse effects concentrate on exposed regions with a low share of college-educated workers. On the other hand, for those exposed areas with a high skill intensity, effects turns positive in terms of college wages, the share of college-educated population and specialization in skill-intensive sectors.

Differential effects are sizable. I find that among regions exposed to a decadal rise of \$1500 per worker in Chinese imports (median value), a 5.5% higher share of college-educated workers in 1990 (1 standard deviation) means a growth of college-educated population of 13.35% faster per decade (equivalent to 1.01 standard deviations), real wages for college-educated workers grow a 5.05% more per decade (0.53 standard deviations) and college wage premium becomes 3.5 percentage points higher per decade (0.83 standard deviations).

Hence, accounting for heterogeneous effects sheds light on the contribution of the growth of Chinese imports to the regional divergence in the US. The effect is not just a depression of areas specialized in manufacturing industries, but an additional relevant axis to understand the results is the educational level in regions and, consequently, their ability to react to the negative shock faced by the manufacturing sector.

Related Work

This work contributes to a number of existing literatures. Concerning the rise of Chinese exports to the US, I show that the interaction between import competition and prior share of college-educated workers plays a key role determining the effect of rising import competition on local labor markets. Growth in exposure to import competition has a significant positive impact on skill premium and skill sorting when it interacts with a high level of college education in the region. In contrast, the average effect of import competition on those variables is null (Autor, Dorn, and Hanson, 2013). Then, as a novelty, this work shows the importance of accounting for overall characteristics of local labor markets, beyond the relative size of those industries exposed the most to trade.

Concerning the literature on regional divergence in the US during the last decades, I introduce import competition as a novel causal factor of growing disparities in wages and college education. Growth in exposure to trade with China makes skilled workers to sort into high-skill areas, and makes college wages to grow faster in those regions. This work also complements previous theories attempting to explain the feature, such as skill- biased technological change or sectoral change. By increasing disparities in skill intensity, growth of import competition places skill-intensive regions in a better position to exploit skill-biased technical improvements.

The first strand of literature that this work speaks to is the regional divergence in the US. This process, coined as "The Great Divergence" by Moretti (2012), involves dispersion in many dimensions. The two features that this work addresses are the sorting of college-educated workers into college-abundant regions and the dispersion in skill premium.

Concerning the latter feature, until the 1980s it took place in the US a wage convergence process among metropolitan areas, but such a trend has been broken since then. Further-more, the stop of convergence was driven by the divergence of college-educated wages. Such process can be explained through the combination of two factors. First, the aforementioned self-reinforcement of prior differences in educational level among regions. Second, that during the same period, the relationship between skill premium and educational intensity started to increase. After 1990, there exists a positive relationship between the relative abundance of college-educated workers and the ratio between college and noncollege-educated wages (Giannone, 2017).

An extensive literature, with Katz and Murphy (1992) as a seminal paper, has focused on the role that skill-biased technological change plays on the rise of skill wage premium at the national level.

At the local level, Autor and Dorn (2013) finds that the effect of computerization is larger in those regions where jobs are more intensive in routine tasks. Giannone (2017) quantifies the large contribution of SBTC and agglomeration economies to the end of wage convergence. Beaudry, Doms, and Lewis (2010) examines the faster PC adoption in skill-abundant metropolitan areas and the subsequent increase in skill premium.

Concerning to technological progress, I show that the growth of Chinese imports competition might accelerate SBTC. Among high-skilled regions the effect of a greater exposure to trade increases both the share and the overall size of college-educated population, whereas the opposite happens among regions with low college intensity. This creates differences not only between regions with different education intensity that are equally exposed to trade, but also among regions with the same college intensity and different degrees of exposure to import competition. Indeed, among highly-educated regions, those with a larger exposure to trade become relatively more college-educated than those with a low exposure. Those regions will be more likely to benefit from any skill-oriented technical progress. Empirically, I test that for the most college-educated regions, exposure to trade has a positive effect on the change of the number of patents per capita. This effect is significant even after controlling for the interaction between growth of import competition and other variables such as the fraction of employment in routine task occupations or the skill composition of the manufacturing sector.

Buera, Kaboski, and Rogerson (2015) focuses instead on skill-biased structural changes, where the larger demand for skilled workers comes from a sectoral reallocation toward high-skill intensive industries. Authors show that economic development is associated with a shift in value added to high-skill intensive sectors and a subsequent increase in skill-premium.

Concerning to sectoral changes, I show that highly-educated regions face a high exposure to Chinese import competition reallocate relatively more employment to STEM-intensive sector and to STEM-related occupations. This positive effect is both compared to low-educated regions, but also with respect to highly-educated regions with low exposure to trade.

Then, this work is in line with Glaeser and Saiz (2003), that shows that cities with more human capital adapt better to changes. In my work, areas with higher college education dodge the adverse effects of exposure to Chinese imports, and they leverage out the losses in employment in manufacturing to grow more skill-intensive sectors.

The same divergence pattern takes place in terms of human capital (Berry and Glaeser, 2005). I show that the growth of Chinese imports competition contributes to the skill sorting. High-skill workers leave low-education regions that suffer a larger growth in import competition; whereas those highly-educated areas facing a larger exposure to trade have a positive net migration flow of skilled workers. Besides, this work also relates to the agglomeration externalities literature. Baum-Snow, Freedman, and Pavan (2014) discusses the existence of skill-biased agglomeration externalities in cities. Duranton and Puga (2004) discuss the micro-fundation of those agglomeration effects. Then, as with SBTC, the combination of high-skill intensity and trade competition acts as a fueling force for productivity agglomeration externalities for skilled workers in cities.

The second literature strand that this work speaks to is the effect on local labor markets of trade liberalization. An essential reference is Autor, Dorn, and Hanson (2013), showing that growth of Chinese imports competition had substantial effects on wages and employment in local labor markets in the US between 1990 and 2007. When a region is specialized in manufacturing industries which are highly exposed to Chinese imports competition, jobs and wages decrease.

However, the same study shows that effects on wages are not significantly different for college-educated or noncollege-educated workers. As well, there are no significant effects on the share of college-educated workers in a region, population growth or migration patterns. Then, if import competition has any contribution to the divergence in skill premium and sorting of college-educated workers, it is necessary to consider heterogeneity in the effects of the growth of import competition.

In the same context, Monte (2015) develops a general equilibrium framework and shows that even if exposure to trade in comparative disadvantage sectors lowers nominal wages, all real wages grow. The reason is that local services and housing prices adjust and workers change commuting patterns within local labor markets. In this work, I show that the positive effect of import exposure in highly educated regions still holds after controlling for local prices. Also, I show that there are important effects of migration between local labor markets, not only within them.

