Can Migration Barriers Save Firm Productivity in a Developing Country?

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Abstract: Migration barriers are often considered significant obstacles to productivity, particularly in developing countries. This study examines the long-term impact of rural-urban migration barriers on firm productivity in China, leveraging the country's "internal passport" policy. Employing an instrumental variable approach, we find that a one-standard-deviation increase in the strength of these barriers enhances average labor productivity among urban manufacturing firm by 22%. This effect is notably pronounced for domestic firms but insignificant for foreign-owned firms. The likely mechanism driving this improvement is the increased adoption of 'management technology' (e.g., pay for performance), rather than greater use of capital and skilled labor. We find similar patterns when using total factor productivity. These findings suggest that migration barriers can potentially enhance efficiency possibly by encouraging firms to implement performance-based reward systems.

Keywords: migration barriers, management practice, pay for performance, firm productivity, China.

JEL Codes: O10; J61; M52

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1 Introduction

The long-run impact of migration barriers on firm productivity remains ambiguous. One strand of literature considers them as sources of labor misallocation and low productivity because they prevent workers from moving to more productive sectors and firms in destinations (Hsieh and Klenow 2009; Tombe and Zhu 2019; Bryan and Morten 2019). However, another strand of literature suggests that migration barriers may enhance efficiency by inducing low-productivity sectors and firms in destinations to adopt labor-saving technologies (Acemoglu 2010; Hornbeck and Naidu 2014; Clemens, Lewis, and Postel 2018; Imbert et al. 2022; Danzer, Feuerbaum, and Gaessler 2024).[1] This article contributes to closing this gap by examining the long-term impact of migration barriers on firm productivity in migration destinations. Based on a prominent "internal passport" policy in China that controls rural-urban migration for more than half a century, we mainly address two questions: Have migration barriers affected long-run firm productivity in migration destinations, and, if so, what is the likely underlying mechanism for its effect?

The Chinese "internal passport" policy was formally implemented in 1958 and since then it became an integral part of the household registration system (also known as the *hukou* system).[2] Owing to the policy, agricultural *hukou* (AH) holders were prohibited from migrating to more productive urban destinations unless they successfully obtained a non-agricultural *hukou* (NAH), and access was strictly controlled by the central government through an annual quota system until the late 1990s.[3] In particular, the annual quota system in the pre-reform era requires that the maximum number of AH holders who can obtain a NAH annually accounts for no more than 0.2 percent of the stocks of NAH holders in each locality and local governments did not have the autonomy to change their local quotas until the late 1990s. By contrast, NAH holders were not prevented from migrating to rural destinations. These distinctive features of the "internal passport" policy allow us to quantify rural-urban migration barriers based on the prevalence of AH holders in the pre-reform era.[4] In this article, we define

[1] For example, according to the multi-task theory of the state enterprise reform, policies such as rural-urban migration barriers allow local state-owned enterprises to adopt more advanced management technology to improve financial performance rather than maintaining more employment to promote social stability (Bai et al. 2000; Bai, Lu, and Tao 2006).

[2] Under the *hukou* system, individuals in rural areas were generally classified as agricultural *hukou* (AH) holders, while individuals in urban areas were generally classified as non-agricultural *hukou* (NAH) holders.

[3] Since the late 1990s, the Chinese authorities have slowly reformed the *hukou* system by making it easier for AH holders to migrate to small cities and towns. That said, migrating to medium and large cities remained difficult for most AH holders in the early 2000s because they had restricted access to local welfare benefits such as child education, the social security program, and so forth. In July 2014, the Chinese authorities announced a decree to make it easier for AH holders to migrate to the remaining urban areas, with the exception of several mega-cities such as Beijing and Shanghai. In the article, we define periods from the late 1990s as the reform era of migration barriers (or *hukou* system), and define periods before the late 1990s as the pre-reform era.

[4] Although a number of studies have measured migration barriers differently in the context of China by either relying on

the extent of rural-urban migration barriers experienced by urban destinations as the percentage of AH holders in the local population in the pre-reform era, and compare long-run firm productivity in urban destinations exposed to higher and lower rural-urban migration barriers.

Such rural-urban migration barriers can sustain largely because early reforms of the "internal passport" policy concentrated on facilitating labor migration without *hukou* conversion, also known as temporary migration. Specifically, although AH holders were allowed to migrate to urban destinations since the mid-1980s in the absence of a local *hukou*, most of them stayed temporarily due to denied access to public services in destinations. In other words, such rural-urban migration barriers can continue affecting migration decisions through restricting migrants' access to public services in destinations. Indeed, a recent study by Jin and Zhang (2023) empirically shows that policies that prevent rural migrants from obtaining a local *hukou* in urban destinations can substantially discourage rural-urban migration.

To estimate the causal impact of rural-urban migration barriers, we use an instrumental variable (IV) approach based on a plausibly exogenous shock on the stocks of NAH holders in the 1950s when the "internal passport" policy was not implemented. Specifically, we construct an IV using the geographical distance between each locality and Jinmen,[5] which is 2 km from the mainland Chinese city of Xiamen but controlled by Taiwan.[6] The rationale is that mainland Chinese cities closer to Jinmen were exposed to more risks of armed conflict in the Taiwan Strait owing to tensions between mainland China and Taiwan in the early 1950s[7] and probably received fewer industrial investments from the central government between 1949 and 1957. Given that the stocks of NAH holders before 1958 were largely determined by industrial investments and the resulting labor demand in the industrial sector during that period, a shorter distance between a mainland Chinese city and Jinmen leads to fewer number of NAH holders and in turn higher rural-urban migration barriers in the pre-reform era due to the annual quotas

variations in the timing of relaxing the *hukou* system across regions (Sun, Bai, and Xie 2011; Song and Li 2014; Kinnan, Wang, and Wang 2018; Jin 2018; Jin and Zhang 2023) or variations in the strictness of the *hukou* system across regions (Fan 2019; Zhang, Wang, and Lu 2019), these measures are only available in the reform era (i.e., after the late 1990s) and do not allow us to examine whether and how the consequences of migration barriers can persist for a long time. Moreover, these post-reform measure quantifies the average migration barriers, including rural-urban and urban-urban migration barriers, while our pre-reform measure quantifies rural-urban migration barriers only. Finally, post-reform measures usually raise concerns owing to unspoken rules and mostly measure city-level rather than county-level migration barriers due to data limitations (Jin and Zhang 2023), which can be mitigated by the pre-reform measure. To some extent, our county-level pre-reform measure is complementary to the existing city-level post-reform measures in quantifying Chinese internal migration barriers.

[5] Our IV approach shares the same spirit of previous valid instruments based on variations in geographical distance (Becker and Woessmann 2009; Nunn and Wantchekon 2011; Chen, Kung, and Ma 2020). For example, Becker and Woessmann (2009) use distance to Wittenberg, the home town of Martin Luther, as an IV for Protestantism. Nunn and Wantchekon (2011) use the historical distance from the coast of an individual's ethnic group as an instrument for slave exports.

