Trade, Migration, and Inequality: An Analysis of China

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Preliminary, Comments Welcome

Abstract

China's profound trade liberalization has been linked with large employment changes around the world. However, the study of Chinese labor market responses to trade liberalization is a relatively less explored topic. Using data from CHIP (Chinese Household Income Project), this paper aims to fill this gap by estimating the effects of trade liberalization on Chinese local labor markets. In addition, it investigates changes in urban to rural wage inequality and skill premium in urban and rural areas separately with the availability of surveys conducted in urban and rural households. In the model, I use a dynamic general equilibrium framework with heterogeneous firms, heterogeneous workers and internal migration to study the impact of policy-generated trade cost reduction and easing of migration restrictions on Chinese wage inequality. I focus on the role of labor mobility that characterizes the large rural-to-urban migration in the midst of trade liberalization in shaping skill premium and urban to rural wage inequality.

1 Introduction

In the early 2000s, there were two policies in China that left far-reaching effects on both of its domestic economy and the global economy. First is China's profound trade liberalization, which culminated with its WTO accession in 2001 and has been linked with large employment changes around the world. [1] Second is the easing of migration restrictions, which generated an internal migration with a size of perhaps the largest flow of migration recorded in world history. However, the study of Chinese labor market's responses to trade liberalization is a relatively less explored topic. Moreover, little work has been done, examining the impact

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[1] According to International Labour Organization, the flow of workers across regions within China represents one of the most extensive migration in human history. In 2015 a total of 277.5 million migrant workers (36% of the total workforce of 770 million) existed in China.

of China's expansion of both international trade and internal migration on Chinese local labor market. This paper aims to bridge this gap by investigating these three questions: How does China's trade liberalization affect its own wage inequality? What role does rural to urban migration play in China's skill premium and rural-urban inequality? How does China's domestic labor market reform regarding migration policy interact with its trade liberalization policies in shaping China's export growth and inequality?

In exploring these questions, this paper uses a two-country dynamic general equilibrium model with internal labor migration within country to study the adjustments of wage inequality in response to trade liberalization and migration cost reduction. The combination of these two policies, one aiming at promoting international trade openness, the other targeting at internal labor market reform that mobilizes labor across regions, contributed to huge growth in China's exports and productivity. It also has large impacts on wage inequality across workers in various scopes: skill premium at the aggregate level, skill premium within the rural area and that within the rural area, as well as urban to rural wage inequality. This paper looks into changes of these three different measures of wage inequality in China and examines the channels through which increasing trade openness and labor mobility interact and affect these wage inequality measures.

On the migration policy side, in 1958, China established a household registration system known as the *hukou* system to control population mobility. Each Chinese citizen is assigned a *hukou* (registration status), classified as "non-agricultural (urban)" or "agricultural (rural)" in one's local administrative unit. In order to change the status of *hukou,* individuals need to get approvals from local governments, which are extremely difficult to obtain. The prohibition of working outside one's *hukou* location or category was prohibited was relaxed in the 1980s but, prior to 2003, workers without local *hukou* still had to apply for a temporary residence permit. It was however, still very difficult to get. In sum, before the early 2000s, barriers and frictions imposed on migration across regions within China remained immensely high. Starting early 2000s, the demand for migrant workers in labor-intensive industries hiked with China's productivity growth and export surge. As a consequence, many provinces eliminated the requirement of temporary residence permit for migrant workers after 2003. There was also a nationwide reform in that same year that accelerated the process for getting a temporary residence permit in other provinces. These policy changes greatly reduced the barriers faced by migrant workers and spawned large migration flows from the rural area to the urban area and also from lower-paid poorer regions to more developed, industrialized and open regions. Tombe and Zhu (2019)estimates that between 2000 and 2005, migration costs did indeed decline by 29 percent on average. Despite the reforms, the costs of being a migrant worker remain high because of limited access to local public services, health care and educational system.

Motivated by these stylized facts, the paper employs a two-country dynamic model featuring internal migration from the rural area to the urban area. The model consists of two countries, Home (H) and Foreign (F). Home is interpreted as China and Foreign can be one of its trade partner. The non-agricultural sector which is housed in the urban area is more skill-intensive than the agricultural sector in the rural area. In the home country, the rural area is endowed with unskilled workers $\bar{L}_{ag,t}$ and skilled workers $\bar{S}_{ag,t}$, whereas the urban area is endowed with $\bar{L}_{na,t}$ unskilled workers and skilled workers $\bar{S}_{na,t}$. Workers with rural *hukou* draw idiosyncratic migration cost and self select into working in the city, which is motivated by China's huge flow of rural to urban migration. There are two sectors of production. The rural area produces agricultural goods while the urban area produces non-agricultural goods. The agricultural goods are consumed by domestic household and are thus non-tradable. The non-agricultural goods are tradable – they are consumed both domestically and exported to the foreign country.

The model is calibrated to match with changes in migration cost, trade cost and productivity increase in the tradable sector and analyzes the impulse responses of different measures of wage inequality and other variables in the home and foreign country in responses to these shocks. The findings of the paper show that migration cost reduction is associated with a fall in urban to rural wage inequality but widening of skill premium in both agricultural sector and non-agricultural sector , as well as in the aggregate level. However, negative trade cost shock and positive productivity shock in the tradable sector each leads to increase in all three measures of wage inequality. The results are consistent with the findings of Li et al. (2013) which show that wage inequality increased post 2000.

The mechanisms driving the changes in wage inequality are rather different across different shocks. First, migration cost reduction affects variables by changing the relative payoffs across sectors, without directly impacting the demand side like productivity. It increases migration cost cutoff for both unskilled and skilled rural workers. Unskilled workers' wage in the non-agricultural sector $w^l_{na,t}$ goes down as there are more unskilled workers working the urban non-agricultural sector. Increase of unskilled migration exceeds that of skilled migration. Price of domestic non-agricultural good decreases due to lower cost of production, giving rise to more exports. On the contrary, both skilled and unskilled wage in the rural area increases due to a lower level of total labor remaining there. Urban to rural wage inequality decreases as urban wages fall relative to rural wages. However, skill premium in both the urban area and the rural area, as well as the aggregate level increase. This is consistent with Feenstra (2011), which states that the rural-urban migration might be a key factor driving the export-led growth in Chinese cities. It infers that this migration keeps wage growth suppressed and allows China to maintain its comparative advantage in the non-agricultural sector (e.g. manufacturing).

Second, trade cost reduction affects variables by lowering the price of home exports and thus boosting demand for home non-agricultural exports. As the demand for labor in the non-agricultural sector builds up, wages of skilled and unskilled workers in that sector climb up too. Therefore, migration cost cutoffs increase, generating larger migration flow into the non-agricultural sector. Meanwhile, with diminished labor supply in the agricultural sector, skilled and unskilled wage in the rural area also go up, putting upward pressure on the price of agricultural good as well. Thus, wages of skilled and unskilled workers in both the urban area and the rural area increase. Urban to rural wage inequality expands because wage increments in the urban area more than offsets that in the rural area. Sectoral skill premium and country-level skill premium widen.

Third, a positive non-agricultural sector productivity shock increases migration cutoffs for rural skilled and unskilled workers through increasing wages in the non-agricultural sector, making migration more rewarding. All three measures of wage inequality rises. Urban-rural wage gap broadens because productivity growth in the urban area boosts the relative wages compared to the rural area. Skill premium in the sector level and aggregate level all go up. Productivity growth in the non-agricultural sector lowers the marginal cost of production, tapering price of the non-agricultural good produced at home. Meanwhile, it contracts the agricultural sector, leading to less demand of labor in production of the agricultural good and thus a downward pressure on wages in the agricultural sector.

1.1 Related Literature

My paper contributes to two broad literature.

First, my paper also contributes to the recent international macroeconomics literature that study labor migration. In the context of DSGE models, examples include Mandelman and Zlate (2012), Mandelman and Zlate (2016) and Lechthaler and Mileva (2019). My work is closely related to Lechthaler and Mileva (2019), which develops a dynamic version of Bernard et al. (2007) along the line of Ghironi and Melitz (2005) and adds low-skilled workers training to become high-skilled workers and labor adjustment costs across sectors to study the effect of trade liberalization on wage inequality. While Lechthaler and Mileva (2019) features labor mobility between two sectors, they do not study the effect of migration cost reduction on wage inequality, which is a key focus of my paper. This paper is closely related to Mandelman and Zlate (2016), which examines the macroeconomic effects of border enforcement and the transmission of aggregate shocks across countries in the presence of labor migration and remittances using a two-country business cycle model. My paper studies internal migration rather than immigration across borders and focuses on the interaction between internal migration and trade liberalization on wage inequality.

Second, although there has been a growing literature that examines the impact of the China shock, most of them focus on the labor market effects on developed countries. Papers studying the effects of the China shock on the U.S. labor market include Asquith et al. (2019), Autor et al. (2013), Autor et al. (2016), Feenstra et al. (2019),Pierce and Schott (2016). Hummels et al. (2014) quantifies the impact of firms' offshoring to China on Danish workers' wages. Cabral et al. (2018) looks at the Portuguese labor market's responses to competing with Chinese imports. Rodriguez-Lopez and Yu (2017) investigates Chinese firm-level employment changes following China's trade liberalization. However, it does not feature migration and thus abstract from the role of migration on trade and labor market adjustment.

My paper is also related to the literature linking international trade and internal migration. For instance, Dix-Carneiro and Kovak (2015) finds support of the amplifying role of interregional migration on trade liberalization's effects on the slow path of Brazilian local labor market adjustment. Some examples of empirical papers investigating trade's effect on internal migration include Aguayo-Tellez et al. (2010), Hering and Paillacar (2016) and Morten and Oliveira (2018) for Brazil, and McCaig and Pavcnik (2018) for Vietnam.

2 Theoretical Model

The model consists of two countries, Home (H) and Foreign (F). The non-agricultural sector which is housed in the urban area is more skill-intensive than the agricultural sector in the rural area. In the home country, the rural area is endowed with unskilled workers $\bar{L}_{ag,t}$ and skilled workers $\bar{S}_{ag,t}$, whereas the urban area is endowed with $\bar{L}_{na,t}$ unskilled workers and skilled workers $\bar{S}_{na,t}$. There is one way migration occurring in the home country: workers with rural *hukou* draw idiosyncratic migration cost and self select into working in the city, which is motivated by China's huge flow of rural to urban migration. There are two sectors of production. The rural area produces agricultural goods while the urban area produces non-agricultural goods. [2] The agricultural goods are consumed by domestic household and are thus non-tradable. The non-agricultural goods are tradable – they are consumed both domestically and abroad. The foreign economy is symmetric with the exception that there is no migration modeled.

[2] See, e.g., Tombe and Zhu (2019).

2.1 Production, trade and goods prices

There are two areas in the economy: the rural area and the urban area . There are two sectors: the agricultural sector and the non-agricultural sector. The former is housed in the rural area and the latter is in the urban area.[3]

2.1.1 Home output

Production of both the agricultural and non-agricultural goods $Y_{ag,t}$ and $Y_{na,t}$ require both skilled and unskilled labor working in those two sectors. The output of each sector is $Y_{j,t} = Z_{j,t}[S_{j,t}]^{\eta_j}[L_{j,t}]^{1-\eta_j}$, where $j = ag, na$. $S_{j,t}$ is total skilled labor in sector j, $L_{j,t}$ is total unskilled labor in sector j, $Z_{j,t}$ is sector-specific productivity. η_j is the sector specific cost share of skilled labor, and more specifically, production of the non-agricultural good is more skill-intensive than the agricultural good: $\eta_{na} > \eta_{ag}$. Since there is no heterogeneity in worker productivity within one type of labor, all unskilled workers are paid the same wage $w^l_{j,t}$ and all skilled workers are paid $w^s_{j,t}$ in the same sector j.