Dix-Carneiro and Kovak (2014) finds, in the context of Brazilian regions from 1990 to 2010, a significant but small negative effect on skill premium in regions that allocate a larger fraction of their skilled workers in sectors facing a larger tariff reduction.

An essential difference of this work with respect to prior literature is that the determinant of differential effects of exposure to trade is the total share of college-educated population in the region. I show that neglecting the overall characteristics of regions, rather than just the size or composition of those directly exposed industries, misses a relevant part of the total effect of import competition.

Theoretical Model

To illustrate the reason why the level of skill intensity in a region would play a relevant role when it interacts with higher import competition, I introduce a model of structural transformation in local economies. The model exemplifies the reaction of regions to a trade shock hitting their manufacturing sector. I show that, even if the shock is the same for every local labor market, areas with a higher skill-intensity react by shifting their production from manufacturing to more skill-intensive sectors. Migration of high-skill workers from low to high-skill regions is the primary driver of the differences in effects of trade competition.

The model has four main ingredients: 1) local economies with two productive sectors that differ in their intensity of skilled employment; 2) positive agglomeration externalities for skilled workers; 3) existence of local production factors supplied in a fixed quantity, and 4) a spatial equilibrium that solves the allocation of skilled workers across local markets.

This is a partial analysis focused on the production side of the economy, so it neglects the consumption side. Each local economy is composed of two different productive sectors: manufacturing sector and an advanced sector. Regions are assumed to be small open economies, and their firms sell their products in the international market, taking prices as given.

Manufacturing sector uses office space and employs unskilled workers following a Cobb Douglas function with constant returns to scale. Production is sold at price $P_{M,c}$. The growth in competition due to Chinese imports is represented in the model as a negative shock to the price of the good produced in the manufacturing sector.

$$P_{M,c} \cdot Y_{M,c} = P_{M,c} O_{M,c}^{\alpha} L_{M,c}^{1-\alpha}$$

The advanced sector also follows a Cobb Douglas production function with office space and labor as inputs. Nonetheless, the labor component combines both skilled and unskilled workers with a constant elasticity of substitution. Its price is normalized to 1. Additionally, the agglomeration of skilled workers creates a skill-specific positive productivity externality.

$$P_{A,c} \cdot Y_{A,c} = P_{A,c} \cdot O_{A,c}^{\alpha} \left(\psi \cdot L_{A,c}^{\sigma} + (1-\psi) \cdot \mathbb{X}_c H_c^{\sigma} \right)^{\frac{1-\alpha}{\sigma}}$$

where $\mathbb{X}_c = H_c^{\eta}$.

Agglomeration externalities for skilled workers are needed to replicate the empirical evidence of positive relationship among skill intensity in the local market and wages for skilled workers.

There are three production factors in the economy: office space, unskilled and skilled labor. There is a fix amount of office space in the region that is competitively allocated by the owners between the manufacturing and the advanced sector $O_c = O_c^M + O_c^A$. Unskilled workers are also geographically immobile[1] and they are also employed in both sectors $L_c = L_c^M + L_c^A$.

Skilled workers are employed only in the advanced sector, and they are imperfectly mobile across regions[2]. Migration of skilled workers has an elasticity with respect to the relative salary in the region of $0 < s < \infty$

$$H_c = H_c^0 \cdot \left(\frac{w_{H,c}}{\bar{w}_H} \right)^s$$

where H_c^0 is a local idiosyncratic parameter that sets pre-existing differences in skill intensity and $\tilde{w}_H = \left(\sum_c w_c^s \cdot \frac{H_c^c}{\bar{H}} \right)^{\frac{1}{s}}$ is the national weighted average wage for skilled workers[34].

[1]This assumption is a simplification of the empirical finding that college educated workers are more mobile than workers without college education (Wozniak, 2010; Malamud and Wozniak, 2012).

[2]This assumption is a simplification of the empirical finding that manufacturing sector is relatively more intensive in low-skilled labor (Bound and Holzer 2000; Notowidigdo 2011; Buera, Kabowski, and Rogerson , 2015).

[3]This is a direct derivation from models of spatial equilibrium as in Rosen (1979) and Roback (1982). A recent update can be found in Moretti (2011).

[4]The rationale for s can be twofold. First, it is assuming that each worker has location specific preferences for every region drawn from a given distribution. The value of s is inversely related to the variance of such distribution. If workers draw their location specific preferences from an infinite variance distribution then $s = 0$ and they do not migrate as any potential salary gain from doing so is offset by their strong preferences for their current location. If the distribution is zero variance $s = \infty$ and wages are perfectly equalized across regions as the only thing workers value about a region is the potential wage. Second, if we consider that local housing supply has positive slope, elasticity of migration with respect to nominal wage changes will be attenuated by the hike of local housing prices. Thus, s will be proportional to the inverse of the sum of the slope of local housing supply and the strength of idiosyncratic location preferences.

It is important to point out that, even if the amount of skilled population depends positively on the wages of skilled workers, the relevant quantity is the wage relative to the national average. Even if at a first moment trade shock would rise skilled wages across the board, the spatial equilibrium will reallocate skilled workers only to those regions where skilled wages grew the most.

Then, the driving force for changes in the model is the competition for productive factors. This competition takes places in two dimensions. In the first place, within each region, the advanced sector competes against the manufacturing sector for the locally limited business space and unskilled labor. The negative import competitions shock sector reduces their returns in manufacturing. On the other hand, the return to local factors in the advanced sector depends positively on the number of skilled workers due to factor complementarity.

In the second place, advanced sectors from every region compete at the national level against other regions' advanced sectors to attract skilled labor. The direction of the flow depends on the competitive salary offered to workers. Again, the productivity of skilled employees in a region depends positively on how intensive in the advanced sector is the region.

Both flows feedback each other. A region that displaces more factors from manufacturing to the advanced sector increases its productivity in the latter, attracting skilled workers. An advanced sector with more skilled workers hoards up a larger fraction of local factors.

Impact of Trade

As stated above, the comparatives I shall show are differences in skilled and unskilled wages, migration of skilled workers as well as the allocation of local production factors across sectors before and after the import competition shock. The way that the growth of import competition is represented in the model is as a negative shock in the price of goods produced in the manufacturing sector$\left(P_1^M < P_0^M\right)$.

In order to properly understand the underlying mechanism, I present the case without skilled-workers mobility as an intermediate step.