[6] In 1949, after losing control of mainland China in the Chinese Civil War, the Republic of China (ROC) government under the Kuomintang (KMT) withdrew to Taiwan.

[7] In fact, two separate crises occurred in the Taiwan Straits during the 1950s, with the first occurring between 1954 and 1955.

system aforementioned. An important assumption for the validity of the instrument is that, conditional on observable characteristics (e.g., exposure to foreign trade, exposure to policies enacted by the central government, industrial structures, human capital stocks, etc.), firm-level outcomes are independent of the geographical distance between the mainland Chinese cities where these firms are located and Jinmen. We provide some empirical validation of the IV assumption.

The main findings of the study are as follows. First, we find that rural-urban migration barriers in the pre-reform era substantially increase average labor productivity among urban manufacturing firms in the long run. Our IV estimate shows that a one-standard-deviation increase in the strength of rural-urban migration barriers increases the average labor productivity by 22%. Second, the impact is more pronounced for domestic firms but becomes insignificant for foreign firms. Third, increased adoption of 'management technology" such as pay for performance, rather than using more capital and skilled workers, is a likely underlying mechanism. Finally, we show that a one-standard-deviation increase in the strength of rural-urban migration barriers leads to an increase of 10.8% in total factor productivity. These findings all suggest that such rural-urban migration barriers can enhance efficiency through the adoption of performance-based reward systems within firms in a developing country.

This study makes several important contributions. First, it sheds light on the ambiguous impact of migration barriers on long-run productivity (Hsieh and Klenow 2009; Acemoglu 2010; Hornbeck and Naidu 2014; Tombe and Zhu 2019). Notably, previous findings are mostly based on theoretical and simulation-based analysis rather than real-world policies. Second, it contributes to filling a research gap regarding the impact of migration barriers on the adoption of performance-based reward systems, complementing previous studies on the factors that determine differences in the adoption of management practices across sectors and firms (Bloom and Van Reenen 2010; Bloom et al. 2019; Frederiksen and Manchester 2020). Finally, this study adds to a growing literature on the causal impact of the adoption of pay for performance on firm productivity. While long-standing theoretical literature acknowledges the importance of pay for performance (Stiglitz 1975; Baker 1992; Lazear 2000), little is known about how the firm-level adoption of pay for performance works, particularly in developing countries (Guiteras and Jack 2018; Cai et al. 2022).

2 Rural-Urban Migration Barriers and Its Economic Effects

Shortly after the founding of People's Republic of China, the Chinese authority established the household registration system (also known as the *hukou* system) in urban areas in July 1951,

which was further extended to rural areas in June 1955. Under this system, individuals in rural areas were classified as agricultural *hukou* (AH) holders, while individual in urban areas were classified as non-agricultural *hukou* (NAH) holders. Both AH and NAH holders were generally free to migrate until 1958 when the Chinese authority adopted an "internal passport" policy in order to control rural-urban migration and since then the policy became an integral part of the *hukou* system. Owing to this policy, AH holders were prohibited from migrating to the urban destinations unless they obtained a NAH, access to which was strictly controlled by the central government through an annual quotas system. In particular, the annual quotas system requires that the maximum number of AH holders who can obtain a NAH annually accounts for no more than 0.2 percent of the stocks of NAH holders in each locality.

Such an "internal passport" policy witnessed some initial relaxations from the mid-1980s when AH holders were de jure allowed to work temporarily in urban destinations without obtaining a NAH (or local *hukou*). However, these migrants without obtaining a NAH were denied access to local welfare benefits such as children's education, healthcare and pension. Obtaining a NAH remained difficult for most AH holders until the late 1990s when the Chinese authority reformed the "internal passport" policy in towns and small cities by substituting a rigid annual quotas system with a quota-free system de jure and lowers entry requirements for NAH application. Unlike the previous, rigid annual quotas system, the new system does not restrict the total number of people who can obtain a NAH in destinations de jure, nor does it set age and education (skill) limits for the application of a NAH. Similar reforms were gradually extended to some medium and large cities in the 2000s, and were finally extended to the remaining cities in July 2014 except for a few mega-cities such as Shanghai and Beijing.

Conceptually, such migration barriers can affect long-run firm productivity through two opposing forces. On the one hand, the higher migration barriers prevent people from moving to more productive sectors and firms, in turn negatively affecting average firm productivity in urban destinations in the long term (Hsieh and Klenow 2009; Tombe and Zhu 2019; Bryan and Morten 2019). We call it a labor misallocation effect. On the other hand, the higher migration barriers reduce relative supply of unskilled workers (i.e., rural-urban migrants) to the urban destinations, which may raise the average firm productivity by encouraging local firms to adopt more labor-saving technologies, including 'management technology' such as pay for performance (Acemoglu 2010; Hornbeck and Naidu 2014; Clemens, Lewis, and Postel 2018; Imbert et al. 2022; Danzer, Feuerbaum, and Gaessler 2024). We call it a technological choice effect. Given the theoretically ambiguous effects of migration barriers on long-run firm

productivity, seeking empirical evidence is important. Apart from examining the causal impact of rural-urban migration barriers on long-term firm productivity in urban destinations, this article attempts to uncover the likely aforementioned mechanism.

3 Data Sources and Variables

To construct the rural-urban migration barriers variable, we use a 1% random sample of the 1982 Chinese Population Census, conducted by the National Bureau of Statistics of China. Specifically, we use the percentage of rural residents in the local population in 1982 to measure rural-urban migration barriers in the pre-reform era across counties.[8] Counties with a higher percentage of rural residents in the local population experienced higher rural-urban migration barriers in the pre-reform era on average. An obvious advantage of using rural-urban migration barriers in the pre-reform era is that such migration barriers were directly regulated by the central government through an annual quota system aforementioned and the local governments did not have the autonomy to change the local migration barriers by themselves until the late 1990s.