Relative labor demand can be described by the following condition:

$$\frac{w^s_{j,t}}{w^l_{j,t}} = \frac{\eta_j}{1-\eta_j}\frac{L_{j,t}}{S_{j,t}},$$

which indicates that relative demand for labor is independent of sectoral productivity and is solely determined by the relative wages paid in that sector. The condition implies that the ratio of the skilled real wage to the unskilled real wage in sector j is equal to the ratio of the marginal contribution of each type of labor input into producing one extra unit of output.

2.1.2 Urban area tradable sector

The urban area produces non-agricultural industrialized goods, which are tradable. Production of the non-agricultural goods takes the form of $Y_{na,t} = Z_{na,t}[S_{na,t}]^{\beta_{na}}[L_{na,t}]^{1-\beta_{na}}$. The price for non-agricultural goods produced at home is equal to marginal cost of production, $p_{na,t} = \frac{\left(w^s_{na,t}\right)^{\beta_{na}}\left(w^l_{na,t}\right)^{\beta_{na}}}{Z_{na,t}}$, where $w^s_{na,t}$ is the real wage paid for skilled workers and $w^l_{na,t}$ is the real wage paid for unskilled workers in the agricultural sector.

The home non-agricultural good is used both domestically and abroad: $Y_{na,t} = Y_{na,h,t} + Y^*_{na,h,t}$, where $Y_{na,h,t}$ denotes the domestic use of the home non-agricultural good, and $Y^*_{na,h,t}$ denotes exports to the foreign country. Consumption basket of the non-agricultural goods

[3] Such production structure follows Tombe and Zhu (2019).

are composites of the home and foreign goods:

$$C_{na,t} = \left[\omega^{\frac{1}{\mu}} \left(Y_{na,h,t}\right)^{\frac{\mu-1}{\mu}} + (1-\omega)^{\frac{1}{\mu}} \left(Y_{na,f,t}\right)^{\frac{\mu-1}{\mu}}\right]^{\frac{\mu}{\mu-1}},$$

where $Y_{na,f,t}$ denotes the imports of home from foreign.

The demand functions for the home and foreign non-agricultural goods are:

$$Y_{na,h,t} = \omega \left(p_{na,h,t}\right)^{-\mu} C_{na,t}, \text{and}$$

$$Y_{na,f,t} = (1-\omega) \left(p_{na,f,t} \tau Q_t\right)^{-\mu} C_{na,t},$$

where $p_{na,h,t}$ and $p_{na,f,t}Q_t$ are the prices of the home and foreign non-agricultural goods expressed in units of the home consumption basket. Thus, the demand ratios for domestic use and exports is: $\frac{Y_{na,t}-Y^*_{na,h,t}}{Y_{na,f,t}} = \frac{\omega}{1-\omega}\left(\frac{p_{na,h,t}}{p_{na,f,t}Q_t\tau}\right)^{-\mu}$. Set the price index for the non-agricultural good in the home country to be numeraire: $1 = \omega \left(p_{na,h,t}\right)^{1-\mu} + (1-\omega)\left(p_{na,f,t}\right)^{1-\mu}$.

2.1.3 Rural area non-tradable sector

The rural area specializes in production of agricultural goods and are consumed by the domestic household, thus are non-tradable. The output of the agricultural sector: $Y_{ag,t} = Z_{ag,t}[S_{ag,t}]^{\beta_{ag}}[L_{ag,t}]^{1-\beta_{ag}}$. The price for agricultural goods, $P_{ag,t} = \frac{\left(w^s_{ag,t}\right)^{\beta_{ag}}\left(w^l_{ag,t}\right)^{\beta_{ag}}}{Z_{ag,t}}$, where $w^s_{ag,t}$ is the real wage paid for skilled workers and $w^l_{ag,t}$ is the real wage paid for unskilled workers in the rural area.

2.2 Home households

Each economy consists of one large representative household, which maximizes the presented discounted value of utility function:

$$E_t\left[\sum_{s=t}^{\infty} \beta^{s-t}\left(\frac{C_s^{1-\gamma}}{1-\gamma}\right)\right],$$

where $\beta \in (0,1)$ is the subjective discount factor, C_t is aggregate consumption, and $\gamma > 0$ is the inverse of the inter-temporal elasticity of substitution. Following Andolfatto (1996), Merz (1995) and much of the subsequent literature, I assume that all workers in the home country are members of this large household which pool income. This implies the distribution of labor income can be ignored for consumption decision. The budget constraint the household faces is:

$$\tilde{\pi}_t^l \bar{L}_t + \tilde{\pi}_t^s \bar{S}_t + (1 + r_t)B_t + (1 + r_t^*)B_{*,t} + T_t = C_t + B_{t+1} + Q_t B_{*,t+1} + \frac{\xi}{2} B_{t+1}^2 + \frac{\xi}{2} Q_t B_{*,t+1}^2.$$

The household spends its income on purchases of international risk-free real home bonds and foreign bonds denominated in the home currency B_{t+1} and $B_{*,t+1}$. Following Turnovsky (1985), the assumption of bond holding adjustment is made. The cost of adjusting home bond is $\frac{\xi}{2} B_{t+1}^2$ and the cost of adjusting foreign bond is $\frac{\xi}{2} Q_t B_{*,t+1}^2$ where ξ is a scalar. The household obtains income from interest on its holdings of home bonds $(1 + r_t)B_t$ and foreign bonds $(1 + r_t^*)B_{*,t}$, where r_t (r_t^*) is the rate of return of home (foreign) bonds. $Q_t = \frac{P_t^* \epsilon_t}{P_t}$ is the consumption based real exchange rate where ϵ_t is the nominal exchange rate. The household also receives total net labor income $\tilde{\pi}_t^l$ and $\tilde{\pi}_t^s$ from supplying unskilled and skilled labor. $\tilde{\pi}_t^l$ is the average net labor income of unskilled workers, $\tilde{\pi}_t^s$ is the average net labor income of skilled workers, which are to be discussed in details in section 2.4. In equilibrium, $T_t = (\xi/2)\left(B_{t+1}^2 + Q_t B_{*,t+1}^2\right)$.

The Euler equations for home bond holdings and foreign bond holdings are:

$$1 + \xi B_{t+1} = \beta \left(1 + r_{t+1}\right) E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \right], \text{and}$$

$$1 + \xi B_{*,t+1} = \beta^* \left(1 + r_{t+1}^*\right) E_t \left[\left(\frac{Q_{t+1}}{Q_t} \right) \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\gamma} \right].$$

The consumption basket C_t aggregates the agricultural consumption goods $C_{ag,t}$ and non-agricultural consumption goods $C_{na,t}$ in Cobb-Douglas fashion:

$$C_t = (C_{ag,t})^{\alpha} (C_{na,t})^{1-\alpha},$$

which comprises consumption of non-tradable agricultural goods $C_{ag,t}$ and tradable non-agricultural goods $C_{na,t}$. α is the share of agricultural good in the consumption basket. From household's expenditure minimization problem, relative demand functions for the two goods follow as:

$$C_{ag,t} = \alpha \frac{P_t}{P_{ag,t}} C_t, \text{and}$$

$$C_{na,t} = (1 - \alpha) \frac{P_t}{P_{na,t}} C_t.$$

The consumer price index is: $P_t = \left(\frac{P_{ag,t}}{\alpha}\right)^{\alpha} \left(\frac{P_{na,t}}{1-\alpha}\right)^{1-\alpha}$. No investment demand exists in this version of the model. By definition, $C_{ag,t} = Y_{ag,t}$. The consumption basket of non-agricultural good has been defined in section 2.1.2 as $C_{na,t} = \left[\omega^{\frac{1}{\mu}} \left(Y_{na,h,t}\right)^{\frac{\mu-1}{\mu}} + (1-\omega)^{\frac{1}{\mu}} \left(Y_{na,f,t}\right)^{\frac{\mu-1}{\mu}}\right]^{\frac{\mu}{\mu-1}}$.

2.3 Home rural workers' migration decision

Each worker is registered to either an agricultural or a non-agricultural *hukou*. There are $\bar{L}_{na,t}$ unskilled workers and $\bar{S}_{na,t}$ skilled workers with *hukou* in the urban area, and $\bar{L}_{ag,t}$ unskilled workers and $\bar{S}_{ag,t}$ skilled workers with *hukou* in the rural area. Rural workers can choose to move to the city, but doing so implies a positive migration cost, which is represented by a common cost variable X_t that all skilled and unskilled migrant workers face and an idiosyncratic $\varepsilon^i \in [1, \infty)$ $(i = l, s)$. Skilled rural workers draw their migration cost ε^s from a common distribution $G(\varepsilon^s)$, and unskilled rural workers draw their cost ε^l from a different distribution $G(\varepsilon^l)$. The migration cost can be interpreted similarly as iceberg trade cost. When rural workers move to the city, a certain portion of their value $\pi^i_{m,t}$ $(i = l, s)$ in the city "melts" away, so that $\frac{1}{X_t \varepsilon^l}$ is left. When there is a negative migration cost shock that lowers X_t, migrant workers' value of working in the city increases. Since skilled and unskilled rural workers face similar rural to urban mobility decisions, it suffices to describe the decision of rural unskilled workers. Analogous equations hold for skilled workers in the rural area. Migration costs are flow costs that workers incur in each period that they work as migrant worker in the city. Following the same spirit of Tombe and Zhu (2019), migration cost is modeled as ongoing cost rather than sunk cost because of the recurring nature of costs that migrants in China have to pay working in the city under the unique *hukou* system (e.g. restricted access to local educational and medical resources, social welfare, employment benefits, etc).

An unskilled rural worker decides to migrate to the city if the net labor income earned in the non-agricultural sector (wage income subject to migration cost) is higher than the labor income earned from staying at the agricultural sector in the rural area: $\frac{w^l_{na,t}}{X_t \varepsilon^l_{na,t}} > w^l_{ag}$. Define rural workers' net labor income as $\pi_{j,t}$, then the migration decision can be rewritten as: $\pi_{na,t} > \pi_{ag,t}$. If the worker chooses to migrate to work in the non-agricultural sector in the urban area, he needs to pay the migration cost ε^l that he drew. Thus, $\pi^l_{na,t} = \frac{w^l_{na,t}}{X_t \varepsilon^l_{na,t}}$. However, if he decides to remain in the rural area, he would not pay such cost, earning full wage rate at the agricultural sector: $\pi_{ag,t} = w^l_{ag}$.

Every period, the rural worker with idiosyncratic migration cost level ε^l compares the net return of remaining working in the rural area and that of moving to the city to work in the non-agricultural sector. Given the migration cost he faces, If $w^l_{ag,t} > \frac{w^l_{na,t}}{X_t \varepsilon^l_{na,t}}$, he would decide to remain in the rural area and continue to work in the agricultural sector because it pays more than the non-agricultural wage discounted by the specific migration cost he needs to pay. However, if $\frac{w_{na,t}^l}{X_t \varepsilon_{na,t}^l} > w_{ag}^l$, he chooses to become a migrant worker and works in the non-agricultural sector in the city. In the next period, if the worker still finds it pays out more to continue to be a migrant worker, he still needs to pay the cost ε^l. Since there is no sunk cost of migration, and that per-period migration cost ε^l works like a flow cost that rural workers need to pay whenever they choose to be migrant workers working in the urban area, workers' migration decision is merely a static decision. It is a decision that workers make every period, evaluating the net payoffs of working in the two areas in the current period.

A threshold, $\bar{\varepsilon}_t^l$, for which a worker is indifferent between moving and not moving to the city can be defined as: $\bar{\varepsilon}_t^l = \frac{1}{X_t}\left(w_{na,t}^l - w_{ag,t}^l\right)$. Share of different categories of unskilled workers can be pinned down by $\bar{\varepsilon}^l$. Rural unskilled workers with idiosyncratic migration cost below the threshold will self select into migration whereas those with cost above the threshold will find net labor income earned in the city lower than that in the rural area and therefore choose to stay.