Figures 1 and 2 have on their vertical axis the percentage change of skilled and unskilled wages, skill premium (top row), skilled population and office space and unskilled labor allocated in the advanced sector (bottom row). Those variables are plotted against the share of skilled workers in the period prior to the import competition shock.

Trade shock without geographical mobility

Figure 1[5] shows the case where skilled workers are not geographically mobile. This setting is useful to understand the movement of local factors across sectors, but it fails on depicting two empirically observed facts: percentage change in skilled wages is almost flat with respect to skill abundance in the region and, by construction, there are no changes in the share of skilled workers.

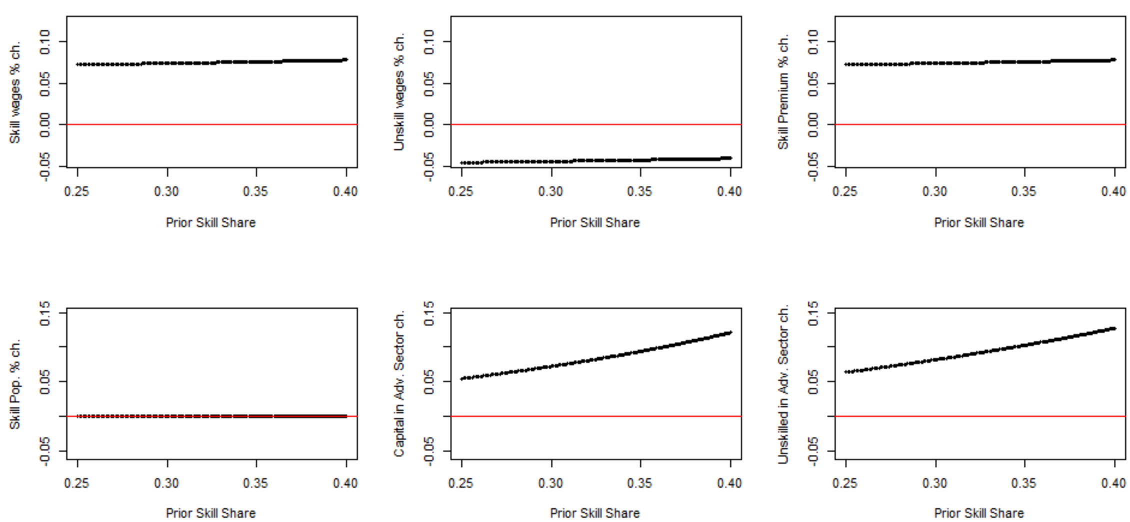

Figure 1: Baseline model, without mobility of skilled workers

The negative shock to the price of manufacturing goods decreases the profitability of employing locally-supplied factors (office space and unskilled workers) in the sector and those resources are transferred to the advanced one. In those regions where the prior level

[5]Parametrization for Figure 2 is as follows: $L_c = K_c = A_c = B_c = 1$, $\alpha = \sigma = \eta = s = \psi = 1/3$, $H_c^0 \sim U\left[1/3, 2/3\right]$, $P^1_{M,c} = .95 \cdot P^0_{M,c}$. In Figure 1 η and s are set 0

of skill intensity is higher, the transfer of production factors happens to a larger extent. The reason is that the advanced sector in those regions is already larger before the shock. In order to compensate the same change in productivity, the required change in the amount of factors is greater.

Skilled wages grow in every region due to the reallocation of local factors from the manufacturing sector to the advanced one. Then, the increase of complementary factors makes skilled wages to hike. Although the percentage change is positive and almost flat in every region, the absolute increase is higher in areas with a larger prior skill intensity. This breaks the spatial equilibrium for skilled workers and will induce the migration of skilled workers once that mobility is introduced in the model. On the other hand, unskilled wages decrease uniformly in every region as unskilled workers are directly affected in their productivity because of the shock to manufactures.

Trade shock with geographical mobility

Skilled wages grow in every region in the case without mobility, but the growth is not homogeneous across regions. When skilled workers mobility is introduced, it makes skilled workers to migrate away from areas with lower skill intensity towards regions with a larger prior skill intensity. This ignites a spiral of divergence. Skilled workers productivity in regions attracting skilled workers grows due to the effect of skill externalities, while the opposite happens in regions that had a low prior skill intensity and they are losing further workers. The overall effect is that changes in skilled wages are no longer positive across the board. For those regions at the top of prior skill intensity distribution, the change in skilled wages due to the negative shock in the unskilled sector is strongly positive. On the other hand, in regions with a low prior skill intensity wages decrease for both types of workers. Otherwise, changes in unskilled wages are negative in every region and basically flat with respect to prior skill intensity. Then, changes in skill premium follow very closely those in skilled wages.

A nation-wide negative shock in the manufacturing sector makes the advanced sector in skill-intensive regions to grow at the expense of their respective manufacturing sectors (by using more offices space and unskilled workers) and at the expense of the advanced sector in low-skill intensity regions (by attracting skilled workers).

On the other hand, the reallocation of factors from manufacturing to the advanced sector is reversed in regions with low prior skill intensity. The dry up of skilled labor intensity inflicts a negative productivity shock in the advanced sector. Then, the negative productivity shock in the advanced sector compensates the negative shock in manufacturing.

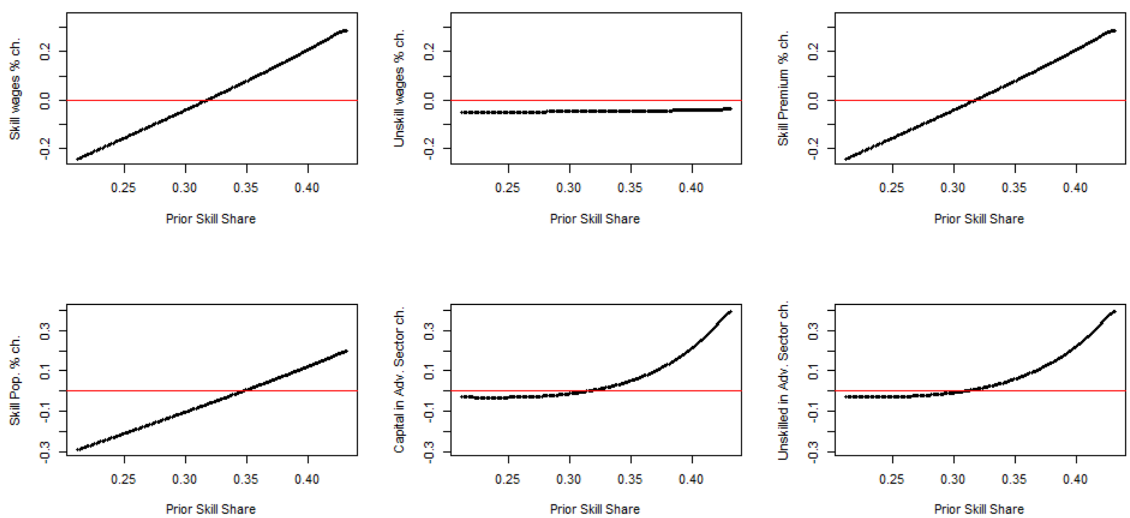

Figure 2: Full model, with skill externalities and mobility of skilled workers

The model provides three testable implications. The effect of a negative shock to manufactures will have a different effect for a skill-intensive region than for a skill-scarce one. The skill-intensive region:

1. becomes relatively more skill-intensive
2. increases its skill wage premium
3. reallocates more resources from manufactures to the advanced sector.