To construct the firm-level variables, we use an investment climate survey for firm managers conducted by the World Bank between July and November 2005. The survey covers 12,400 Chinese manufacturing firms in 1,137 counties, located in all provinces, autonomous regions, and directly administrated cities, with the exception of Tibet.[9] The survey covers a broad range of firm-level information, including firm age, ownership, industry, employee wage components, labor conditions, financial statements, and labor statistics. We focus on two variables: pay for performance and firm productivity. We define the pay for performance variable as the extent to which each firm adopts bonuses and piece-rate wages for permanent workers. Firms with a higher percentage of bonuses and piece-rate wages in permanent workers' total compensation are identified as having greater adoption of pay for performance. We use total sales per worker to measure firm-level labor productivity in the benchmark analysis, combined with firm-level total factor productivity for additional checks (Levinsohn and Petrin 2003; Ackerberg, Caves, and Frazer 2015).[10] After matching firm-level data in 2005 with the rural-urban migration barriers variable in 1982 through the adjusted county-level IDs, we

[8] The 1982 Chinese Population Census only provides information on whether or not an individual was residing in rural areas. Given that it was very difficult for AH holders to migrate to urban areas in the early 1980s, we use information on whether individuals were residing in rural areas or not to proxy for whether they were AH holders or not. In fact, less than 1% of the total population were living away from their registered places in 1982. We also use the 1990 Chinese Population Census and the 2000 Chinese Population Census, which provide information on whether an individual was an AH holder or not, to construct rural-urban migration barriers in 1990 and 2000 for robustness checks.

[9] More information on the survey methodology can be found at http://www.enterprisesurveys.org/Methodology.

[10] We will further resort to another firm-level census data (i.e., Chinese Annual Survey of Industrial Firms, 1999–2007) for robustness checks, mitigating the concern regarding labor productivity measurement error.

identify a final sample of 11,100 firms, located in 1,036 counties.

We complement our main analysis with the Chinese Annual Survey of Industrial Firms (1999–2007), constructed by the National Bureau of Statistics of China. This survey includes all industrial firms that are owned by the state or have sales above 5 million RMB. It covers all industrial sectors, including the mining sector, and accounts for roughly 88% of the national industrial output. The survey contains extensive information about firm production, including total output, employment, wages, assets, total sales, exports, and so on, but little information on management practices.[11] We construct a balanced panel data set of 25,951 firms located in about 1,700 counties for each year from 1999 to 2007. These additional data help to mitigate the concern regarding error arising from measuring labor productivity based on survey data, and they also allow us to study the heterogeneous impacts of rural-urban migration barriers on firm productivity by groups or over time.[12]

Finally, we construct several other important variables as follows. (1) We use the China City Statistical Yearbook (1985–1986), also provided by the National Bureau of Statistics of China, to construct other city-level variables, such as industrial structures (e.g., ownership, size, type), local quality of infrastructure (e.g., railway passenger traffic, highway passenger traffic, number of subscribers of telephones), local human capital stocks (e.g., total registered population, number of scientists, number of social scientists), and foreign direct investments in 1984, and total exports in 1985, the earliest city-level official data available to us. (2) We use hand-collected archival data on the number of universities and colleges in each mainland city in 1949 to proxy for human capital stocks accumulated prior to the establishment of the PRC. (3) We use hand-collected archival data on the date of KMT's defeat by the CPC in each Chinese mainland city during the civil var to construct a dummy variable indicating whether the armed conflict of civil var ended before October, 1949 in each city. (4) We construct a measure of the severity of Cultural Revolution at the county level following the literature (Walder and Lu 2017; Chen et al. 2020) (5) We use geographic coordinates (i.e., latitude and longitude) of each location to generate geographical distance variables such as distance to Jinmen, distance to coastline, and distance to Beijing. **Appendix A1 (Table A1)** reports summary statistics for the main variables.

4 Model Specification and Identification Strategy

[11] Several studies, including Bloom et al. (2018) and Hau et al. (2020), have tried to match other survey data about management practices in 564 Chinese firms sampled in 2006, 2007, 2008, and 2010 by Bloom and Van Reenen (2010). However, the sample size of this data set is too small to conduct our analysis.

[12] In fact, we find similar results using different firm-level data sets, reducing the concern of measurement error regarding labor productivity.

To examine the causal impact of rural-urban migration barriers on long-run firm productivity, we use the following two-stage least squares model:

$$T_c = \beta_T^Z \cdot Z_c + \beta_T^K \mathrm{K_{ic}} + \varepsilon_{ic} \quad (1)$$

$$Y_{ic} = \beta_Y^T \cdot T_c + \beta_Y^K \mathrm{K_{ic}} + \eta_{ic} \quad (2)$$

where Y_{ic} is the logarithm of total sales per worker (or total factor productivity) for each firm i in county c. T_c is the strength of rural-urban migration barriers in county c, defined as the percentage of rural residents in the local population in each county in 1982. Z_c is our IV, defined as the geographical distance between the centroid of each mainland Chinese city where county c is located in and the centroid of Jinmen. K_{ic} refers to firm characteristics such as age, skill of the general manager, ownership dummies, 2-digit industry dummies for firm i in county c, the logarithm of the geographical distance between the county c in which firm i is located and the coastline, and the logarithm of the geographical distance between the county c in which firm i is located and Beijing. ε_{ic} and η_{ic} are error terms. β_Y^T is the parameter of interest. We cluster standard errors at the county level.[13]

Estimating the causal impact of rural-urban migration barriers on firm-level productivity presents some empirical challenges. Firms may self-select into localities exposed to different rural-urban migration barriers, resulting in reverse causality issues that consequently make the OLS estimate biased and inconsistent. Additionally, firms may differ in terms of production technology. If production technology is relevant for rural-urban migration barriers, omitting this variable also makes the OLS estimate biased and inconsistent.

Our IV approach takes advantage of plausible exogenous variations in the changes in the stocks of NAH holders prior to adopting the internal passport policy. Specifically, we use the geographical distance between the centroid of each mainland Chinese city and the centroid of Jinmen to capture the city-level exposure to the risks of armed conflict between mainland China and Taiwan in the Taiwan Strait in the 1950s. The rationale is that mainland Chinese cities closer to Jinmen were exposed to more risks of armed conflict and probably received fewer industrial investments from the central government from 1949 to 1957. Given that industrial investments and the resulting labor demand in the industrial sector largely determines the changes in the stocks of NAH holders before 1958, a shorter distance between a mainland Chinese city and Jinmen leads to fewer number of NAH holders and in turn higher rural-urban migration barriers in the pre-reform era due to the annual quota system aforementioned.

[13] To test whether our results are robust to alternative standard errors, we apply Conley standard errors to account for spatial autocorrelation (Conley 1999; Conley 2008). We find that the coefficient of interest remains significant. Conley standard errors were estimated using the *spatial_hac_iv* command for Stata (Foreman 2020).

The validity of the IV depends on two important assumptions. The first is that the geographical distance between the centroid of each mainland Chinese city where a firm is located and the centroid of Jinmen is negatively associated with the rural-urban migration barriers variable (relevance assumption). The second is that, conditional on observable characteristics (e.g., exposure to foreign trade, exposure to policies enacted by the central government, industrial structures, human capital stocks, etc.), the IV affects firm-level outcomes only through the rural-urban migration barriers variable (exclusion restriction assumption). While we can directly test the first assumption empirically,[14] testing the second assumption is more challenging. Although it is empirically impossible to rule out all other factors that vary with distance to Jinmen and could be correlated (even incidentally) with labor productivity, it is possible to test some of the mostly likely channels that may threaten the validity of our instrument. We provide some empirical validation of the IV assumption as follows.