The migration cost cutoff $\bar{\varepsilon}_t^l$ responds to fluctuations in the relative cost of labor across regions, and thus affects migration flow and labor supply in the rural area and the urban area. When there are exogenous shocks that change the payoffs (wages) in the two regions, the migration cutoff will be affected. For any given level of rural-worker-specific migration cost, a relatively higher wage in the city implies higher net labor income, and therefore leads to a larger fraction of migrant workers in equilibrium. For instance, if there is a positive productivity shock happening in the non-agricultural sector which increases $Z_{na,t}$, wages in the urban non-agricultural sector w_{na} rises, increasing the cost cutoff $\bar{\varepsilon}_t^l$. It makes more rural workers to find it more profitable to work in the city, leading to a larger wave of rural to urban migration.

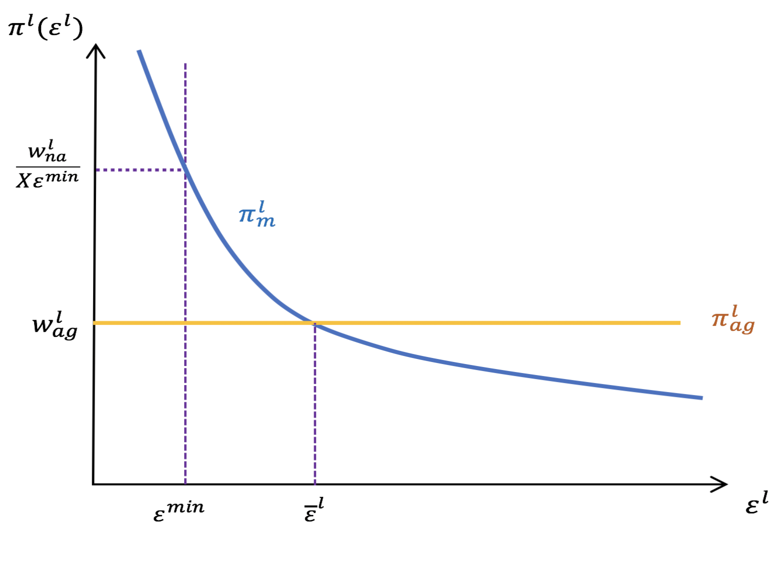

Figure 1: The migration cost cutoff.

In equilibrium, the existence of productivity cutoff $\bar{\varepsilon}_t^l$ requires a cross-country asymmetry in the cost of effective labor, which ensures that some of the rural workers have an incentive to work in the city. To illustrate this point, fig.**??** plots the two sets of net labor income for unskilled rural workers as functions of the idiosyncratic migration cost ε^l over the support interval $[\varepsilon_{min}, \infty)$, with $\pi_{ag,t}^l = w_{ag,t}^l$, $\pi_{m,t}^l = \frac{w_{na,t}^l}{X_t \varepsilon^l}$. The net income function from migrating is steeper than the net income function from staying in the countryside $slope\{\pi_{m,t}^l\} > slope\{\pi_{ag,t}^l\}$ as $\frac{w_{na,t}^l}{X_t\left(\varepsilon^l\right)^2} > 0$. Therefore, to ensure that the cost cutoff $\bar{\varepsilon}_t^l$ exists in equilibrium, the net payoff at ε_{min} must be greater than w_{ag}^l, which implies that $\frac{w_{na,t}^l}{X_t \varepsilon_{min}} > w_{na}^l$ at all times. Same applies to $\bar{\varepsilon}_t^s$, the condition that $\frac{w_{na,t}^s}{X_t \varepsilon_{min}} > w_{na}^s$ must be satisfied. The model calibration and the magnitude of exogenous shocks ensure that these conditions are satisfied every period. The graph visually shows that becoming a migrant worker generates larger net payoff than remaining in the rural area for the subset of workers with idiosyncratic cost ε^i in the interval $(\varepsilon_{min}, \bar{\varepsilon}_t^i)$.

2.4 Worker averages and distributions

Assume the worker-specific labor migration cost for skilled workers ε^s are random draws from a common Pareto distribution $G(\varepsilon^s)$ with density $g(\varepsilon^s)$. Therefore, migrant workers are heterogeneous in the sense that they face heterogeneous costs of migration. All the information about $G(\varepsilon^s)$ that is relevant for aggregate outcomes can be summarized by means of average cost levels, as in average productivity levels in Melitz (2003). The average cost level for workers whose migration cost fall below the threshold can be defined as: $\tilde{\varepsilon}_{m,t}^l = \left[\frac{1}{G(\bar{\varepsilon}_t^l)} \int_{\varepsilon_{min}^l}^{\bar{\varepsilon}_t^l} \left(\varepsilon^l\right)^{-1} g(\varepsilon^l) d\varepsilon^l\right]$. The average net labor income for unskilled rural migrant worker is $\tilde{\pi}_{m,t}^l = \pi_{m,t}^l\left(\tilde{\varepsilon}_{m,t}^l\right) = \frac{w_{na,t}^l}{X_t \tilde{\varepsilon}_{m,t}^l}$, whereas the average net labor income for rural workers who choose to remain in the rural area is $\pi_{ag,t}^l = w_{ag,t}^l$. For urban workers who do not face the mobility decision, their net labor income is just their wage income working in the non-agricultural sector $\pi_{na,t}^l = w_{na,t}^l$. The intuitions for the net labor income for these three types of workers ($L_{na,t}$, $L_{ag,t}$ and $L_{m,t}$) are the following: because of the assumption that there is no heterogeneity across unskilled workers with urban *hukou*, native unskilled workers in the urban area all face the same wage. Similarly, for unskilled workers in the rural area who choose to stay in the rural area, they do not pay the actual migration costs and are thus ex-post homogeneous. Therefore, they are also paid the same wage. For rural migrant workers, they are paid the same wage rate as the native unskilled workers with urban *hukou,* which means they are ex-post homogeneous too in terms of the wage they are paid. However, since they paid the migration cost when they selected into moving to work in the urban area, their net labor income are different though since the migration costs are idiosyncratic.

Every period, after rural workers make their migration decision and pay corresponding costs if they choose to move to the city, there will be $L_{ag,t}$ workers working in the rural area and $L_{na,t}$ workers working in the urban area, with $L_{ag,t} = \bar{L}_{ag,t} - L_{m,t}$ and $L_{na,t} = \bar{L}_{na,t} + L_{m,t}$. Average worker return is expressed as the average between net labor income earned by workers working in the urban area and those working in the rural area, weighted by the share of these different workers:

$$\tilde{\pi}_t^l = \frac{L_{na,t}}{L_t}\tilde{\pi}_{na,t}^l + \frac{L_{ag,t}}{L_t}\tilde{\pi}_{ag,t}^l,$$

where $\tilde{\pi}_{na,t}^l = \frac{\bar{L}_{na,t}}{\bar{L}_{na,t}+L_{m,t}}\pi_{na,t}^l + \frac{L_{m,t}}{\bar{L}_{na,t}+L_{m,t}}\tilde{\pi}_{m,t}^l$ and $\pi_{ag,t}^l = w_{ag,t}^l$. Since $L_{na,t} = \bar{L}_{na,t} + L_{m,t}$, and $L_{ag,t} = \bar{L}_{ag,t} - L_{m,t}$, average worker net labor income can be expressed as $\tilde{\pi}_t^l = \frac{\bar{L}_{na,t}}{\bar{L}_t}w_{na,t}^l + \frac{L_{m,t}}{\bar{L}_t}\tilde{\pi}_{m,t}^l + \frac{\bar{L}_{ag,t}-L_{m,t},}{\bar{L}_t}w_{ag,t}^l = \frac{\bar{L}_{na,t}}{\bar{L}_t}w_{na,t}^l + \frac{\bar{L}_{ag,t}}{\bar{L}_t}w_{ag,t}^l + \frac{L_{m,t}}{\bar{L}_t}\left(\tilde{\pi}_{m,t}^l - w_{ag,t}^l\right)$.

The distribution of workers can be written as the following: $\frac{L_{m,t}}{\bar{L}_{ag,t}} = G(\bar{\varepsilon}_t^l)$ and $\frac{L_{ag,t}}{\bar{L}_{ag,t}} = 1 - G(\bar{\varepsilon}_t^l)$. This implies that $\frac{L_{m,t}}{\bar{L}_t} = \frac{L_{m,t}}{\bar{L}_{ag,t}}\frac{\bar{L}_{ag,t}}{\bar{L}_t} = G(\bar{\varepsilon}_t^l)\frac{\bar{L}_{ag,t}}{\bar{L}_t}$. If the migration cost distributions are assumed to be exponential with rate parameter λ, then $\frac{L_{m,t}}{\bar{L}_{ag,t}} = G(\bar{\varepsilon}_t^l) = \left(\bar{\varepsilon}_t^l\right)^{-k}$. Substituting the distribution information and the expression of the share of unskilled migrant workers out of total unskilled labor supply into the average net unskilled labor income: $\tilde{\pi}_t^l = \frac{\bar{L}_{na,t}}{\bar{L}_t}w_{na,t}^l + \frac{\bar{L}_{ag,t}}{\bar{L}_t}w_{ag,t}^l + G(\bar{\varepsilon}_t^l)\frac{\bar{L}_{ag,t}}{\bar{L}_t}\left(\tilde{\pi}_{m,t}^l - w_{ag,t}^l\right)$.

The average cutoffs for rural workers who choose to migrate are:

$$\tilde{\varepsilon}_t^l = \frac{k+1}{k}\varepsilon_{min}\bar{\varepsilon}^l\frac{\left(\bar{\varepsilon}^l\right)^{k+1} - \left(\varepsilon_{min}\right)^{k+1}}{\left(\bar{\varepsilon}^l\right)^{k} - \left(\varepsilon_{min}\right)^{k}},$$

$$\tilde{\varepsilon}_t^s = \frac{k+1}{k}\varepsilon_{min}\bar{\varepsilon}^s\frac{\left(\bar{\varepsilon}^s\right)^{k+1} - \left(\varepsilon_{min}\right)^{k+1}}{\left(\bar{\varepsilon}^s\right)^{k} - \left(\varepsilon_{min}\right)^{k}}.$$

Therefore, average worker return can be expressed as the following equation:

$$\tilde{\pi}_t^l = \frac{\bar{L}_{na,t}}{\bar{L}_t}w_{na,t}^l + \frac{\bar{L}_{ag,t}}{\bar{L}_t}\left(1 - \left(\bar{\varepsilon}^l\right)^{-k}\right)\frac{w_{na,t}^l}{X_t\tilde{\varepsilon}_t^l} + \frac{\bar{L}_{ag,t}}{\bar{L}_t}\left(\bar{\varepsilon}^l\right)^{-k}w_{ag,t}^l.$$

2.5 Foreign households and output

The foreign economy also produces agricultural goods and non-agricultural goods, the former sector being non-tradable and the latter being tradable. Rural to urban migration is not modeled in foreign, so that there is no between sector migration occurring. The foreign non-agricultural good is also used both domestically and abroad: $Y_{na,t}^* = Y_{na,f,t}^* + Y_{na,h,t}^*$, where $Y_{na,f,t}^*$ denotes the use of the foreign non-agricultural good by foreign households, and $Y_{na,h,t}^*$

denotes exports to the home country. The foreign non-agricultural tradable consumption basket is:

$$C_{na,t}^{*}=\left[(\omega^{*})^{\frac{1}{\mu^{*}}}\left(Y_{na,f,t}^{*}\right)^{\frac{\mu^{*}-1}{\mu^{*}}}+(1-\omega^{*})^{\frac{1}{\mu^{*}}}\left(Y_{na,h,t}^{*}\right)^{\frac{\mu^{*}-1}{\mu^{*}}}\right]^{\frac{\mu^{*}}{\mu^{*}-1}},$$

where $Y_{na,f,t}^{*}$ denotes foreign domestic the foreign country's domestic use of the foreign non-agricultural good and $Y_{na,h,t}^{*}$ denotes the exports of home to foreign. The demand functions for the home and foreign non-agricultural goods are $Y_{na,f,t}^{*}=\omega^{*}\left(p_{na,f,t}\right)^{-\mu^{*}}C_{na,t}^{*}$ and $Y_{na,h,t}^{*}=\omega^{*}\left(p_{na,h,t}\tau^{*}/Q_{t}\right)^{-\mu^{*}}C_{na,t}^{*}$, where are the prices of the home and foreign non-agricultural goods expressed in units of the foreign consumption basket. Therefore, the demand ratios for domestic use in the foreign country and exports to the home country is: $\frac{Y_{na,f,t}^{*}}{Y_{na,h,t}^{*}}=\frac{\omega^{*}}{1-\omega^{*}}\left(\frac{p_{na,f,t}Q_{t}}{p_{na,h,t}\tau^{*}}\right)^{-\mu}$. The price index for the non-agricultural good in the foreign country is also normalized to be numeraire, and it can be expressed as: $1=\omega^{*}\left(p_{na,f,t}\right)^{1-\mu^{*}}+(1-\omega^{*})\left(p_{na,h,t}\tau^{*}/Q_{t}\right)^{1-\mu^{*}}$.