Emprical Analysis

The main target of the empirical specification is to identify changes in the variables of interest due to the growth of import competition, and to assess whether those changes are heterogeneous depending on the prior skill intensity in different regions. The empirical strategy follows closely the one in Autor, Dorn, and Hanson (2013). I expand their analysis building interactions of the measure of exposure to Chinese import competition with other variables in order to account for the potential heterogeneous effect. The interaction of interest is the one with the share of college-educated workers at the beginning of the period.

Concerning the regional divergence, dependent variables are grouped into three categories, mapping the hypotheses delivered by the theoretical model. About skill sorting, I test differences in population growth and migration flows by educational level; about income inequality, changes in wages and skill premium; and finally, I examine the skill-oriented sectoral reallocation with the change in patents per capita and the growth of employment in STEM-intensive sectors and occupations.

Data and Sample

Following ADH, the unit of analysis are time-region observations. The sample is composed by two stacked quasi-decadal differences in the outcomes of interest for the periods 1990-2000 and 2000-2007 for each region. The geographical units of measure are commuting zones (CZ), as developed by Tolbert and Sizer (1996). These zones are clusters of US counties that replicate local labor markets by designing areas where most of its inhabitants work inside it and most of the workers also live in the area.

A first discrepancy with respect to the ADH approach is that I will run the analysis only with those CZs overlapping metropolitan areas. The reason is that the suitable framework for the analysis of potential agglomeration forces is the urban environment. Although this decision reduces notably the number of observations from 722 to 321, the reduced sample still covers above the 90% of the US population. As long as the regressions are population weighted the effect of reducing the sample does not significantly change the results.

Import exposure

I shall use the sharp rise that Chinese exports to the US experienced since 1990 as the measure the growth of import competition for each local labor market. Two reasons support this decision. First, the deep comparative advantage in labor-intensive goods that China has with respect to the US. Second, that trade with China is responsible for nearly all of the expansion in U.S. imports from low-income countries since the early 1990s.

The variable of growth of import exposure of a commuting zone is the same as in ADH. It consists of a shift-share procedure, apportioning the growth of Chinese imports per worker in each manufacturing industry j according to each region i's proportion of employment in the industry.

$$\Delta IPW_{it} = \sum_j \frac{\Delta Imports_{j,t}^{CH,US}}{Employment_t^{CZ}} \frac{Employment_{j,t}^{CZ}}{Employment_{j,t}^{US}}$$

Growth in import penetration exposure per worker is then measured in thousand dollars per worker in the region.

To identify the supply-driven component of Chinese imports, the previous variable is instrumented using the previous decade composition and growth of Chinese imports in eight other developed countries.

$$\Delta IPW_{oit} = \sum_j \frac{\Delta Imports_{j,t}^{CH,Ot}}{Employment_{t-1}^{CZ}} \frac{Employment_{j,t-1}^{CZ}}{Employment_{j,t-1}^{US}}$$

The instrumental strategy relies on two pillars. Instead of computing industry-level import penetration with U.S. imports by industry it uses realized imports from China by other high-income markets. Secondly, it replaces all other variables with lagged values to mitigate any simultaneity bias.

Skill intensity

Following Acemoglu and Autor (2011) I use education as a proxy for skills. Thus, skill intensity is proxied by the share of the population between 25 and 64 years with 4 or more years of college education in 1990.

Since the hypothesis I am working with implies a causal effect for the interaction between import competition and prior skill intensity, I need to instrument the proportion of college-educated population with a variable that is not affected by potential underlying trends confounding educational attainment and import competition growth. Not doing so could bias the estimations as long as college share in 1990 could be endogenous to the expectation in relative wage changes or industrial composition. To address that issue, I instrument for the share of college-educated population in 1990 with the percentage of college-educated population in 1970, introducing a two-decade lag. This lag also mitigates the potential bias introduced by the contemporaneous process of skilled-bias technological change that starts in the 1980s. Thus, this strategy also follows the approach of Valero and Van Reenen (2016), that analyzes the long-term implication of the number of established colleges an area.

Econometric Specification

I show three different econometric specifications. First, I include the analysis with homogeneous import competition effects, which just replicates the analysis in ADH. These regressions are included, for information purposes, to show that under the standard analysis, skill sorting or the dispersion of skill premium cannot be explained by the rise of Chinese imports.

Then, I include an intermediate step, where I augment the econometric specification only with the interaction between growth in import competition and prior skill intensity. Besides, I discuss how to address some econometric pitfalls that appear with the inclusion of the interaction.

Finally, I show the fully augmented specification. This specification controls for other potentially relevant interaction of import competition with other variables, such as population or share of offshorable employment. Then, this is a fully interacted version of the baseline regression in ADH.

Homogeneous Effect of Import Competition

In order to have a comparison in hand, the first set of regressions reproduces some of the results from ADH.

The dependent variables in the top panel of Table 1 are the percentage growth in the college-educated, noncollege-educated and total population; and the change in the share of the population with college education between 25 and 64 years.

The bottom panel shows the percentage growth of average, college and non-college weekly wages. Changes in wages are discounted by one-third of the percentage growth of the median rental price in the commuting zone. This controls for changes in local housing prices, that typically accounts for that fraction of total households' expenditure. Change in college premium is defined as the difference of growth rates of college and noncollege wages.