First, regions with a high versus low distance from Jinmen may differ from one another in characteristics that are not observed. We address this concern by controlling for and investigating several likely factors through which the IV may affect labor productivity in the 2000s:

(1) Exposure to foreign trade. Distance to Jinmen (IV) may be correlated with other geographical characteristics such as distance to coastline and thus exposure to foreign trade. In addition to controlling for the geographical distance to coastline, we further control for total exports and foreign direct investments at the city level.

(2) Exposure to policies enacted by the central government. Distance to Jinmen may be correlated with other geographical characteristics such as distance to the capital of the PRC and thus exposure to policies enacted by the central government. In addition to controlling for distance to Beijing, we further control for a dummy variable indicating whether the armed conflict of civil war ended before October 1, 1949. Intuitively, the central government may be in favor of cities the ending the armed conflict of civil war at an earlier point in time.

(3) Industrial structures. The government may have enacted other industrial policies to support the military industry or related industries in locations close to Taiwan, and firms closer to Taiwan may be more likely to be state-owned or in different industries. To mitigate these concerns, we control for industrial structures (e.g., state-owned versus non-state-owned, heavy

[14] In addition to testing the overall relationship between the IV and the rural-urban migration barriers variable, we further check whether or not this relationship occurs over a plausible distance.

industry versus light industry, large firms versus small firms) at the city level.

(4) Human capital stocks. To allow for the possibility that distance to Jinmen affects human capital stocks and therefore labor productivity, we control for the number of universities and colleges in each mainland city in 1949 accumulated prior to the establishment of the PRC, the number of scientists, the number of social scientists, and the total population.

(5) Quality of infrastructure. To allow for the possibility that distance to Jinmen affects investments in local infrastructures and therefore labor productivity, we control for railway passenger traffic per capita, highway passenger traffic per capita, and the number of telephone subscribers per capita at the city level.

(6) Cultural Revolution. To allow for the possibility that distance to Jinmen affects Cultural Revolution and therefore labor productivity, we control for the local intensity of the Cultural Revolution (Walder and Lu 2017; Chen et al. 2020). If including all of these control variables does not significantly affect our parameter of interest, then the IV exclusion restriction assumption is more likely to be satisfied in our context.

As an additional test, we further regress the measure of past human capital stocks, timing of ending the armed conflict of civil war, and local intensity of the Cultural Revolution on the IV with included controls, respectively. If the instrument is valid, we should not find significant impact of the IV on these variables.

Second, to mitigate the concern that the IV may affect local firm productivity through other unobservable factors e.g., the rapid development of coastal area in China due to global trade, we construct two counterfactual IVs based on the geographical distance between each mainland Chinese city and major Chinese coastal ports that are adjacent to Hong Kong (e.g., Shenzhen port) or Macau (e.g., Zhuhai Port) for placebo analyses. Unlike Taiwan, neither Hong Kong (under British rule until 1997) nor Macau (under Portuguese rule until 1999) was exposed to risks of armed conflict with the mainland China. If our benchmark estimates, that is, using distance to Jinmen IV, are mainly driven by unobservable factors correlated to the rapid development of coastal area in China due to global trade, then it is very likely that we will find similar estimates when using these placebo IVs. Otherwise, the IV exclusion restriction assumption is less likely to be a concern in our context.

Third, to allow for the possibility that the placebo IVs do not entirely address the concern that the exclusion restriction assumption is not satisfied (e.g., the risk of war itself causes nearly places to be different from faraway places in other unobserved way), we propose a new IV

based on the city-level access to the 156 Projects,[15] through which the Soviet Union helped China to establish the initial foundation of its socialist industrialization during its "First Five-Year Plan" period (1953–1957). The 156 Projects were unevenly adopted across Chinese cities, largely determined by factors such as proximity to resources, ability to change economically underdeveloped areas, and military considerations (Bo 1991).

To measure a mainland Chinese city's access to the 156 Projects, we manually extract a data set from a number of historical studies (Dong and Wu 2004; Chen 2020). This data set contains information such as the name, industry, geographical location (city-level), and total amounts of investments received from the central government for each industrial project. We then construct a dummy variable to capture whether a city had any access to the 156 Projects from 1953 to 1957. Differing from our main IV (i.e., distance to Jinmen), the new IV takes advantage of a plausible exogenous policy shock on industrial investments aided by the Soviet Union. Based on our data, the correlation between the distance to Jinmen IV and the 156 Projects IV is 0.4432, suggesting that a shorter distance to Jinmen is associated with a lower probability of having access to the 156 Projects. The additional IV allows us to (a) estimate and compare the parameter of interest using different IVs and (b) test the validity of instruments through the Hansen overidentification test.[16]

5 Empirical Results

5.1 Impact of Rural-Urban Migration Barriers on Long-run Firm Productivity

Table 1 reports the main results. Columns 1 and 2 show the OLS estimate of the impact of rural-urban migration barriers in the pre-reform era on firm productivity. Without controlling for additional variables, we find that the coefficient of interest is −0.0006. After we control for other firm-level characteristics, the coefficient increases slightly to -0.0004. Neither coefficient is statistically significant at the conventional level.

As discussed above, the OLS estimate may be biased owing to endogeneity problems. Column 3 shows the IV estimate. We find that the coefficient of interest increases substantially to 0.0052, suggesting that a one-standard-deviation increase in the strength of rural-urban

[15] The 156 Projects Soviet aid program was intended to develop China's economy and to organize it along Soviet lines. As part of its First Five-Year Plan (1953–1957), China was the recipient of the most comprehensive technology transfer in modern industrial history. The Soviet Union provided aid for 156 major industrial projects concentrated in mining, power generation, and heavy industry. Following the Soviet model of economic development, these projects were large-scale, capital-intensive undertakings. By the late 1950s, China had made substantial progress in such fields as electric power, steel production, basic chemicals, and machine tools, as well as in the production of military equipment such as artillery, tanks, and jet aircraft (Worden, Savada, and Dolan 1987).

[16] An alternative approach is using heteroscedasticity to construct an additional IV (Lewbel 2012); however, this approach does not work in our context. As Baum and Lewbel (2019) indicate, it is almost always preferable to use any available external instruments rather than constructed instruments such as those of Lewbel (2012) owing to the greater difficulty of confirming that constructed instruments are valid.

migration barriers improves the average firm productivity by 22%. The OLS estimate is biased downward for at least two reasons. First, the more-productive firms are more likely to relocate to where rural-urban migration barriers are lower to improve access to labor resources, resulting in reverse causality issues. Second, firms differ in their production technology, and omitting this variable causes the OLS estimate to be biased downward.