Budget constraint for foreign household is:

$$\tilde{\pi}_{t}^{l*}\bar{L}_{t}^{*}+\tilde{\pi}_{t}^{s*}\bar{S}_{t}^{*}+(1+r_{t})B_{t}^{*}+(1+r_{t}^{*})B_{*,t}^{*}+T_{t}^{*}=C_{t}^{*}+Q_{t}^{-1}B_{t+1}^{*}+B_{*,t+1}^{*}+\frac{\xi}{2}Q_{t}^{-1}B_{*,t+1}^{2}+\frac{\xi}{2}B_{*,t+1}^{*2},$$

where $B_{t}^{*}$is Foreign holdings of Home bonds and $B_{*,t}^{*}$ is Foreign holdings of Foreign bonds.

2.6 Aggregate accounting and balanced trade

The change in net foreign assets between t and $t+1$ is determined by the current account:

$$B_{t+1}-B_{t}+Q_{t}\left(B_{*,t+1}-B_{*,t}\right)=CA_{t}\equiv p_{na,h}\tau^{*}Y_{na,h}^{*}-p_{na,f,t}\tau Q_{t}Y_{na,f,t}+r_{t}B_{t},$$

where $p_{na,h,t}^{*}\tau^{*}Y_{na,h,t}^{*}-p_{na,f,t}\tau Q_{t}Y_{na,f,t}=TB_{t}$ is the trade balance, which is characterized by total exports minus imports expressed in units of the home consumptions basket. Bond market clearing implies $B_{t+1}+B_{t+1}^{*}=0$ and $B_{*,t+1}+B_{*,t+1}^{*}=0$.

2.7 Measures of wage inequality

2.7.1 Definition of wage inequality measures:

Since the goal of this paper is to analyze the effect of China's trade liberalization and migration policy change on wage inequality, this section define a set of wage inequality measures. There are three measures of inequality that one can study under the framework of this model: within-area or within-sector skill premium, country-level skill premium, urban to rural wage inequality. Derivations are in the appendix.

First, within-sector skill premium is straightforward to measure:

$$\frac{w^s_{ag,t}}{w^l_{ag,t}} = \frac{\eta_{ag}}{1-\eta_{ag}} \frac{L_{ag,t}}{S_{ag,t}}, \text{ and}$$

$$\frac{w^s_{na,t}}{w^l_{na,t}} = \frac{\eta_{na}}{1-\eta_{na}} \frac{L_{na,t}}{S_{na,t}}.$$

Second, country-level skill premium is by definition $\frac{w^s_t}{w^l_t}$, the ratio of skilled wage over unskilled wage at the aggregate level. Skilled wage w^s_t is the weighted average of skilled wage in the non-agricultural sector and that in the agricultural sector, weighted by corresponding labor share, similarly for unskilled wage w^l_t:

$$w^s_t = \frac{S_{na,t}}{\bar{S}_t} w^s_{na,t} + \frac{S_{ag,t}}{\bar{S}_t} w^s_{ag,t}, \text{ and}$$

$$w^l_t = \frac{L_{na,t}}{\bar{L}_t} w^l_{na,t} + \frac{L_{ag,t}}{\bar{L}_t} w^l_{ag,t}.$$

Third, one can also calculate urban to rural wage inequality, which is the wage difference between the average wage at the non-agricultural sector and that at the agricultural sector $\frac{w_{na,t}}{w_{ag,t}}$, where rural wage and urban wage are defined by:

$$w_{na,t} = \frac{L_{na,t}}{L_{na,t}+S_{na,t}} w^l_{na,t} + \frac{S_{na,t}}{L_{na,t}+S_{na,t}} w^s_{na,t}, \text{ and}$$

$$w_{ag,t} = \frac{L_{ag,t}}{L_{ag,t}+S_{ag,t}} w^l_{ag,t} + \frac{S_{ag,t}}{L_{ag,t}+S_{ag,t}} w^s_{ag,t}.$$

2.7.2 Expression of wage inequality measures:

This section expresses wage inequality measures using other equations described in the theoretical model.

Sector-level skill premium:

Since the share of migrant workers out of total agricultural labor endowment is a function of migration cost cutoffs for skilled and unskilled labor, skill premium in the rural area (the agricultural sector) is derived as:

$$\frac{w^s_{ag,t}}{w^l_{ag,t}} = \frac{\bar{L}_{ag,t}\left(\bar{\varepsilon}_t{}^l\right)^{-k}}{\bar{S}_{ag,t}\left(\bar{\varepsilon}^s\right)^{-k}} \frac{\eta_{ag}}{1-\eta_{ag}}.$$

Similarly, skill premium in the urban area (the non-agricultural sector) can be obtained as:

$$\frac{w^s_{na,t}}{w^l_{na,t}} = \frac{\bar{L}_{na,t} + \left(1 - \left(\bar{\varepsilon}^l_t\right)^{-k}\right)\bar{L}_{ag}}{\bar{S}_{na,t} + \left(1 - \left(\bar{\varepsilon}^s_t\right)^{-k}\right)\bar{S}_{ag}} \frac{\eta_{na}}{1-\eta_{na}}.$$

The sector-level skill premium at period t depends on one endogenous variable: the migration cost cutoffs for skilled migrant workers and unskilled migrant workers $\bar{\varepsilon}^l_t$ and $\bar{\varepsilon}^s_t$. In other words, skill premium within each region depends on the fraction of skilled workers who choose to move and the fraction of unskilled workers who decide to move, which are pinned down by other aggregate variables in the economy.

Country-level skill premium:

After substituting labor demand functions in terms of skilled wage and unskilled wage in the two sectors, country-level skill premium can be expressed as:

$$\frac{w^s_t}{w^l_t} = \left[\frac{\eta_{na}\frac{Y_{na,t}p_{na,h,t}}{Y_{ag,t}P_{ag,t}} + \eta_{ag}}{\left(1-\eta_{na}\right)\frac{Y_{na,t}P_{na,t}}{Y_{ag,t}P_{ag,t}} + \left(1-\eta_{ag}\right)}\right]\frac{\bar{L}_t}{\bar{S}_t}.$$

The above equation means that at the aggregate level, skill premium only depends on one endogenous variables: the ratio of revenue in the urban area non-agricultural sector over that in the rural area agricultural sector $\frac{Y_{na,t}P_{na,t}}{Y_{ag,t}P_{ag,t}}$. Since $\frac{\partial \frac{w^s_t}{w^l_t}}{\partial \frac{Y_{na,t}P_{na,t}}{Y_{ag,t}P_{ag,t}}} > 0$ as $\eta_{na} > \eta_{ag}$, the conclusion that country-level skill premium rises can be easily obtained. Proof is in the appendix.

Urban-rural wage inequality:

$$\frac{w_{na,t}}{w_{ag,t}} = \frac{Y_{na,t}P_{na,t}}{Y_{ag,t}P_{ag,t}}\frac{L_{ag,t}+S_{ag,t}}{L_{na,t}+S_{na,t}}.$$

This implies that urban-rural wage inequality is determined by two forces: ratio of output in these two areas $\frac{Y_{na,t}}{Y_{ag,t}}$ and the ratio of total labor working in the rural area over the total mass of labor working in the urban area $\frac{L_{ag,t}+S_{ag,t}}{L_{na,t}+S_{na,t}}$. These two forces work in opposite directions.

The amount of labor working in the agricultural sector $L_{ag,t}$ and $S_{ag,t}$ equal the total rural labor endowment $\bar{L}_{ag,t}$ and $\bar{S}_{ag,t}$ subtracted by the migrant workers $L_{m,t}$ and $S_{m,t}$. Similarly, the mass of labor working in the non-agricultural sector $L_{na,t}$ and $S_{na,t}$ are urban labor endowment plus the migration flow. Therefore, urban to rural wage inequality can also be written as:

$$\begin{aligned}\frac{w_{na,t}}{w_{ag,t}} &= \frac{Y_{na,t}P_{na,t}}{Y_{ag,t}P_{ag,t}}\frac{\bar{L}_{ag,t}+\bar{S}_{ag,t}-(L_{m,t}+S_{m,t})}{\bar{L}_{na,t}+\bar{S}_{na,t}+(L_{m,t}+S_{m,t})} \\ &= \frac{Y_{na,t}P_{na,t}}{Y_{ag,t}P_{ag,t}}\frac{\bar{L}_{ag}\left(\bar{\varepsilon}^{l}\right)^{-k}+\bar{S}_{ag}\left(\bar{\varepsilon}^{l}\right)^{-k}}{\bar{L}_{na}+\bar{S}_{na}+\left(\left(1-(\bar{\varepsilon}^{l})^{-k}\right)\bar{L}_{ag}+\left(1-(\bar{\varepsilon}^{s})^{-k}\right)\bar{S}_{ag}\right)}.\end{aligned}$$

Therefore, changes in urban-rural wage inequality depends on change in the ratio of non-agricultural to agricultural output $\frac{Y_{na,t}}{Y_{ag,t}}$, as well as changes in the number of total migrant workers $L_{m,t}+S_{m,t}$.

Derived equations for these three different measures of wage inequality delineate a very interesting phenomenon for inequality. When migration cost is lowered, at the aggregate level, it is straightforward to conclude that skill premium rises as migration into the city increases relative output in the urban area. However, it might not be the case if we dig deeper than the aggregate level and look at skill premium within the urban area and that within the rural area, as well as urban to rural wage inequality. Exogenous shocks may lead to increase or decrease in urban-rural inequality and within-sector wage inequality.

3 Long-run effects and adjustment to trade liberalization and migration policy

3.1 Steady state analysis

In the steady state, migration cost cutoffs satisfy:

$$\bar{\varepsilon}^{l}=\frac{1}{X}\frac{(1-\eta_{na})(1-\alpha)}{(1-\eta_{ag})\alpha}\frac{\left(\bar{\varepsilon}^{l}\right)^{-k}}{\frac{\bar{L}_{na}}{\bar{L}_{ag}}+1-(\bar{\varepsilon}^{l})^{-k}},$$

$$\bar{\varepsilon}^{s}=\frac{1}{X}\frac{\eta_{na}(1-\alpha)}{\eta_{ag}\alpha}\frac{(\bar{\varepsilon}^{s})^{-k}}{\frac{\bar{S}_{na}}{\bar{S}_{ag}}+1-(\bar{\varepsilon}^{s})^{-k}}.$$

These two equations imply that in the steady state, migration cost cutoff for unskilled workers $\bar{\varepsilon}^{l}$ depends only on common migration cost shock X, ratio of skilled cost share in production $\frac{\eta_{na}}{\eta_{ag}}$, relative share of non-agricultural good to agricultural good in the aggregate consumption basket $\frac{1-\alpha}{\alpha}$ and ratio of urban to rural unskilled endowment $\frac{\bar{L}_{na}}{\bar{L}_{ag}}$. Similarly, migration cost cutoff for skilled workers $\bar{\varepsilon}^{s}$ depends only on common migration cost shock X, ratio of skilled cost share in production $\frac{\eta_{na}}{\eta_{ag}}$ and ratio of urban to rural unskilled endowment

$\frac{\bar{S}_{na}}{\bar{S}_{ag}}$. Once we obtain $\bar{\varepsilon}^s$ and $\bar{\varepsilon}^l$, migration flow L_m and S_m are also derived. Because there is no closed form solution for $\bar{\varepsilon}^s$ and $\bar{\varepsilon}^l$, fig 3.1 plots the relationship between cost cutoff $\bar{\varepsilon}^l$ and common migration cost shock X with plausible values of other variables. The two variables are negatively correlated: the lower the common cost level X, the higher the cost cutoff of migration. This is rather intuitive because lower cost of migration allows more rural workers to find working in the city generating more net income. Thus, when there is a reduction in the common migration cost, the cutoffs for skilled and unskilled workers rise and more rural workers find it profitable to leave their *hukou* location and work in the city, increasing the migration flows L_m and S_m.