These are 2SLS estimates, with the instrumental variable described in the previous section, without any interaction of the measure of trade exposure. It includes the full set of demographic and regional controls of the original paper: college education, offshorability index, share of routine-intensive jobs, female labor participation, foreign-born population, and Census regions and time dummies.

$$\Delta Y_{t,i} = \alpha_1 \cdot \Delta IPW^{US}_{t,s} + \Gamma X_{1990} + \epsilon_{t,i}$$

As previously stated, those local labor markets specialized in manufacturing industries that are more exposed to trade suffered a negative and very significant change in average wages. For the full sample of workers, an increase of 1000$ per worker in exposure to Chinese imports decreases the average weekly wage by 0.56% in a decade. As a motivation for the

TABLE 1. Homogeneous effects of import competition

	Demographics			
	Population (% Change)	College Educ. Pop (% Change)	No College Educ. Pop (% Change)	College Educ. Sh. (pp Change)
ΔIPW	0.184	-0.320	0.487	-0.0938
	(0.429)	(0.686)	(0.571)	(0.505)
	Wages			
	College Premium (p.p. change)	Avg. Weekly Wage (% change)	Avg. Weekly College Wage (% change)	Avg. Weekly Non College Wage (% change)
ΔIPW	0.063	-0.562***	-0.512***	-0.575***
	(0.050)	(0.045)	(0.133)	(0.030)

N=316 CZ x 2 observations. Robust standard errors are clustered by CZ

Models are weighted by start of the period region share of population share

further analysis in this work, it is noteworthy that the magnitude of the effect is pretty similar for workers with college education and workers with no college education. The estimated impact on the skill premium of the growth of import exposure is not significant.

Similarly, import competition does not affect demographic variables in the local labor market, neither in growth of total or college-educated population nor the share of college-educated population.

Heterogeneous Effect of Import Competition

Following the finding of the previous section, to analyze whether regional divergence can be explained by the rise in trade with China, it is necessary to look for heterogeneous effects of exposure to trade. In this section, I introduce the set of regressions of interest for this work. As the dimension of interest is the heterogeneity with respect to the prior skill intensity, the estimator of interest will be the one associated with the interaction of ΔIPW with the prior share of college educated population in 1990.

As an intermediate step I show the results of the regression augmented only with the previously mentioned interaction.

$$\Delta Y_{t,i} = \alpha_1 \cdot \Delta IPW^{US}_{t,s} + \alpha_2 \cdot College_{1990,i} + \beta \cdot \Delta IPW^{US}_{t,s} \cdot College_{1990,i} + \Gamma X_{1990} + \epsilon_{t,i}$$

This regression includes the same controls as in the baseline regression. Besides, it also adds two other controls to address potential threats to the econometric specification. The first issue is that the way in which the variable of import competition imputes trade exposure to each local labor market assumes implicitly homogeneity within manufacturing industries. The second one is the positive time trend in the same variable.

Manufacturing Sector Heterogeneity

An important issue that must be addressed is the way in which import exposure is measured. The strategy in ADH implicitly assumes homogeneity within manufacturing industries. The imputation factor in the shift-share strategy is the share of employees within a region working in each manufacturing industry. Hence, every worker contributes to the same extent to the degree of import exposure of their area, regardless of the nature of the tasks carried out in their jobs.

For instance, it can be taken the example of a company operating in any given manufacturing industry that has its workforce split in two establishments located in two different regions. The first region hosts the headquarters, with typically white collar workers carrying tasks related to executive, marketing, design or legal tasks. The second region hosts production facilities with typically blue collar workers doing hands-on-the-product jobs more directly related to the production process.

Then, it is less likely that the workforce in the first facility will be offshored or substituted by imports. However, as stated above, as long as all the workers are employed in the same manufacturing industry, they will be all contributing to the same extent to the measure of import competition exposure of their regions.

If the previous case is a general pattern, it would mean that the import exposure variable would be overestimating the actual exposure to trade in those highly educated regions. Of course, this is particularly relevant for the empirical analysis as long as the estimations would be under a clear attenuation bias.

I control for this effect including as a control the inteaction of ΔIPW with the share of workers in manufacturing with management occupations, reflecting the composition of the local manufacturing sector.

Imports Growth Acceleration

The second issue is that the growth of Chinese imports in the US accelerates in the period 2000-2007 with respect to 1990s decade. This means that the interaction between ΔIPW and the share of college-educated population in 1990 has a clear time trend by construction. Then, the estimation of its effect could include a spurious correlation between the interaction of interest and any dependent variable with a time trend. To address this problem, I include the interaction between the college variable and a time dummy.

Fully Interacted Specification

The third set of regressions includes additional interacted controls to isolate other potential channels that could be masked by the interaction of education and import competition. On the one hand, some controls are included because the share of workers in management occupations might not be enough to tackle the heterogeneity within manufacturing sectors. On the other hand, other controls are related to demographic or geographic factors. The fully augmented specification is then

$$\begin{aligned} \Delta Y_{t,i} &= \alpha_1 \cdot \Delta IPW^{US}_{t,s} + \alpha_2 \cdot College_{1990,i} + \beta \cdot \Delta IPW^{US}_{t,s} \cdot College_{1990,i} + \\ &+ \Gamma X_{1990} + \mathit{\Gamma} \cdot \Delta IPW^{US}_{t,s} \cdot X_{1990} + \epsilon_{t,i} \end{aligned}$$

I include the interaction between ΔIPW with the percentage of employment in routine occupations and with the average offshorability index of occupations. The reason is that the percentage of college-educated workers might not be enough to describe the difference in the real exposure to import competition.Also, these controls disjoin the effect of a larger share of college-educated workers in the region and the effect of the skill-biased technological change. As long as the rise in Chinese import competition and SBTC are contemporaneous, if the controls were not included, the interaction of interest would be just showing that more college-educated regions benefit more from technological progress.

Additionally, I include the interaction between ΔIPW and the percentage of foreign-born population, employment share among women and dummies for nine Census divisions. These three interactions match the three remaining controls in the fully expanded regressions in ADH and they are included to test the robustness of the analysis.

Concerning other demographic variables, I augment the model by including the interaction between ΔIPW and the population at the beginning of the period. The reason to do so is checking that the ability to adapt to and leverage out the effect of the growth in import competition does not come from a generic agglomeration force, but from the density of college-educated workers. Including this controls ensures that the relevant demographic variable is the share of population with a college degree rather than just the aggregate population. Given that big cities usually host a larger fraction of college-educated population, not including this control would give rise to a biased estimation.

As long as these additional controls are interactions including the growth in import exposure, I instrument them with the interaction of each of the variables and the instrument for the growth in import exposure.

Results

Skill Sorting

Table 2 shows the results concerning demographic variables: percentage growth of total, college-educated and noncollege-educated populaion, and the change in percentage points of the share of population with college education between 25 and 64 years. For each table, columns 1 repeat the results for the case with homogeneous effects of trade competition introducing the control for task heterogeneity within the manufacturing sector, as discussed above. Columns 2 introduce the results of the regressions augmented only with the interaction of the trade variable and prior level of college education. Columns 3 present the results of the fully augmented regressions.