The first stage results reported in Column 4 show that a one-standard-deviation increase in the geographical distance between each mainland Chinese city and Jinmen leads to rural-urban migration barriers that are 13.3 units lower on average, which accounts for about 22.8% of the average rural-urban migration barriers across counties. The bottom rows of **Table 1** report the results of the weak identification test and the endogeneity test. The Kleibergen-Paap rk Wald F statistic is 57, leading us to reject the null hypothesis that the IV suffers from weak identification problems. Moreover, the p-values from the endogeneity test of endogenous regressors lead to rejecting the null hypothesis that the OLS estimator is consistent and efficient at the 5% level. This evidence collectively does not reject the validity of our IV approach.

To rule out the possibility that the IV may not be plausible beyond or below a limited number of kilometers from Jinmen, we further explore the first stage and reduced form results in more detail to confirm that the effects identified occur over a plausible distance (and over the same distances). First, we focus on cities that are at least 300, 500, and 800 km from Jinmen, respectively (Columns 1–6 of **Table 2**). Second, we focus on cities that are at most 3,500, 3,000, and 2,500 km from Jinmen, respectively (Columns 7–12 of **Table 2**). Third, we focus on cities that are between 800 and 2,500 km from Jinmen (Columns 13 and 14 of **Table 2**). All these findings confirm that the first stage and reduced form effects occur over a plausible distance (and over the same distances).

To mitigate the concern that regions with a high versus low distance from Jinmen differ from one another in characteristics that are not observed, we control for and investigate some of the mostly likely channels (see Section 4) through which the IV may affect labor productivity. After controlling for all of the factors that are observable, we find that the coefficient of interest changes slightly from 0.0052 to 0.0054 (Columns 1 to 7 of **Table 3**), suggesting that omitting these factors have minimal impact on our main findings.

We further regress the measures of timing of ending the armed conflict of civil war, past human capital stocks, and local intensity of Cultural Revolution on the IV with the included controls, respectively. We find that the distance to Taiwan had no obvious impact on all of these variables (Columns 8 to 10 of **Table 3**), further mitigating concern that the IV assumption is

violated.

Considering that the IV may affect local firm productivity through other factors that are unobservable (e.g., the rapid development of coastal area in China due to global trade), we move a little further by constructing two counterfactual IVs based on the geographical distance between each mainland Chinese city and major Chinese coastal ports that are adjacent to Hong Kong (e.g., Shenzhen port) or Macau (e.g., Zhuhai Port) for placebo analyses. Using these placebo IVs, we find that the coefficient of interest is 0.0012 for Hong Kong and 0.0006 for Macau.[17] Both values are much smaller than the benchmark result, and neither is statistically significant at the conventional level (Columns 11 and 12 of **Table 3**). These findings further mitigate the concern that the IV exclusion restriction assumption is violated in our context due to some unobservable factors.

Given that the placebo IVs do not entirely address the concern that the exclusion restriction assumption may be violated, we propose a new IV based on a plausible exogenous policy shock on industrial investments aided by the Soviet Union (i.e., the 156 Projects) from 1953 to 1957. We start by comparing the coefficient of interest using two different IVs. Using the adoption of the 156 Projects as an instrument, we find that the coefficient of interest is 0.0031 (Column 13 of **Table 3**), which is close to the benchmark result. The first stage and reduced-form results also confirm that the adoption of the 156 Projects leads to lower rural-urban migration barriers and long-term labor productivity, respectively (Columns 14 and 15 of **Table 3**). Additionally, we exploit both instruments to test the validity of IVs. We find that the coefficient of interest is 0.0039 (Column 16 of **Table 3**). The bottom row of **Table 3** reports results of the Hansen overidentification test (p-value is 0.3181), which fails to reject the null hypothesis that the instruments are valid. All of these exercises suggest that the exclusion restriction assumption is not likely to be violated in our context.

Overall, we provide consistent evidence that rural-urban migration barriers in the pre-reform era substantially increase firm productivity, which contradicts the conventional wisdom that considers migration barriers as sources of labor misallocation and low productivity, particularly in developing countries (Hsieh and Klenow 2009; Tombe and Zhu 2019; Bryan and Morten 2019) but aligns with the argument that labor scarcity could potentially drive technological progress if new (management) technologies are strongly labor-saving (Acemoglu 2010; Danzer, Feuerbaum, and Gaessler 2024).

[Place Tables 1,2 and 3 about here]

[17] We also find no significant effect of these counterfactual IVs on labor productivity (the reduced form estimates).

5.2 How Do Rural-Urban Migration Barriers Improve Firm Productivity?

Various reasons may explain the increase in firm productivity in localities with relatively higher rural-urban migration barriers. One of them is that rural-urban migration barriers induce low-productivity firms to adopt more labor-saving technologies (Acemoglu 2010; Hornbeck and Naidu 2014; Clemens, Lewis, and Postel 2018; Danzer, Feuerbaum, and Gaessler 2024). Existing studies have shown that the adoption of pay for performance substantially increases workers' productivity (Lazear 2000; Shearer 2004), and we further explore whether the adoption of pay for performance, an important component of management practices (Bloom, Sadun, and Van Reenen 2016), is a likely underlying mechanism whereby rural-urban migration barriers improve firm productivity.

We now estimate the causal impact of rural-urban migration barriers in the pre-reform era on firms' adoption of pay for performance, where

$$M_{ic} = \beta_M^T \cdot T_c + \beta_M^K \mathrm{K}_{ic} + \epsilon_{ic} \quad (3)$$

is identical to equation (2), except M_{ic} replaces Y_{ic}. The first-stage equation (1) remains the same as before. M_{ic} is the intensity of pay for performance adopted by firm i in county c, defined as the percentage of bonuses and piece-rate wages in total compensation given to permanent workers. β_M^T is the parameter of interest. We cluster standard errors at the county level.

Table 4 reports the main results. Columns 1 and 2 show the OLS estimate of the impact of rural-urban migration barriers on firms' adoption of pay for performance. The coefficient of interest is 0.0989, without any control variables. After we control for other variables, the coefficient of interest is 0.0920. As discussed earlier, the OLS estimates are still likely to be biased due to endogeneity problems. With the use of the same IV approach, the coefficient of interest increases substantially to 0.4080 (Column 3 of **Table 4**), suggesting that a one-standard-deviation increase in the strength of rural-urban migration barriers leads to an increase of 17.6 units in the intensity of pay for performance on average. Further details on the first-stage results, reduced-reform results, and relevant tests for the IV are presented in **Table 4**.

[Place Table 4 about here]

Here, the extent to which rural-urban migration barriers affect firm productivity through the adoption of pay for performance remains unclear, and a mediation analysis is needed. A mediation model consists of a treatment variable T, a final outcome Y, and a mediating variable M, which represents a mechanism through which T affects Y. Essentially, mediation models decompose the "total effect" of T on Y into a "direct effect" and an

"indirect effect" running through M. Traditional approaches to mediation analysis assume that both T and M are exogenous (Baron and Kenny 1986; MacKinnon 2008). However, such approaches cannot deal with setups in which T, M, or both *T* and *M* are endogenous.