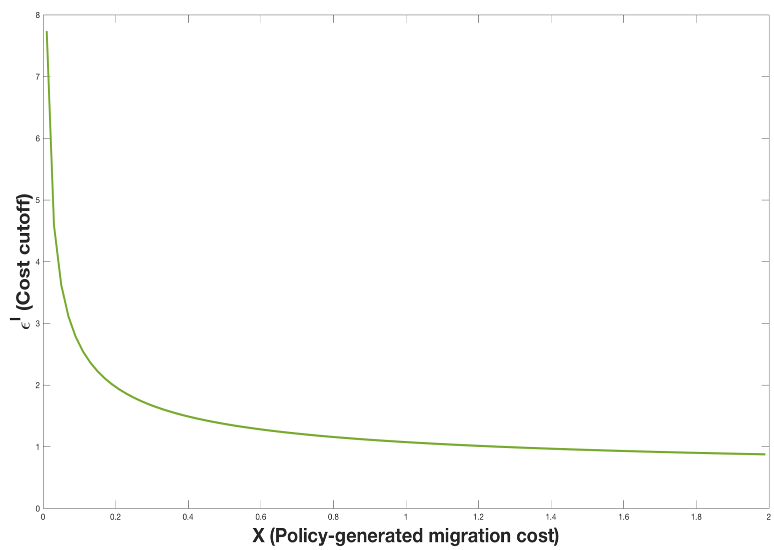

Figure 2: Migration cost cutoff as a function of common cost shock.

The three measures of wage inequality in the steady state are also obtained as the following. First, skill premium in the agricultural sector and that in the non-agricultural sector are:

$$\frac{w^s_{ag,t}}{w^l_{ag,t}} = \frac{\eta_{ag}}{1-\eta_{ag}} \frac{\bar{L}_{ag}\left(\bar{\varepsilon}^l\right)^{-k}}{\bar{S}_{ag}\left(\bar{\varepsilon}^s\right)^{-k}} \quad \text{and} \quad \frac{w^s_{na,t}}{w^l_{na,t}} = \frac{\eta_{na}}{1-\eta_{ag}} \frac{\bar{L}_{na}+\left(1-\left(\bar{\varepsilon}^l\right)^{-k}\right)\bar{L}_{ag}}{\bar{S}_{na}+\left(1-\left(\bar{\varepsilon}^s\right)^{-k}\right)\bar{S}_{ag}}.$$

Within sector skill premium $\frac{w^s_j}{w^l_j}$ depends on the sector level endowment ratio $\frac{\bar{L}_j}{\bar{S}_j}$ and sector specific ratio of skilled to unskilled cost share in the production function $\frac{\eta_j}{1-\eta_j}$ and equilibrium migration cost cutoffs $\bar{\varepsilon}^s$ and $\bar{\varepsilon}^l$ for skilled and unskilled rural workers, which are shown above.

Second, urban to rural wage inequality does not depend on depends on η_j, but only depends on $\frac{1-\alpha}{\alpha}$, endowments $\bar{L}_{na}, \bar{L}_{ag}, \bar{S}_{na}, \bar{S}_{ag}$ and cutoffs $\bar{\varepsilon}^s, \bar{\varepsilon}^l$, as the following:

$$\frac{w_{na}}{w_{ag}} = \frac{1-\alpha}{\alpha} \frac{\bar{L}_{ag} \left(\bar{\varepsilon}^l\right)^{-k} + \bar{S}_{ag} \left(\bar{\varepsilon}^l\right)^{-k}}{\bar{L}_{na} + \bar{S}_{na} + \left(\left(1 - \left(\bar{\varepsilon}^l\right)^{-k}\right) \bar{L}_{ag} + \left(1 - \left(\bar{\varepsilon}^s\right)^{-k}\right) \bar{S}_{ag}\right)}.$$

Third, country level skill premium is:

$$\frac{w^s}{w^l} = \left(\frac{\eta_{na}\frac{1-\alpha}{\alpha} + \eta_{ag}}{\left(1-\eta_{na}\right)\frac{1-\alpha}{\alpha} + \left(1-\eta_{ag}\right)}\right) \frac{\bar{L}}{\bar{S}}.$$

This means that in the steady state, country level skill premium is pinned down by only the unskilled to skilled endowment ratio $\frac{\bar{L}_t}{\bar{S}_t}$, cost share in the production function η_{na}, η_{ag} and relative share of non-agricultural good to agricultural good in the aggregate consumption basket $\frac{1-\alpha}{\alpha}$.

3.2 Calibration

This section describes the parametrization of the model that I use for numerical simulations. Following the practice of Ghironi and Melitz (2005), each period is interpreted as a quarter. The household discount rate set to 0.99, which is the standard value for business cycle models at quarterly frequency. The parameters of the Pareto distribution are set to $\varepsilon_{min} = 1$ and $k = 2$, respectively. Share of domestic non-agricultural good in total non-agricultural consumption in Home and Foreign are $\omega = 0.75$ and $\omega^* = 0.85$, allowing for slightly more trade openness for the foreign economy than home. Share of non-agricultural consumption in total consumption basket is $\alpha = 0.6$.

Iceberg trade costs are calibrated to deliver an average share of US manufacturing trade with China in US manufacturing value added of 6% during 1988-2000 (the pre-liberalization period) and 25% during 2001-20013 (the post-liberalization period). Assuming symmetric trade costs, this share implies trade costs of $\tau = \tau^* = 1.5$ before liberalization and $\tau = \tau^* = 1.1$ after that. The policy-controlled migration cost X_t is also calibrated to match with a share of migrant workers in rural workers from 6% to 27.8% from 1995 to 2007. Productivity shock in the non-agricultural sector is modeled as an AR(1) process with persistence parameter $\rho = 0.9$.

Using the CHIP surveys in rural households and urban households, during the whole sample period of 1988-2013, the share of endowed skilled workers in total endowed workers $\bar{S}^j / \left(\bar{S}^j + \bar{L}^j\right)$ is roughly 4.572% in the rural area and 38.6% in the urban area. In the U.S., the share of skilled to total workers is 31%, according to Burstein and Vogel (2017). Because there is no rural to urban migration modeled in the foreign country, I assume the rural area and the urban area has the same share of skilled workers endowment.

3.3 Dynamic adjustment, impulse responses

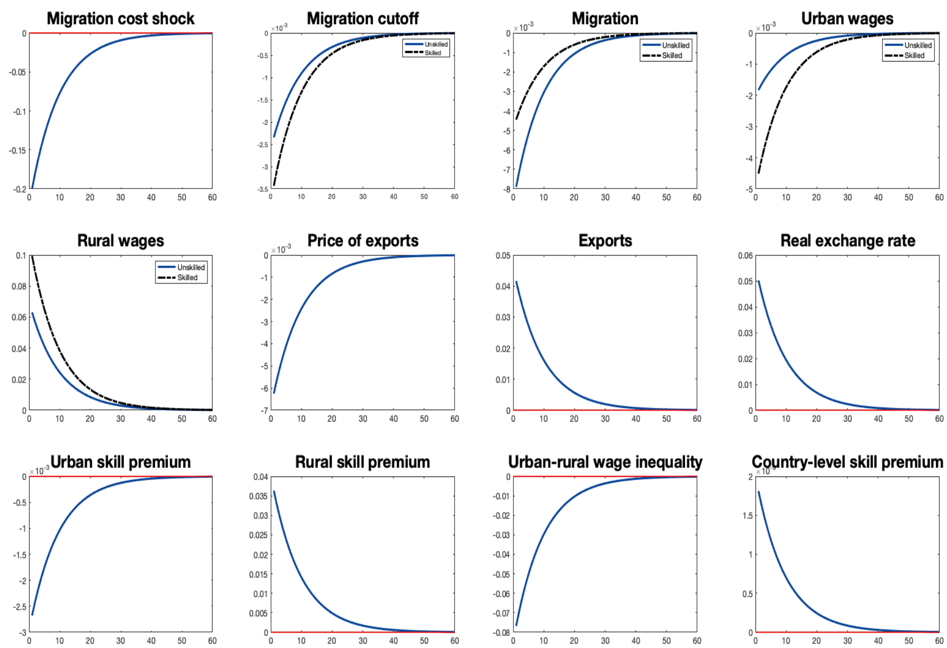

Figure 3: This figure shows the impulse response functions of variables following a reduction in common migration cost X_t. Variables are in percentage deviations from the steady state.

Migration cost shock Fig.3.3 plots the impulse responses of macroeconomics and labor market variables following a negative migration cost shock. Migration cost cutoffs increase, leading to increase in both skilled and unskilled migration. Unskilled workers' wage in the non-agricultural sector $w^l_{na,t}$ goes down as there are more unskilled workers working the urban non-agricultural sector. Increase of unskilled migration exceeds that of skilled migration. Since $p_{na,h,t} = \frac{1}{Z_{na,t}(1-\eta_{na})} w^l_{na,t} \left(\frac{\bar{L}_{na}+L_{m,t}}{\bar{S}_{na}+S_{m,t}}\right)^{\eta_{na}}$, price of domestic non-agricultural good decreases, giving rise to more exports. On the contrary, both skilled and unskilled wage in the rural area increases due to a lower level of total labor remaining there. As a consequence, price of agricultural good increases as $p_{ag,t} = \frac{1}{Z_{ag,t}(1-\eta_{ag})} w^l_{ag,t} \left(\frac{\bar{L}_{ag}-L_{m,t}}{\bar{S}_{ag}-S_{m,t}}\right)^{\eta_{ag}}$. Exports and imports both increase. The share of sectoral goods in the home aggregate consumption basket changes due to lowering of $p_{na,h,t}$ and rise of $p_{ag,t}$: consumption of agricultural good $C_{ag,t}$ shrinks whereas consumption of non-agricultural good $C_{na,t}$ expands. In terms of wage inequality, with more workers reallocating from the rural area to the urban area increasing the relative labor supply in the urban area, urban to rural wage inequality decreases. However, skill premium in both the urban area and the rural area, as well as the aggregate level increase. In the urban area, skill premium increases as urban skilled wage rises but urban unskilled wage decreases. Skill premium in the rural area escalates because the rise of rural skilled wage far exceeds that of rural unskilled wage. Real exchange rate depreciates as the price of home non-agricultural good decreases and the price of foreign non-agricultural good increases.