Variables, except the two shown in the table, are demeaned by the national average. Then, the two estimators in the table can be interpreted as the intercept (Δ IPW) and the slope (ΔIPW $\cdot$College$_{90}$) of the predicted effect of the growth of exposure to Chinese import competition. This setting makes the estimates for Δ IPW in columns 1 not comparable with those in columns 2 and 3. Nonetheless, it allows, under the assumption that the rest of variables for each region are in the national average, a straightforward computation of the level of prior college education at which the effect of import competition changes its sign.

Differences among estimators in columns 2 and 3 are not statistically significant. Still, not including further controls in the regressions in columns 2 creates a negative bias in the estimation of the effect of the interaction between import competition and prior college education. Most of the bias disappears with the inclusion of the interaction between ΔIPW with total population. This result should be expected. The effect of import competition is, on average, negative regarding wages; then, if workers in larger metropolitan areas are more likely to migrate, an adverse shock will have a greater impact in terms of population. Besides, population size and the share of college-educated workers are positively correlated.

TABLE 2.Effects of import competition on skill sorting

	(1) Baseline	(2) College Interaction	(3) Full Controls	(1) Baseline	(2) College Interaction	(3) Full Controls
	Population (% Change)			College Educ. Sh. (pp Change)		
ΔIPW	0.063	-0.062	-0.112**	-0.074	-0.030***	-0.047***
	(0.421)	(3.939)	(4.981)	(0.092)	(0.980)	(2.918)
ΔIPW ·College_{90}		0.391	0.590**		0.189***	0.261***
		(0.245)	(0.260)		(0.063)	(0.077)
	College Educ. Pop (% Change)			No College Educ. Pop (% Change)		
ΔIPW	-0.014	-0.170***	-0.281***	-0.115	0.029	0.016
	(0.589)	(0.059)	(0.099)	(0.541)	(0.056)	(0.049)
ΔIPW ·College_{90}		1.083***	1.618***		-0.192	-0.330
		(0.376)	(0.530)		(0.358)	(0.254)

N=316 CZ x 2 observations. Robust standard errors are clustered by CZ

Models are weighted by start of the period region share of population share

The bottom left panel illustrates the consequences of breaking up the estimated effect of increasing import competition into an intercept and the interacted term with the level of education. Even if the average effect in column 1 is not significantly different from zero, outcomes are very different for regions with a high or a low share of college-educated workforce.

In column 3, the intercept is strongly and significantly negative, so the regression predicts adverse consequences regarding college population due to exposure to Chinese imports among regions with low level of college education. However, the positive estimator for the effect of the interacted variable implies that the predicted effect is attenuated, or even reversed, as regions have a more college-educated workforce. Indeed, among the most educated areas, higher exposure to Chinese import competition relatively increases the college-educated population.

To better illustrate the heterogeneity of effects of import competition I shall introduce the predicted difference in outcomes for three pairs of regions. The first pair consists of a high and a low-education commuting zones exposed to the median level of import penetration. The second pair are high-education regions, with difference in their growth of exposure to trade. Similarly, the third pair consists of two regions with low level of college education that differ in their level of growth of exposure to trade.

The first comparison takes two regions at the median level of growth of exposure to Chinese imports ($\sim$ \$1450/worker). The first one is at the 75th percentile of the education ranking in 1990, whereas the second one is at the 25th percentile. In this case, the more college-educated region will have a 6.99% faster population growth per decade, which accounts for 0.74 standard deviations of the dependent variable. The difference with college-educated population is larger. The number of college-educated workers will grow 19.18% faster per decade in the skill-intensive region; this magnitude is 1.45 standard deviations. The share of workers with college education in the skill-intensive region will increase 3.09 percentage points more per decade respect to the one in the low-educated region; this means a difference equal to 1.65 standard deviations.

On top of that, among highly educated areas, greater exposure to trade has actually positive effects for its college-educated workforce. To show it, I compare two regions in the 75th percentile of the college-education ranking in 1990. One of them is highly exposed to trade, at the 75th percentile of the distribution ($\sim$ \$2800/worker), whereas the other one is at the 25th percentile ($\sim$ \$800/worker).

The highly exposed region will have a 4.13% faster decadal population growth due to higher import higher competition than the one with little exposure. Concerning college-educated workers, it grows 16.53% per decade faster in the highly exposed region, which accounts for 1.25 standard deviations. The share of college-educated workers grows 2.35 percentage points more per decade in the highly exposed area; this is equivalent to 1.26 standard deviations.

Among regions with a low share of college-educated workers, the effect is the opposite. Comparing two areas in the 25th percentile of education raking in 1990, an area in the 75th percentile of exposure to trade loses 5.49% more of its population, the 9.85% of college-educated workers and the share of college-educated workers decreases by 1.9 percentage points per decade compared to a region in the 25th percentile of exposure to import competition.

The previous comparisons assumed that value of the controls for every commuting zone was on the national average. Certainly, this is not a realistic assumption, as discussed with the population example. Figures 1 and 2 show the total predicted effect of import competition on skill sorting. Those values are the sum of all the interactions of the variable of exposure to trade multiplied by the corresponding value. These figures show the plot against the share of college-educated population maintains a positive slope. Then, besides the proper causal effect, the correlation between the total predicted effect and the share of college education remains positive.

Migration

The growth of import competition has significant effects on the change of college-educated population. Table 3 shows that those changes reflect actual migration patterns of college-educated workers, rather than just changes in graduation rates. The regressions include the full set of controls. The dependent variables are the total migration flows as a fraction of the respective population groups. Thus, these estimators are comparable with those in Table 2.

TABLE 3.Effects of import competition on migration

	Full Controls		
	Net Migr.	Immigration	Outmigration
		Total Population	
ΔIPW	-0.033	-0.057	-0.024
	(0.059)	(0.068)	(0.049)
ΔIPW $\cdot$College$_{90}$	0.386	0.581**	0.195
	(0.281)	(0.281)	(0.254)
		College Educated	
ΔIPW	-0.140**	-0.242***	-0.102
	(0.069)	(0.087)	(0.081)
ΔIPW $\cdot$College$_{90}$	1.175***	1.629***	0.454*
	(0.332)	(0.540)	(0.253)
		Non College Educated	
ΔIPW	0.040	0.042	-0.002
	(0.064)	(0.062)	(0.053)
ΔIPW $\cdot$College$_{90}$	-0.005	0.018	0.023
	(0.310)	(0.335)	(0.273)

N=316 CZ x 2 observations. Robust standard errors are clustered by CZ

Models are weighted by start of the period region share of population share

The estimated effects from Table 3 show that most of the change in the educational composition of commuting zones is accounted by migration of college-educated workers. Highly-educated regions facing a larger import competition actually attract skilled workers, despite the tougher conditions for its manufacturing sector. Consistent with the assumptions in the theoretical model, the predicted effect of growth in exposure to import competition is significant only for college-educated workers.