We therefore employ an identification framework for a causal mediation analysis in IV settings, as developed by Dippel et al. (2019, 2020), which enables using the same IV Z to assess the causal effect of intermediate outcome M on final outcome Y. We further estimate the following two-stage model:

$$M_{ic} = \gamma_M^Z \cdot Z_c + \gamma_M^T \cdot T_c + \gamma_M^K \mathrm{K_{ic}} + \epsilon_{ic} \quad (4)$$

$$Y_{ic} = \beta_Y^M \cdot M_{ic} + \beta_Y^T \cdot T_c + \beta_Y^K \mathrm{K_{ic}} + \eta_{ic} \quad (5)$$

The estimation procedure associated with equations (1) and (2) is the standard IV approach. By contrast, the estimation procedure associated with equations (4) and (5) is novel to the framework of Dippel et al. (2019), where Z_c is our IV to identify the causal effect of M_{ic} on Y_{ic} when conditioned on T_c. All variables are the same as before. β_Y^M and β_Y^T are the coefficients of interest. We cluster standard errors at the county level.

According to Dippel et al. (2019), identifying β_Y^M and β_Y^T using a single instrument variable Z_c requires an additional partial confounding assumption; that is, unobserved confounding variables that jointly cause the treatment and the intermediate outcomes (first causal relation) are independent of the confounders that cause the intermediate and the final outcomes (second causal relation). In our context, confounders in the first causal relation capture unobserved characteristics of people who work in the industrial sector. The greater adoption of pay for performance could be due to workers' values and beliefs (e.g., collectivism versus individualism) or to rural-urban migration barriers. By contrast, the confounders in the second causal relation represent firms' production technology that supports both pay for performance adoption and firm productivity. If workers' values and beliefs are uncorrelated with firms' production technology, the partial confounding assumption is likely to hold.

Table 5 reports the main results. Panel A presents the results of the second-stage equation (4). Column 1 assesses the mediating effect changes in the adoption of pay for performance. The point estimate $\hat{\beta}_Y^M$ in column 1 indicates that a 10-percentage-point increase in the intensity of pay for performance improves the average firm productivity by 17.6%. This is the overall effect of the adoption of pay for performance on firm productivity, whether caused by rural-urban migration barriers or not.

The real importance of the point estimates $\hat{\beta}_Y^M$ lies in generating the indirect effect $IE = \hat{\beta}_Y^M \times \hat{\beta}_M^T$. Panel B of **Table 5** reports this, along with the other relevant parameters of the

mediation model. The $\hat{\beta}_M^T$ of rural-urban migration barriers on the adoption of pay for performance is estimated in **Table 5** to be 0.41. IE represents the effect of changing the adoption of pay for performance, which was caused by rural-urban migration barriers, on firm productivity. If the strength of rural-urban migration barriers increases by one standard deviation, the intensity of pay for performance also increases, which in turn increases firm productivity by 31%. Relating this to the total effect of rural-urban migration barriers on firm productivity estimated in **Table 5**, the adoption of pay for performance can, as mediator *M*, explain around 140% of the overall effect of rural-urban migration barriers on firm productivity. β_Y^T and $\beta_M^T \cdot \beta_Y^M$ add up to the effect estimated in **Table 5** (i.e., DE+IE=TE).

[Place Table 5 about here]

The indirect effect of rural-urban migration barriers being larger than the total effect implies a moderating direct effect, whereby larger rural-urban migration barriers cause lower firm productivity through channels unrelated to the adoption of pay for performance (e.g., labor misallocation). This suggests that rural-urban migration barriers would have a stronger efficiency-enhancing effect if they affected the adoption of pay for performance alone. But the effect would be different: rural-urban migration barriers would not positively affect or might even adversely affect firm productivity if the impact of rural-urban migration barriers on the adoption of pay for performance could be mitigated (e.g., widespread adoption of performance-based reward systems across firms).

5.3 Heterogeneous Effects of Rural-Urban Migration Barriers

To further explore whether the effects of rural-urban migration barriers change over time, we use the Chinese Annual Survey of Industrial Firms (1999–2007) and construct a balanced panel data set of 25,951 firms located in about 1,700 counties in each year from 1999 to 2007. Panel A of **Table 6** reports the main results. Using the same IV approach, we find that the effects of rural-urban migration barriers on firm productivity are robust over time. The similar results using an alternative dataset also mitigate the concern regarding firm productivity measurement error. Moreover, we report the dynamic impacts of rural-urban migration barriers on firm productivity by firm ownership in Panels B to D of **Table 6**. We find that, in contrast to private Chinese firms that experienced a slight decline in the impact of rural-urban migration barriers on firm productivity over time (Panel B), the impact is growing larger over time among state-owned enterprises (Panel C). These contrasting findings are consistent with the fact that state-owned enterprises lag behind private Chinese firms with respect to the adoption of performance-based reward systems within firms. Moreover, the dynamic impact of rural-urban

migration barriers on firm productivity is negative and is not statistically significant at the conventional level in most cases among foreign-owned firms (Panel D), consistent with the advantaged adoption of performance-based reward systems by foreign-owned firms over other domestic firms during that period. These findings together imply that the positive impact of rural-urban migration barriers on firm productivity largely depends on the adoption of performance-based reward systems within firms.

[Place Table 6 about here]

5.4 Competing Mechanisms

As mentioned before, various reasons may explain the rising firm productivity in localities with relatively higher rural-urban migration barriers. To further mitigate the concern that the positive impact of rural-urban migration barriers on firm productivity is driven by other competing mechanism, we further analyze the effects of rural-urban migration barriers in the pre-reform era on several firm-level outcomes such as capital-labor ratio, skill composition of employees, and technology adoption in terms of computer use. Using the same IV approach, we find no obvious evidence that rural-urban migration barriers affects local firms' capital-labor ratio and the percentage of employees who regularly use computers. By contrast, we find that rural-urban migration barriers decrease the percentage of employees with high school education or above and the percentage of employees with college education or above in the firms. All of these findings mitigate the concern that rural-urban migration barriers affect firm productivity through alternative channels such as using more capital and skilled workers, and further supports that the adoption of pay for performance is an underlying mechanism through which rural-urban migration barriers positively affect firm productivity in the long term. Further details on the estimation results can be found in **Appendix A4** (**Table A4**).