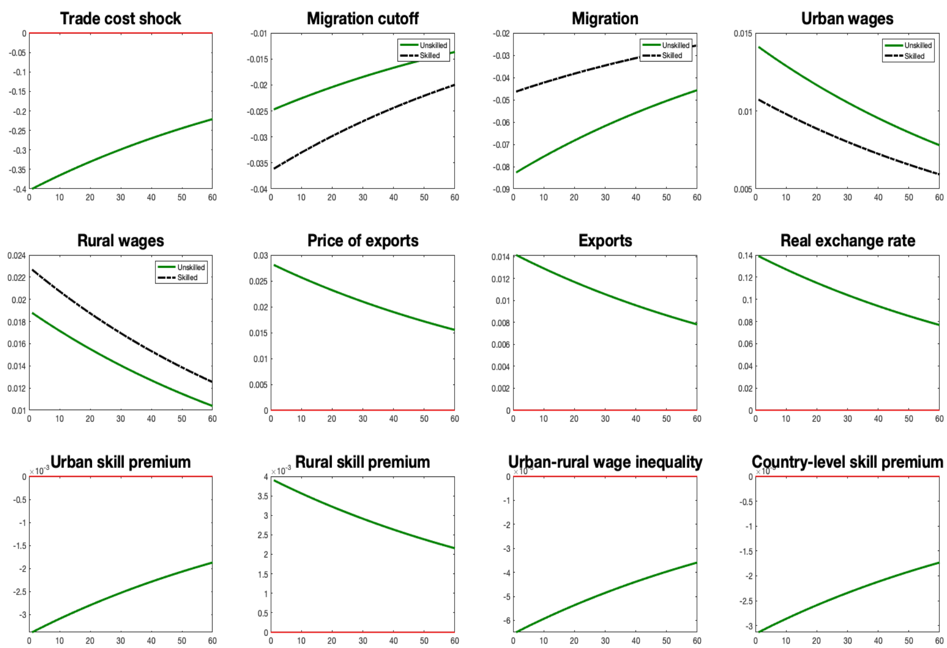

Figure 4: This figure shows the impulse response functions of variables in the home country following a negative trade cost shock τ_t^*.

Trade cost shock Fig.3.3 shows the effect of trade cost reduction on the labor market and macroeconomic dimension. A decline in the trade cost of home exports τ^* lowers the price of exports $p_{na,h,t}\tau^*/Q_t$, boosting foreign demand for home non-agricultural exports. Real exchange rate depreciates. As the demand for labor in the non-agricultural sector builds up, wages of skilled and unskilled workers in that sector climb up too. Therefore, migration cost cutoffs increase, generating larger migration flow into the non-agricultural sector. Meanwhile, with diminished labor supply in the agricultural sector, skilled and unskilled wage in the rural area also go up, putting upward pressure on the price of agricultural good as well. Thus, wages of skilled and unskilled workers in both the urban area and the rural area increase. Urban to rural wage inequality expands because wage increments in the urban area more than offsets that in the rural area. Sectoral skill premium and country-level skill premium widen.

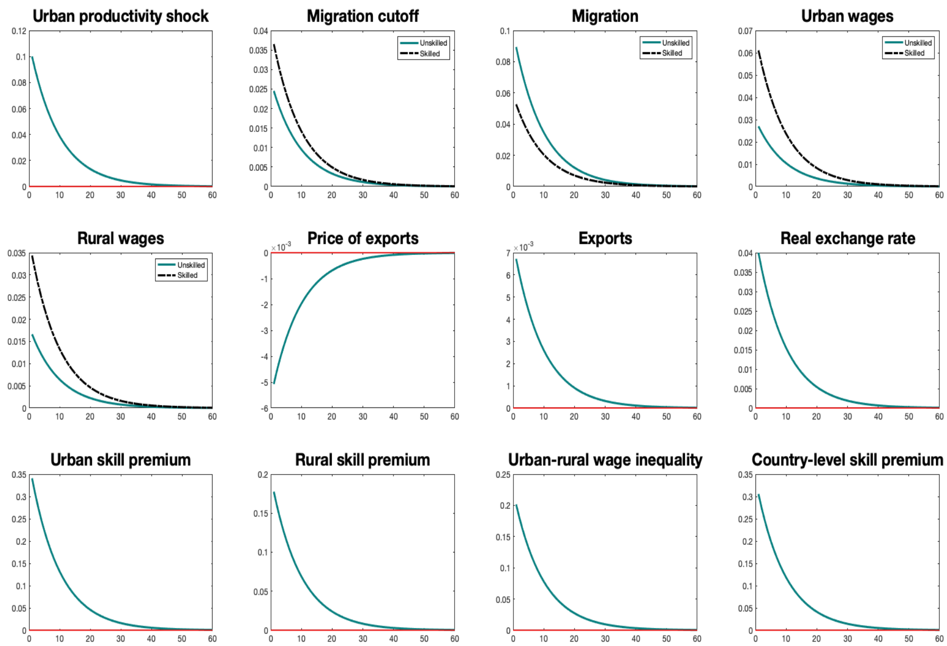

Figure 5: This figure shows the impulse response functions of variables in the home country following a positive productivity shock in the non-agricultural sector in the urban area $Z_{na,t}$.

Productivity shock in the non-agricultural sector As described in section3.2, productivity shock in the non-agricultural sector follows an autoregressive process with degree 1: $logZ_{na,t+1} = \rho logZ_{na,t} + \xi_t$, where $\rho = 0.9$. Fig.3.3 plots the impulse responses of variables following a positive productivity shock. A positive non-agricultural sector productivity shock increases migration cutoffs for rural skilled and unskilled workers through increasing wages in the non-agricultural sector, making migration more rewarding. All three measures of wage inequality rises. Urban-rural wage gap broadens because productivity growth in the urban area boosts the relative wages compared to the rural area. Skill premium in the sector level and aggregate level all go up. Productivity growth in the non-agricultural sector lowers the marginal cost of production, tapering price of the non-agricultural good produced at home $p_{na,h,t}$. Meanwhile, it contracts the agricultural sector, leading to less demand of labor in production of the agricultural good and thus a downward pressure on wages in the agricultural sector. Therefore, there will be a fall in the price $p_{ag,t}$. Both agricultural consumption and non-agricultural consumption increase due to a double lowering of the prices $p_{na,h,t}$ and $p_{ag,t}$. Rural skilled wage climbs up because the effect of a weakened labor supply on wage outweighs that of a suppressed labor demand. However, the opposite is true for rural unskilled wage, leading to a reduction in rural unskilled wage.

4 Conclusion

This paper examines the effects of China's domestic migration policy change and trade liberalization on wage inequality in China using a dynamic general equilibrium model of international trade and internal migration across regions. Calibrating the changes in policy-generated migration cost reduction and trade cost decline, as well as productivity increase in the tradable sector, this paper analyzes the responses of different measures of wage inequality and other macroeconomics variables following these shocks.

All these three exogenous changes are associated with rise in urban to rural wage inequality, sectoral skill premium and aggregate-level skill premium, with the exception that easing of migration restriction lead to lowering of urban-rural wage inequality. However, the channels leading to the outcomes are different across the three scenarios. Under all of these scenarios, there is simultaneous rise in migration and exports. Curtailing migration cost affects variables by changing the relative payoffs across sectors, increases migration cost cutoff for both unskilled and skilled rural workers. Price of domestic non-agricultural good decreases due to lower cost of production, giving rise to more exports. Trade cost reduction affects wages by lowering the price of home exports and thus boosting demand for home non-agricultural exports. As wages of skilled and unskilled workers in that sector climb up, migration cost cutoffs increase, generating larger migration flow into the non-agricultural sector. A positive non-agricultural sector productivity shock increases migration cutoffs for rural skilled and unskilled workers through increasing wages in the non-agricultural sector, making migration more rewarding. Meanwhile, productivity growth in the non-agricultural sector lowers the marginal cost of production, contributing to lower price of exports.

The findings in this paper has important policy implications. It shows that easing of migration restriction and trade barriers both encourage rural to urban migration and help with export surge. However, both of these two policies, one domestic one international, have distributional consequences on the skill premium as they broaden skill premium in both the non-agricultural sector and the agricultural sector.

Table 1: Employment and wage in China, 1995-2007

	1995	2007	%1995-2007	% per annum
Millions				
Rural areas labor force	490	476	-2.9	-0.03
Urban areas labor force	196	325	66.8	4.43
Rural-urban migrants stock	30	132	340	13.14
Yuan per annum, average (1995 prices)				
Urban real wage	5,348	19,904	272.2	11.16
Rural real income per capita	1,578	3,289	108.4	6.31

Source: China's National Bureau of Statistics

Table 2: Summary of model equations

$1=\beta\left(1+r_{t+1}\right)E_t\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}$
$1+\xi B_{*,t+1}=\beta^*\left(1+r^*_{t+1}\right)E_t\left[\left(\frac{Q_{t+1}}{Q_t}\right)\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\gamma}\right]$
$1=\omega\left(p_{na,h,t}\right)^{1-\mu}+(1-\omega)\left(p_{na,f,t}\right)^{1-\mu}$
$1=\omega^*\left(p_{na,f,t}\right)^{1-\mu^*}+(1-\omega^*)\left(p_{na,h,t}/Q_t\right)^{1-\mu^*}$
$P_t=\left(\frac{P_{ag,t}}{\alpha}\right)^{\alpha}\left(\frac{P_{na,t}}{1-\alpha}\right)^{1-\alpha}$
$P^*_t=\left(\frac{P^*_{ag,t}}{\alpha}\right)^{\alpha}\left(\frac{P^*_{na,t}}{1-\alpha}\right)^{1-\alpha}$
$C_t=(C_{ag,t})^{\alpha}(C_{na,t})^{1-\alpha}$
$C_{na,t}=\left[\omega^{\frac{1}{\mu}}\left(Y_{na,h,t}\right)^{\frac{\mu-1}{\mu}}+(1-\omega)^{\frac{1}{\mu}}\left(Y_{na,f,t}\right)^{\frac{\mu-1}{\mu}}\right]^{\frac{\mu}{\mu-1}}$
$C_{ag,t}=Y_{ag,t}$
$C^*_t=(C^*_{ag,t})^{\alpha}(C^*_{na,t})^{1-\alpha}$
$C^*_{ag,t}=Y^*_{ag,t}$
$C^*_{na,t}=\left[\omega^{\frac{1}{\mu}}\left(Y^*_{na,f,t}\right)^{\frac{\mu-1}{\mu}}+(1-\omega)^{\frac{1}{\mu}}\left(Y^*_{na,h,t}\right)^{\frac{\mu-1}{\mu}}\right]^{\frac{\mu}{\mu-1}}$
$Y_{na,h,t}=\omega\left(p_{na,h,t}\right)^{-\mu}C_{na,t} \qquad Y_{na,f,t}=(1-\omega)\left(p_{na,f,t}Q_t\right)^{-\mu}C_{na,t}$
$\tilde{\pi}^l_t=\frac{\bar{L}_{na,t}}{\bar{L}_t}w^l_{na,t}+\frac{\bar{L}_{ag,t}}{\bar{L}_t}\left(1-\left(\bar{\varepsilon}^l_{m,t}\right)^{-k}\right)\tilde{v}^l_{m,t}+\frac{\bar{L}_{ag,t}}{\bar{L}_t}\left(\bar{\varepsilon}^l_{m,t}\right)^{-k}w^l_{ag,t}$
$\tilde{\pi}^s_t=\frac{\bar{S}_{na,t}}{\bar{S}_t}w^s_{na,t}+\frac{\bar{S}_{ag,t}}{\bar{S}_t}\left(1-\left(\bar{\varepsilon}^s_{m,t}\right)^{-k}\right)\tilde{v}^s_{m,t}+\frac{\bar{S}_{ag,t}}{\bar{S}_t}\left(\bar{\varepsilon}^s_{m,t}\right)^{-k}w^s_{ag,t}$
$\tilde{\pi}^l_t\bar{L}_t+\tilde{\pi}^s_t\bar{S}_t+(1+r_t)B_t+(1+r^*_t)B_{*,t}+T_t=C_t+B_{t+1}+Q_tB_{*,t+1}$
$\tilde{\pi}^{l*}_t\bar{L}^*_t+\tilde{\pi}^{s*}_t\bar{S}^*_t+(1+r_t)B^*_t+(1+r^*_t)B^*_{*,t}+T^*_t=C^*_t+Q^{-1}_tB^*_{t+1}+B^*_{*,t+1}$
$B_{t+1}-B_t+Q_t\left(B_{*,t+1}-B_{*,t}\right)=p^*_{na,h,t}\tau^*Y^*_{na,h,t}-p_{na,f,t}\tau Q_tY_{na,f,t}+r_tB_t$
$\tilde{\varepsilon}^l_t=\frac{k}{k+1}\left(\varepsilon_{min}\bar{\varepsilon}^l\right)^{-1}\frac{\left(\bar{\varepsilon}^l\right)^k-\left(\varepsilon_{min}\right)^k}{\left(\bar{\varepsilon}^l\right)^{k+1}-\left(\varepsilon_{min}\right)^{k+1}}$
$\tilde{\varepsilon}^s_t=\frac{k}{k+1}\left(\varepsilon_{min}\bar{\varepsilon}^s\right)^{-1}\frac{\left(\bar{\varepsilon}^s\right)^k-\left(\varepsilon_{min}\right)^k}{\left(\bar{\varepsilon}^s\right)^{k+1}-\left(\varepsilon_{min}\right)^{k+1}}$