These numbers show that the way in which large cities adapt to the rise of Chinese competition plays a pivotal role in The Great Divergence. Given the secular trend of migration of skilled workers to major cities, the fact that some metropolitan areas can leverage out the import competition shock to reallocate factors into more skill-intensive sectors makes them more attractive to college workers.

Finally, as long as workers are not specialized in the same sector, nor they have homogeneous skills, the reallocation argument is consistent with the fact that the combination of import competition and high college-education also mildly increases the number of college-educated outmigrants.

Wages and Skill Premium

Table 4 shows the results of regressions of the percentage change in average weekly wages for college and noncollege workers, and college premium. Changes in wages are discounted by one-third of the percentage growth of the median rental price in the commuting zone to account for changes in local housing prices. Change in college premium is defined as the difference of growth rates of college and noncollege wages. The structure is the same as in Table 2. Column 1 shows homogeneous effects, column 2 lists the regressions with only the interaction of ΔIPW and college education in 1990, and column 3 shows the results of the fully augmented regressions.

TABLE 4.Effects of import competition on wages and college premium

	(1) Baseline	(2) College Interaction	(3) Full Controls
	College Premium (p.p. change)		
ΔIPW	0.063	-0.180***	-0.147***
	(0.05)	(0.056)	(0.045)
ΔIPW $\cdot$College$_{90}$		0.894***	0.685***
		(0.274)	(0.186)
	Weekly Wage College Educated (% change)		
ΔIPW	-0.512***	-0.937***	-0.888**
	(0.133)	(0.271)	(0.442)
ΔIPW $\cdot$College$_{90}$		4.461***	4.258**
		(1.291)	(1.808)
	Weekly Wage Non College Educated (% change)		
ΔIPW	-0.575***	0.858*	0.671
	(0.030)	(0.441)	(0.409)
ΔIPW $\cdot$College$_{90}$		-4.478**	-2.588
		(2.126)	(1.677)

N=316 CZ x 2 observations. Robust standard errors are clustered by CZ

Models are weighted by start of the period region share of population share

Looking at columns 2 and 3, the regression with only the college interaction seems unbiased for wages of college-educated workers. Nonetheless, there is a negative bias in the regression of noncollege wages. Most of this bias is accounted by the interaction of the import competition variable and the share of routine-task intensive employment

Empirical evidence supports the predictions of the theoretical model. As in the case of demographic changes, there are substantial heterogeneous effects of the growth in import competition, but only concerning changes for college-educated workers.

The effects are significant comparing regions with different college intensity, but also when comparing regions with similar college intensity but different exposure to trade. I reproduce the same inter-regional comparisons than in the previous section. Taking two regions with a median level of exposure to trade, but with different levels of college education in 1990 (75th versus 25th percentile), wages for college-educated workers grow a 5.56% more in the skill-intensive area per decade, accounting for 0.53 standard deviations. Also, the college wage premium increases 8.12 percentage points more than in the low-educated region, equal to1 standard deviations.

Differential effects are also significant among highly-educated regions. Taking two areas in the 75th educational percentile, a commuting zone exposed to the 75th percentile of import competition has a 5.01% faster growth per decade than one at the 25th percentile of exposure. The wage premium grows 4.24 percentage points per decade, or 0.47 standard deviations, in the more exposed region due to the effect of import competition.

The comparisons among low educated regions draw the opposite sign. Low educated areas facing a large growth of import competition have a decrease of 1.93% in college wages and a relative decline of 6.93 percentage points in the college premium per decade than another low-educated but little-exposed region.

Figures 3 and 4 show the plot against the share of college-educated workers in 1990 of the total predicted effects of import competition on college wages and skill premium.

Trade Competition and Innovation

In the previous section I showed that the joint effect of import competition and prior skill intensity has a positive and significant effect for the skill premium as well as for the skill sorting. In the current section I show some preliminary evidence that the driving force the previous facts is a skill-oriented sectoral change, analyzing the third testable hypothesis.

Patents per capita

The first dependent variable to proxy for skilled biased change is the variation in number of patents per capita. I take data from U.S. Cluster Mapping Project, HBS (2014). Data of patents comes from the US Patents and Trademark Office, it is fractionated by the number of inventors and they are geographically assigned according to the location of the inventors.

STEM intensive employment

I compute the change in employment in STEM-intensive sectors in the CZ and the overall growth in STEM intensive occupation. I define a sector as STEM intensive when at least the 30% of the jobs in the sector require proficiency in science, technology, engineering or maths as measured by the O*Net database. For instance, according to this definition, sectors labeled as STEM intensive account for roughly the 20% of employment in 1990.

TABLE 5.Effects of import competition oninnovation and sectoral change

	(1)	(2)	(3)
	Baseline	College Interaction	Full Controls
	Patents per capita (per 1.000)		
ΔIPW	-0.0175	-0.060	-0.049
	0.304	0.042	0.030
ΔIPW $\cdot$College$_{90}$		0.367**	0.333**
		0.173	0.134
	Employment in STEM-intensive sector (pp. change)		
ΔIPW	-0.137	-0.660**	-0.412*
	0.191	0.301	0.227
ΔIPW $\cdot$College$_{90}$		0.280**	0.181**
		0.125	0.074
	STEM Employment (% growth)		
ΔIPW	-0.294	-0.445***	-0.379***
	1.031	0.162	0.124
ΔIPW $\cdot$College$_{90}$		1.872***	1.618***
		(0.678)	(0.531)

N=316 CZ x 2 observations. Robust standard errors are clustered by CZ

Models are weighted by start of the period region share of population share

The size of the effect is in line with previous regressions. Among regions in the median of exposure to import competition, commuting zones at the 75th educational percentile create 0.0462 patents per capita (0.62 standard deviations) due to growth of import competition. They reallocate 3.53 percent more of their workforce into STEM-intensive industries (0.7 standard deviations), and the growth in STEM-related occupation is 24.9% faster per decade (1.09 standard deviations) than commuting zones in the 25th percentile of the education ranking.