5.5 Why do Pre-reform Migration Barriers Matter?

There are several reasons regarding the persistence of migration barriers over time. Firstly, early reforms of the "internal passport" policy concentrated on facilitating labor migration without *hukou* conversion. A recent study by Jin and Zhang (2023) empirically shows that policies that prevent rural migrants from obtaining a local *hukou* in urban destinations can substantially discourage rural-urban migration. Secondly, the relaxation of entry requirements for obtaining a local hukou was very gradual, lasting for more than two decades. Indeed, our data confirms the persistence of migration barriers over time from 1982 to 2000. For instance, the correlation between migration barriers in 1982 and 2000 is 0.69, aligns with the fact that the relaxation of migration barriers was very gradual. Thirdly, to mitigate the concern that firms

exposed to the same migration barriers may experience various degree of labor scarcity due to heterogeneous labor demand shocks induced by China's accession to WTO, we further investigate the impact of migration barriers on the probability of suffering from labor shortage among manufacturing firms. Our findings show that a one-standard-deviation increase in the strength of migration barriers increases firms' probability of suffering from labor shortage by 3.3 percentage points, which further supports our main argument that the labor supply consequences of pre-reform migration barriers can persist for a longer period. Further details on the estimation results can be found in **Appendix A6** (**Table A6**).

5.6 Do Migration Barriers Optimize the Use of Other Inputs?

Up to now, our analysis concentrates on whether and how migration barriers affect the optimization of labor input within manufacturing firms. It remains unclear whether or not the labor productivity gains of migration barriers also apply to the use of other inputs within firms. To address this issue, we construct measures of total factor productivity (Ackerberg, Caves, and Frazer 2015), and estimate the impact of migration barriers on total factor productivity using the similar empirical strategies. Our findings show that a one-standard-deviation increase in migration barriers leads to an increase in total factor productivity by 10.8 percent. As a result, migration barriers optimize the use of all inputs within manufacturing firms. Again, we find that the adoption of performance-based reward system is an underlying mechanism behind. Further details on the estimation results can be found in **Appendix A5** (**Table A5**).

5.7 Do Migration Barriers Affect Management Technology Adoption?

Management technology within firms not only consist of performance-based pay but also promotion and demotion. To mitigate the concern that pay for performance variable cannot fully capture the management technology adoption within firms, we resort to additional management practices outcomes. Specifically, we observe four management practice variables that can be used to assess management technology adoption mechanism M: (i) Percentage of bonuses and piece-rate wages among permanent workers, (ii) Whether or not the general manager (GM)'s annual income is directly related to the company's performance, (iii) Whether or not demoted mid-level managers in the past 3 years, and (iv) For employees who received a wage increase, the percentage of employees who received a promotion in the previous year. Each of those variables could qualify as mediator, but our empirical approach allows for identifying the mediating effect of one M per T and Z only.[18] We therefore aggregate the

[18] Causally disentangling the mediating effects of different variables would require additional instruments, while omitting mediating channels from the model does not bias the estimates for M (Dippel et al. 2019).

observed management practice variables into principal components and focus on the mediating effects of management practices adoption M in the aggregate. A principal component analysis is attractive because it generates indices that are purely statistical measurements based on the total variation in management practice outcomes, and are orthogonal to one another by construction. We label the principal components as 'Management technology components' (MTCs).

One can best interpret the MTCs through their relation to the observed management practice outcomes, i.e., their factor loadings reported in Table A7. By construction, there are as many MTCs as variables but following the Kaiser-Guttman criterion, it is common to regard only principal components with an eigenvalue larger than 1. This holds for the first MTC. In our data, MTC_1 explain about 34% of the variation in the management practice data. Therefore, we focus on MTC_1 as our key mechanism M that plausibly captures the core management practice adjustments to migration barriers. Using the similar empirical approach, we show that a one-standard-deviation increase in the strength of migration barriers increases MTC_1 by 0.51, equivalent to 43% of its standard deviation. Moreover, the adoption of management technology can, as mediator *M*, explain around 120% of the overall effect of rural-urban migration barriers on firm productivity. Further details on the estimation results can be found in **Appendix A7** (**Table A7**).

5.8 How do Migration Barriers Facilitate Management Technology Adoption?

We explore further the underlying mechanism by which migration barriers foster the adoption of management technologies. One plausible explanation is that firms located in cities with higher migration barriers are incentivized to target external product market (e.g., other cities, foreign markets) rather than internal ones (e.g., local market). These firms, facing more competitive external market, are more likely to adopt advanced management technologies to enhance their competitiveness. In contrast, firms that focus on local markets may be more influenced by non-market forces, especially during periods when demand from the public sector is significant.

Our empirical analysis reveals that a one-standard-deviation increase in the strength of rural-urban migration barriers leads to a 16.9 percentage-point increase in the share of products sold to other cities and countries, representing a 22% increase from the sample mean. Additionally, a one-standard-deviation increase in the strength of rural-urban migration barriers results in a 15.7 percentage-point decrease in the share of products sold to government entities and state-owned enterprises, accounting for 69% of the sample mean. Further details

on these results can be found in **Appendix A8** (**Table A8**) and **Appendix A9** (**Table A9**).

5.9 Do Migration Barriers Affect Firm Size and Firm Creation?

We further investigate how firm size and firm creation respond to migration barriers. For example, a more competitive product market may stimulate the expansion of existing firms as well as the creation of new ones. Our empirical analysis shows that a one-standard-deviation increase in the strength of rural-urban migration barriers leads to a 39.7 percent increase in firm employment. Additionally, the same increase in the strength of rural-urban migration barriers raise the probability of new firm creation (i.e., firms established within the past three /five years) by approximately 0.8 to 1.2 percentage points. Further details on these results are provided in **Appendix A10** (**Table A10**) and **Appendix A11** (**Table A11**).

5.10 Robustness Checks

We conduct several robustness checks for the main findings. First, we use the following alternative measures of rural-urban migration barriers: (1) the percentage of AH holders in the local population in 1990, provided by the 1990 Chinese population census, to measure rural-urban migration barriers in 1990; and (2) the percentage of AH holders in the local population in 2000, provided by the 2000 Chinese population census, to measure rural-urban migration barriers in 2000.[19] Second, we use the following alternative measures of pay for performance to measure firms' adoption of performance-based reward systems: (1) the percentage of bonuses in total compensation (excluding piece-rate wages) paid to permanent workers; (2) the percentage of piece-rate wages in total compensation (excluding bonuses) paid to permanent workers; (3) the percentage of bonuses and piece-rate wages in total compensation paid to all workers (including temporary workers); and (4) a dummy variable for whether the general manager's annual income is directly related to the company's performance. We find no obvious evidence that our main findings are rejected. Further details on these robustness checks are in **Appendix A2** (**Tables A2–A3**).