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A Derivation of equations

A.1 Wage inequality equations

Within-sector skill premium

$$\frac{w^s_{ag,t}}{w^l_{ag,t}} = \frac{\eta_{ag}}{1-\eta_{ag}} \frac{L_{ag,t}}{S_{ag,t}} \quad \text{and} \quad \frac{w^s_{na,t}}{w^l_{na,t}} = \frac{\eta_{na}}{1-\eta_{na}} \frac{L_{na,t}}{S_{na,t}}$$

Country level skill premium Country-level skill premium is by definition $\frac{w^s_t}{w^l_t}$, the ratio between skilled wage and unskilled wage at the aggregate level.

$$w^s_t = \frac{S_{na,t}}{\bar{S}_t} w^s_{na,t} + \frac{S_{ag,t}}{\bar{S}_t} w^s_{ag,t}, \text{and}$$

$$w^l_t = \frac{L_{na,t}}{\bar{L}_t} w^l_{na,t} + \frac{L_{ag,t}}{\bar{L}_t} w^l_{ag,t}.$$

Substituting relative labor demand, skill wage and unskilled wage can be written as:

$$\begin{aligned} w^s_t &= \left[S_{na,t} * \eta_{na} Z_{na,t} S^{\eta_{na}-1}_{na,t} L^{1-\eta_{na}}_{na,t} + S_{ag,t} * \eta_{ag} Z_{ag,t} S^{\eta_{ag}-1}_{ag,t} L^{1-\eta_{ag}}_{ag,t} \right] / \left(S_{na,t} + S_{ag,t} \right) \\ &= \eta_{na} Z_{na,t} L^{1-\eta_{na}}_{na,t} \frac{S^{\eta_{na}}_{na,t}}{\bar{S}_t} + \eta_{ag} Z_{ag,t} L^{1-\eta_{ag}}_{ag,t} \frac{S^{\eta_{ag}}_{ag,t}}{\bar{S}_t}. \end{aligned}$$

$$\begin{aligned} w^l_t &= \left[L_{na,t} * \left(1-\eta_{na}\right) Z_{na,t} S^{\eta_{na}}_{na,t} L^{-\eta_{na}}_{na,t} + L_{ag,t} * \left(1-\eta_{ag}\right) Z_{ag,t} S^{\eta_{ag}}_{ag,t} L^{-\eta_{ag}}_{ag,t} \right] / \left(L_{na,t} + L_{ag,t} \right) \\ &= \left(1-\eta_{na}\right) Z_{na,t} S^{1-\eta_{na}}_{na,t} \frac{L^{\eta_{na}}_{na,t}}{\bar{L}_t} + \left(1-\eta_{ag}\right) Z_{ag,t} S^{1-\eta_{ag}}_{ag,t} \frac{L^{\eta_{ag}}_{ag,t}}{\bar{L}_t}. \end{aligned}$$

Therefore, the country-level skill premium follows:

$$\begin{aligned} \frac{w^s_t}{w^l_t} &= \left[\frac{\eta_{na} Z_{na,t} L^{1-\eta_{na}}_{na,t} S^{\eta_{na}}_{na,t} + \eta_{ag} Z_{ag,t} L^{1-\eta_{ag}}_{ag,t} S^{\eta_{ag}}_{ag,t}}{\left(1-\eta_{na}\right) Z_{na,t} L^{\eta_{na}}_{na,t} S^{1-\eta_{na}}_{na,t} + \left(1-\eta_{ag}\right) Z_{ag,t} L^{\eta_{ag}}_{ag,t} S^{1-\eta_{ag}}_{ag,t}} \right] \frac{\bar{L}_t}{\bar{S}_t} \\ &= \left[\frac{\eta_{na} p_{na,h,t} \tilde{Y}_{na,t} + \eta_{ag} p_{ag,t} Y_{ag,t}}{\left(1-\eta_{na}\right) p_{na,h,t} \tilde{Y}_{na,t} + \left(1-\eta_{ag}\right) p_{ag,t} Y_{ag,t}} \right] \frac{\bar{L}_t}{\bar{S}_t} \\ &= \left[\frac{\eta_{na} \frac{p_{na,h,t} \tilde{Y}_{na,t}}{p_{ag,t} Y_{ag,t}} + \eta_{ag}}{\left(1-\eta_{na}\right) \frac{p_{na,h,t} \tilde{Y}_{na,t}}{p_{ag,t} Y_{ag,t}} + \left(1-\eta_{ag}\right)} \right] \frac{\bar{L}_t}{\bar{S}_t} \end{aligned}$$

Urban-rural wage inequality Urban-rural wage inequality is defined as $\frac{w_{na,t}}{w_{ag,t}}$.

Since $w_{na,t}$ is the average wage of the unskilled non-agricultural wage and the skilled non-agricultural wage,

$$\begin{aligned}
w_{na,t} &= \frac{L_{na,t}}{L_{na,t}+S_{na,t}} w^{l}_{na,t} + \frac{S_{na,t}}{L_{na,t}+S_{na,t}} w^{s}_{na,t} \\
&= Z_{na,t} p_{na,h,t} \left[(1-\eta)_{na} S^{\eta_{na}}_{na,t} L^{1-\eta_{na}}_{na,t} + \eta_{na} S^{\eta_{na}}_{na,t} L^{1-\eta_{na}}_{na,t} \right] / \left(L_{na,t} + S_{na.t} \right) \\
&= \frac{Z_{na,t} p_{na,h,t} S^{\eta_{na}}_{na,t} L^{\eta_{na}}_{na,t}}{L_{na,t}+S_{na,t}} \\
&= \frac{p_{na,h,t} Y_{na,t}}{L_{na,t}+S_{na,t}}.
\end{aligned}$$

Similarly, $w_{ag,t}$, which is the average wage of the unskilled wage and the skilled wage in the agricultural sector can be written as:

$$\begin{aligned}
w_{ag,t} &= \frac{L_{ag,t}}{L_{ag,t}+S_{ag,t}} w^{l}_{ag,t} + \frac{S_{ag,t}}{L_{ag,t}+S_{ag,t}} w^{s}_{ag,t} \\
&= \frac{Z_{ag,t} p_{ag,t} S^{\eta_{ag}}_{ag,t} L^{\eta_{ag}}_{ag,t}}{L_{ag,t}+S_{ag,t}} \\
&= \frac{p_{ag,t} Y_{ag,t}}{L_{ag,t}+S_{ag,t}}.
\end{aligned}$$

Therefore, urban-rural wage inequality, which is the wage ratio between the average wage at the non-agricultural sector and that at the agricultural sector is the following:

$$\begin{aligned}
\frac{w_{na,t}}{w_{ag,t}} &= \frac{p_{na,h,t} Y_{na,t}}{p_{ag,t} Y_{ag,t}} \frac{L_{ag,t}+S_{ag,t}}{L_{na,t}+S_{na,t}} \\
&= \frac{p_{na,h,t} Y_{na,t}}{p_{ag,t} Y_{ag,t}} \frac{\bar{L}_{ag,t}+\bar{S}_{ag,t}-(L_{m,t}+S_{m,t})}{\bar{L}_{na,t}+\bar{S}_{na,t}+(L_{m,t}+S_{m,t})}.
\end{aligned}$$

This implies that urban-rural wage inequality is pinned down by two forces: ratio of output in these two areas $\frac{Y_{na,t}}{Y_{ag,t}}$ and the ratio of total labor working in the rural area over the total mass of labor working in the urban area $\frac{L_{ag,t}+S_{ag,t}}{L_{na,t}+S_{na,t}}$. These two forces work in opposite directions.

A.2 Steady state equations

The price indexes for the composite good of each country are:

$$1 = \omega \left(p_{na,h,t} \right)^{1-\mu} + (1-\omega) \left(p_{na,f,t} \tau Q_t \right)^{1-\mu},$$

$$1 = \omega^{*} \left(p_{na,f,t} \right)^{1-\mu^{*}} + (1-\omega^{*}) \left(p_{na,h,t} \tau^{*} / Q_t \right)^{1-\mu^{*}}.$$

The relationship between $p_{na,h}$ and $p_{na,f}$ are obtained:

$$p_{na,f} = \left[\frac{1-\omega\left(p_{na,h}\right)^{1-\mu}}{1-\omega}\right]^{\frac{1}{1-\mu}} \frac{1}{\tau Q},$$

$$p_{na,h} = \left[\frac{1-\omega^*\left(p_{na,f}\right)^{1-\mu^*}}{1-\omega^*}\right]^{\frac{1}{1-\mu^*}} \frac{Q}{\tau^*}.$$

Assuming $\mu = \mu^*$, price of the Home non-agricultural good $p_{na,h}$ is a function of $Q, \tau, \tau^*, \omega, \omega^*$, μ and μ^*:

$$\omega^*\left(\frac{1-\omega\left(p_{na,h}\right)^{1-\mu}}{1-\omega}\right)\tau^{\mu-1} + \left(1-\omega^*\right)\left(p_{na,h}\right)^{1-\mu}\left(\tau^*\right)^{1-\mu} = Q^{1-\mu}.$$

From the balanced trade equation:

$$p_{na,h}\tau^* Y^*_{na,h} = p_{na,f}\tau Q Y_{na,f}.$$

Substitute price ratios of $p_{na,h}$ to $p_{na,f}$ and that $Y^*_{na,h} = \left(1-\omega^*\right)\left(p_{na,h}\tau^*/Q\right)^{-\mu^*} C^*_{na}$ and $Y_{na,f} = \left(1-\omega\right)\left(p_{na,f}\tau Q\right)^{-\mu} C_{na}$ into the above equation and assume $\mu = \mu^*$, it follows that:

$$C^*_{na} = \frac{\left(p_{na,h}\right)^{\mu-1} - \omega}{1-\omega^*} C_{na} Q^{\mu}\left(\tau^*\right)^{\mu-1}.$$

Thus, the consumption ratio in units of the same consumption basket is:

$$\frac{C_{na}}{C^*_{na}Q} = Q^{1-\mu}\tau^{1-\mu}\frac{1-\omega^*}{\left(p_{na,h}\right)^{\mu-1} - \omega}.$$

Since $p_{na,h} = \left(Z_{na}\left(1-\eta_{na}\right)\right)^{-1} w^l_{na}\left(\frac{\bar{L}_{na}+L_m}{\bar{S}_{na}+S_m}\right)^{\eta_{na}}$, the consumption ratio in units of the same consumption basket can also be written as:

$$\frac{C_{na}}{C^*_{na}Q} = Q^{\mu-1}\left(1-\omega^*\right)\left[\left(\frac{w^l_{na}}{Z_{na}\left(1-\eta_{na}\right)}\right)^{\mu-1}\left(\frac{\bar{L}_{na}+L_m}{\bar{S}_{na}+S_m}\right)^{\eta_{na}(\mu-1)} - \omega\right]^{-1}.$$

From the relative demand equation, price of home non-agricultural good and agricultural good are:

$$p_{na,h} = \left(Z_{na}\left(1-\eta_{na}\right)\right)^{-1} w^l_{na}\left(\frac{\bar{L}_{na}+L_m}{\bar{S}_{na}+S_m}\right)^{\eta_{na}},$$

$$p_{ag} = \left(Z_{ag}\left(1-\eta_{ag}\right)\right)^{-1} w^l_{ag}\left(\frac{\bar{L}_{ag}-L_m}{\bar{S}_{ag}-S_m}\right)^{\eta_{ag}}.$$