Conclusions

The main conclusion of this work is that the effects of import competition over wages, skill premium and skill sorting are significantly heterogeneous among regions depending on their share of college-educated population prior to the trade shock.

The average negative effect of import competition over college-educated wages is attenuated in skill-intensive regions. In some cases, the overall effect actually turns positive. Import competition has a uniformly negative effect on noncollege-educated wages. Consequently, the joint effect of import competition and college-educated population is positive over the skill premium, driven by the changes above in wages for college-educated workers.

Import competition has no effect on average over the absolute growth, migration or the share of college-educated population, but the effect is positive for skill-intensive regions and negative for the nonskill-intensive ones.

Finally, as a driving channel for the previous findings, regions that are already highly educated, and face import competition reallocate relatively more their workforce towards STEM-intensive sectors and increase the number of patents per capita.

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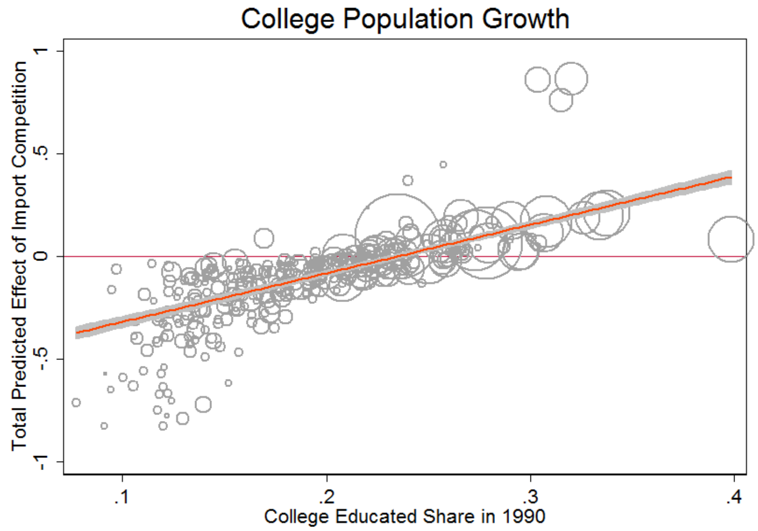

Figure 1: Total predicted decadal effect of rise in import competition

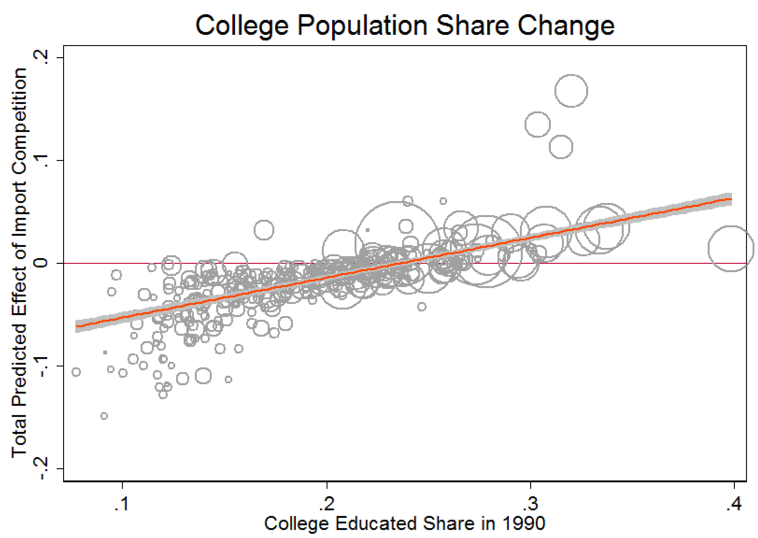

Figure 2: Total predicted decadal effect of rise in import competition

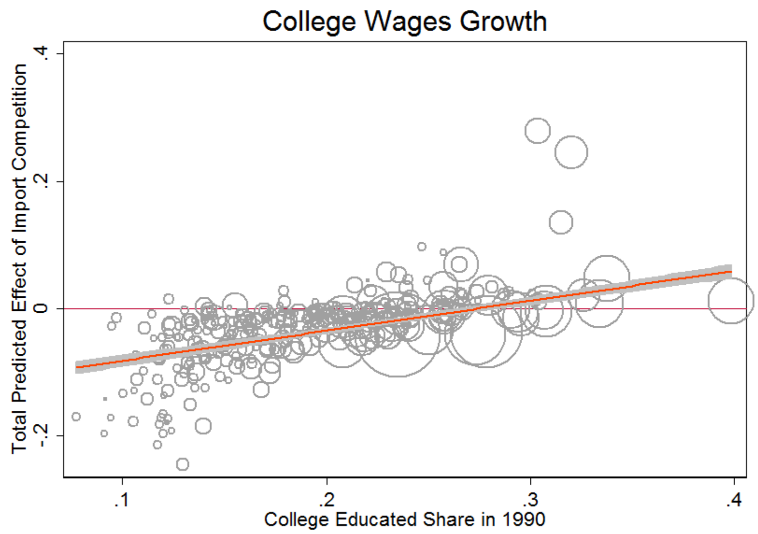

Figure 3: Total predicted decadal effect of rise in import competition

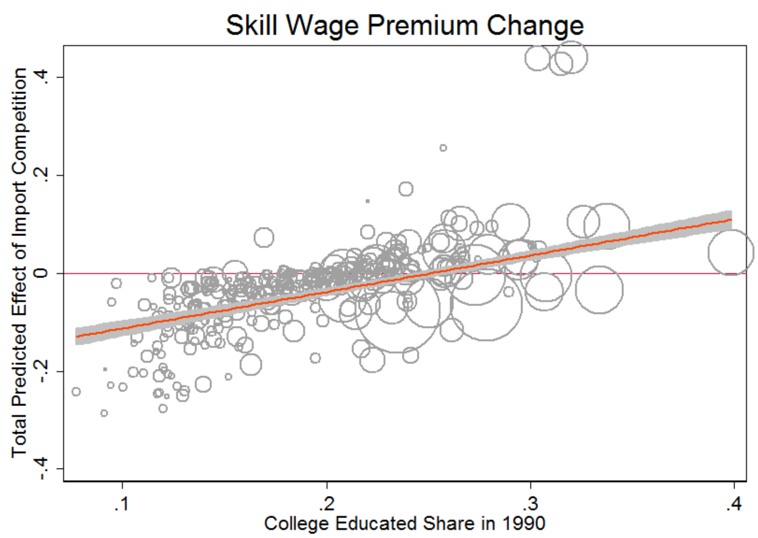

Figure 4: Total predicted decadal effect of rise in import competition