The expression for the real exchange rate in steady state is:

$$
\begin{aligned}
Q^u &= \frac{1-\omega p_{na,h}^{1-\mu}}{(1-\omega^*)\, p_{na,h}^{1-\mu}} \frac{\tilde{\pi}^l \bar{L} + \tilde{\pi}^s \bar{S}}{\tilde{\pi}^{l*} \bar{L}^* + \tilde{\pi}^{s*} \bar{S}^*} \\
&= \frac{p_{na,h}^{\mu-1} - \omega}{(1-\omega^*)} \frac{w_{na}^l \left[\bar{L}_{na} + L_m \left(\frac{1}{X\bar{\varepsilon}^l} + \frac{\left(\bar{\varepsilon}^l\right)^k - 1}{X\bar{\varepsilon}^l}\right)\right] + w_{na}^s \left[\bar{S}_{na} + S_m \left(\frac{1}{X\bar{\varepsilon}^s} + \frac{(\bar{\varepsilon}^s)^k - 1}{X\bar{\varepsilon}^s}\right)\right]}{w_{na}^{l*}\bar{L}_{na}^* + w_{na}^{s*}\bar{S}_{na}^* + w_{ag}^{l*}\bar{L}_{ag}^* + w_{ag}^{s*}\bar{S}_{ag}^*} \\
&= \frac{p_{na,h}^{\mu-1} - \omega}{(1-\omega^*)} \frac{w_{na}^l \left[\bar{L}_{na} + \bar{L}_{ag} \left(\frac{1}{X\bar{\varepsilon}^l} + \frac{\left(\bar{\varepsilon}^l\right)^{-k}}{X\bar{\varepsilon}^l} + \frac{\left(\bar{\varepsilon}^l\right)^{-k}}{X\bar{\varepsilon}^l}\right)\right] + w_{na}^s \left[\bar{S}_{na} + \bar{S}_{ag} \left(\frac{1}{X\bar{\varepsilon}^s} + \frac{(\bar{\varepsilon}^s)^{-k}}{X\bar{\varepsilon}^s} + \frac{(\bar{\varepsilon}^s)^{-k}}{X\bar{\varepsilon}^s}\right)\right]}{w_{na}^{l*}\bar{L}_{na}^* + w_{na}^{s*}\bar{S}_{na}^* + w_{ag}^{l*}\bar{L}_{ag}^* + w_{ag}^{s*}\bar{S}_{ag}^*} \\
&= \frac{\left(Z_{na}\left(1-\eta_{na}\right)\right)^{1-\mu} \left(w_{na}^l\right)^{\mu-1} \left(\frac{\bar{L}_{na}+L_m}{\bar{S}_{na}+S_m}\right)^{\eta_{na}(\mu-1)} - \omega}{(1-\omega^*)} * \\
&\quad \frac{w_{na}^l \left[\bar{L}_{na} + \bar{L}_{ag} \left(\frac{1}{X\bar{\varepsilon}^l} + \frac{\left(\bar{\varepsilon}^l\right)^{-k}}{X\bar{\varepsilon}^l} + \frac{\left(\bar{\varepsilon}^l\right)^{-k}}{X\bar{\varepsilon}^l}\right)\right] + w_{na}^s \left[\bar{S}_{na} + \bar{S}_{ag} \left(\frac{1}{X\bar{\varepsilon}^s} + \frac{(\bar{\varepsilon}^s)^{-k}}{X\bar{\varepsilon}^s} + \frac{(\bar{\varepsilon}^s)^{-k}}{X\bar{\varepsilon}^s}\right)\right]}{w_{na}^{l*}\bar{L}_{na}^* + w_{na}^{s*}\bar{S}_{na}^* + w_{ag}^{l*}\bar{L}_{ag}^* + w_{ag}^{s*}\bar{S}_{ag}^*}.
\end{aligned}
$$

A.2.1 Derivation of migration cost cutoffs:

Take skilled workers' urban and rural wage link as an example: $w_{na}^s / w_{ag}^s = X\bar{\varepsilon}^l$. Using $w_{na}^s = p_{na,h}\eta_{na}\tilde{Y}_{na}/S_{na}$, $w_{ag}^s = p_{ag,h}\eta_{ag}Y_{ag}/S_{ag}$, $C_{na}/C_{ag} = (1-\alpha)\, P_{ag}/\alpha P_{na}$, $P_{ag}Y_{ag} = P_{ag}C_{ag}$ as well as $p_{na,h}\tilde{Y}_{na} = C_{na}$ in equilibrium,

$$
\begin{aligned}
\bar{\varepsilon}^s &= \frac{1}{X} \frac{p_{na,h}}{P_{ag}} \frac{\eta_{na}}{\eta_{ag}} \frac{\tilde{Y}_{na}}{Y_{ag}} \frac{S_{ag}}{S_{na}} \\
&= \frac{1}{X} \frac{C_{na}}{P_{ag}C_{ag}} \frac{\eta_{na}}{\eta_{ag}} \frac{\bar{S}_{ag} - S_m}{\bar{S}_{na} + S_m} \\
&= \frac{1}{X} \frac{\eta_{na}(1-\alpha)}{\eta_{ag}\alpha} \frac{\bar{S}_{ag} - \left(1 - (\bar{\varepsilon}^s)^{-k}\right)\bar{S}_{ag}}{\bar{S}_{na} + \left(1 - (\bar{\varepsilon}^s)^{-k}\right)\bar{S}_{ag}}.
\end{aligned}
$$

Therefore, migration cost cutoffs satisfy:

$$
\bar{\varepsilon}^l = \frac{1}{X} \frac{\left(1-\eta_{na}\right)\left(1-\alpha\right)}{\left(1-\eta_{ag}\right)\alpha} \frac{\left(\bar{\varepsilon}^l\right)^{-k}}{\frac{\bar{L}_{na}}{\bar{L}_{ag}} + 1 - \left(\bar{\varepsilon}^l\right)^{-k}},
$$

$$
\bar{\varepsilon}^s = \frac{1}{X} \frac{\eta_{na}(1-\alpha)}{\eta_{ag}\alpha} \frac{(\bar{\varepsilon}^s)^{-k}}{\frac{\bar{S}_{na}}{\bar{S}_{ag}} + 1 - (\bar{\varepsilon}^s)^{-k}}.
$$

These imply that in the steady state, migration cost cutoff for unskilled workers $\bar{\varepsilon}^l$ depends only on common migration cost shock X, ratio of non-agricultural to agricultural good's share in the consumption basket $\frac{(1-\alpha)}{\alpha}$, ratio of skilled cost share in production $\frac{\eta_{na}}{\eta_{ag}}$ and ratio of urban to rural unskilled endowment $\frac{\bar{L}_{na}}{\bar{L}_{ag}}$. Similarly, migration cost cutoff for skilled workers $\bar{\varepsilon}^s$ depends only on common migration cost shock X, ratio of skilled cost share in production $\frac{\eta_{na}}{\eta_{ag}}$ and ratio of urban to rural unskilled endowment $\frac{\bar{S}_{na}}{\bar{S}_{ag}}$. Once we obtain $\bar{\varepsilon}^s$ and $\bar{\varepsilon}^l$, migration flow L_m and S_m are also derived.

From the budget constraint, $PC = w_{ag}^l\left(\bar{L}_{ag} - L_m\right) + w_{ag}^s\left(\bar{S}_{ag} - S_m\right) + w_{na}^l\left(\bar{L}_{na} + L_m\frac{1}{X\bar{\varepsilon}^l}\right) + w_{na}^s\left(\bar{S}_{na} + S_m\frac{1}{X\bar{\varepsilon}^s}\right)$. Since $C_{na} = \tilde{Y}_{na}p_{na,h} = w_{na}^l L_{na} + w_{na}^s S_{na}$ and $PC = \frac{C_{na}}{1-\alpha}$,

$$w_{na}^l\left[\left(\frac{1-\left(\bar{\varepsilon}^l\right)^{-k}}{X\tilde{\varepsilon}^l} + \frac{\left(\bar{\varepsilon}^l\right)^{-k}}{X\bar{\varepsilon}^l} - \frac{1-\left(\bar{\varepsilon}^l\right)^{-k}}{1-\alpha}\right)\bar{L}_{ag} - \frac{\alpha}{1-\alpha}\bar{L}_{na}\right] = w_{na}^s\left[\frac{\alpha}{1-\alpha}\bar{S}_{na} - \left(\frac{1-\left(\bar{\varepsilon}^s\right)^{-k}}{X\tilde{\varepsilon}^s} + \frac{\left(\bar{\varepsilon}^s\right)^{-k}}{X\bar{\varepsilon}^s} - \frac{1-\left(\bar{\varepsilon}^s\right)^{-k}}{1-\alpha}\right)\bar{S}_{ag}\right].$$

Substitute $w_{na}^s = w_{na}^l\frac{\eta_{na}}{1-\eta_{na}}\frac{\bar{L}_{na}+L_m}{\bar{S}_{na}+S_m}$ into the above equation,

$$\frac{\left(\frac{1-\left(\bar{\varepsilon}^l\right)^{-k}}{X\tilde{\varepsilon}^l} + \frac{\left(\bar{\varepsilon}^l\right)^{-k}}{X\bar{\varepsilon}^l} - \frac{1-\left(\bar{\varepsilon}^l\right)^{-k}}{1-\alpha}\right)\bar{L}_{ag} - \frac{\alpha}{1-\alpha}\bar{L}_{na}}{\frac{\alpha}{1-\alpha}\bar{S}_{na} - \left(\frac{1-\left(\bar{\varepsilon}^s\right)^{-k}}{X\tilde{\varepsilon}^s} + \frac{\left(\bar{\varepsilon}^s\right)^{-k}}{X\bar{\varepsilon}^s} - \frac{1-\left(\bar{\varepsilon}^s\right)^{-k}}{1-\alpha}\right)\bar{S}_{ag}} = \frac{\eta_{na}}{1-\eta_{na}}\frac{\bar{L}_{na} + \left(\bar{\varepsilon}^l\right)^{-k}\bar{L}_{ag}}{\bar{S}_{na} + \left(\bar{\varepsilon}^s\right)^{-k}\bar{S}_{ag}}.$$

From the expression of $p_{na,h}$, which depends on Q, ω, ω^*, μ, and expressions of $\bar{\varepsilon}^s$ and $\bar{\varepsilon}^l$, combined with $w_{na}^l = p_{na,h}Z_{na}\left(1-\eta_{na}\right)\left(\frac{\bar{S}_{na}+\left(1-\left(\bar{\varepsilon}^s\right)^{-k}\right)\bar{S}_{ag}}{\bar{L}_{na}+\left(1-\left(\bar{\varepsilon}^l\right)^{-k}\right)\bar{L}_{ag}}\right)^{\eta_{na}}$, w_{na}^l can be obtained as a function of $Q, \omega, \omega^*, \mu, Z_{na}, \eta_{na}, \eta_{ag}, \bar{S}_{na}, \bar{L}_{na}, \bar{S}_{ag}, \bar{L}_{ag}$. Once w_{na}^l is pinned down, w_{ag}^l can be obtained as $w_{ag}^l = \frac{w_{na}^l}{X\bar{\varepsilon}^l}$. w_{na}^s can also be derived as $w_{na}^s = w_{na}^l\frac{\eta_{na}}{1-\eta_{na}}\frac{\bar{L}_{na}+\left(1-\left(\bar{\varepsilon}^l\right)^{-k}\right)\bar{L}_{ag}}{\bar{S}_{na}+\left(1-\left(\bar{\varepsilon}^s\right)^{-k}\right)\bar{S}_{ag}}$, and w_{ag}^s follows as $w_{ag}^s = \frac{w_{na}^s}{X\bar{\varepsilon}^s}$.