6 Conclusion

To the best of our knowledge, this study is the first to investigate the causal impact of migration barriers on long-run firm productivity in migration destinations in a developing country. The most important finding of this study is that rural-urban migration barriers lead to higher long-run firm productivity in urban destinations. Another important finding is that this effect is likely driven by the adoption of management technology such as pay for performance, rather than the

[19] In fact, the correlation between rural-urban migration barriers in 1982 and rural-urban migration barriers in 2000 is 0.675, suggesting the persistence of rural-urban migration barriers over time.

availability of capital and skilled workers, within firms. These findings also complement a recent study by Imbert et al. (2022) showing that rural-urban migration induces labor-oriented technological change and lowers productivity in a developing country. Given that substantial differences in management technology still exist across countries and firms (Bloom et al. 2019), this article suggests that restrictive migration policies in a developing country are not necessarily harmful for its firm productivity. Instead, they can lead to more productivity in the long run possibly by inducing low-productivity domestic firms to improve the adoption of management practices such as performance-based reward systems. Consequently, how to liberalize migration in developing countries such as China without disincentivizing firms in destinations from improving their management practices poses another challenge for policy makers in the future.

Table 1 Impact of rural-urban migration barriers on labor productivity

Variables	(1) OLS	(2) OLS	(3) IV	(4) First Stage	(5) Reduced
Rural-urban migration barriers	-0.0006	-0.0004	0.0052***		
	(0.0006)	(0.0006)	(0.0019)		
IV: Distance to Jinmen				-0.0217***	-0.0001***
				(0.0029)	(0.0000)
Observations	11100	11095	11095	11095	11195
R-squared	0.0005	0.2400	0.2060	0.1606	0.2402
F-stat	1.1174	57.0912	52.5534	13.8274	57.2673
Weak IV test (F statistic)			57.3129		
Endogeneity test (p-value)			0.0007		
Control variables	NO	YES	YES	YES	YES

Notes: This table reports the impact of rural-urban migration barriers on labor productivity. Columns 1 and 2 report the OLS results, with and without control variables, respectively. Columns 3 to 5 report the IV, first stage, and reduced form estimates. Control variables consist of firm-level variables such as age, skill of the general manager, ownership dummies, 2-digit industry dummies, the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 2 First-stage and reduced form in more detail

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	⩾800 km		⩾500 km		⩾300 km		⩽3,500 km	
	First Stage	Reduced Form	First Stage	Reduced Form	First Stage	Reduced Form	First Stage	Reduced Form
IV: Distance to Jinmen	-0.0319***	-0.0002***	-0.0244***	-0.0002***	-0.0239***	-0.0001***	-0.0234***	-0.0002***
	(0.0034)	(0.0001)	(0.0029)	(0.0000)	(0.0029)	(0.0000)	(0.0034)	(0.0000)
Observations	7796	7796	9995	9995	10495	10495	10995	10995
R-squared	0.2263	0.2627	0.1790	0.2525	0.1733	0.2459	0.1537	0.2430
F-stat	14.7801	54.4400	16.9693	61.2144	16.2672	60.4402	12.8027	56.9309

Variables	(9)	(10)	(11)	(12)	(13)	(14)
	⩽3,000 km		⩽2,500 km		800–2,500 km	
	First Stage	Reduced Form	First Stage	Reduced Form	First Stage	Reduced Form
IV: Distance to Jinmen	-0.0234***	-0.0002***	-0.0230***	-0.0002***	-0.0390***	-0.0003***
	(0.0034)	(0.0000)	(0.0039)	(0.0001)	(0.0043)	(0.0001)
Observations	10995	10995	10795	10795	7496	7496
R-squared	0.1537	0.2430	0.1408	0.2433	0.2125	0.2675
F-stat	12.8027	56.9309	11.1544	55.6123	15.5869	53.3162

Notes: This table reports first stage and reduced form results in more detail. Columns 1 and 2 report first stage and reduced form results by focusing on cities that are at least 800 km from Jinmen. Columns 3 and 4 report first stage and reduced form results by focusing on cities that are at least 500 km from Jinmen. Columns 5 and 6 report first stage and reduced form results by focusing on cities that are at least 300 km from Jinmen. Columns 7 and 8 report first stage and reduced form results by focusing on cities that are at most 3,500 km from Jinmen. Columns 9 and 10 report first stage and reduced form results by focusing on cities that are at most 3,000 km from Jinmen. Columns 11 and 12 report first stage and reduced form results by focusing on cities that are at most 2,500 km from Jinmen. Columns 13 and 14 report first stage and reduced form results by focusing on cities that are between 800 and 2,500 km from Jinmen. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3 Test the validity of the IV exclusion restriction assumption

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV: Control for other likely channels							Regress
	Foreign trade	Armed conflict	Industrial structures	Human capital	Infrastructure	Cultural revolution	All channels	armed conflict on IV
Rural-urban migration barriers	0.0059***	0.0050***	0.0055**	0.0054**	0.0062**	0.0050***	0.0054*	
	(0.0019)	(0.0018)	(0.0027)	(0.0024)	(0.0025)	(0.0019)	(0.0031)	
Instrument								-0.0000
								(0.0001)
Observations	11095	11095	11095	11095	11095	11095	11095	11195
R-squared	0.1984	0.2101	0.2105	0.2285	0.1952	0.2083	0.2376	0.3662
F-stat	50.3910	51.2588	49.7794	56.3362	50.3927	51.2404	47.1244	3.3402
Weak IV (F statistic)	60.6319	59.4055	29.6035	44.4926	40.9419	58.1195	26.5593	
Endogeneity test (p-value)	0.0001	0.0009	0.0093	0.0095	0.0005	0.0009	0.0378	

Variables	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Regress human capital on IV	Regress Cultural Revolution on IV	Placebo IV			New IV		Both IVs
			Hong Kong	Macau	IV	First Stage	Reduced	
Rural-urban migration barriers			0.0012	0.0006	0.0031**			0.0039***
			(0.0014)	(0.0013)	(0.0015)			(0.0013)
Instrument	-0.0002	0.0000				-31.7373***	-0.1050**	
	(0.0004)	(0.0000)				(3.9021)	(0.0477)	
Observations	11195	11195	11095	11095	11095	11095	11195	11095
R-squared	0.0927	0.0496	0.2371	0.2388	0.2266	0.1827	0.2395	0.2198
F-stat	1.6436	2.0662	56.0922	56.3772	55.6876	14.5754	57.8621	55.0231
Weak IV test (F statistic)			97.0664	103.6567	66.1522			54.5994
Endogeneity test (p-value)					0.0167			0.0002
Hansen test (p-value)								0.3181

Notes: This table tests the validity of the IV exclusion restriction assumption. Columns 1 to 7 shows the IV estimate by controlling for other likely channels through which the IV may affect the local labor productivity. Columns 8 to 10 regresses the timing of ending the armed conflict of civil war, past human capital stocks in 1949, and local intensity of Cultural Revolution on the IV with included controls, respectively. Columns 11 and 12 show the IV estimates using two counterfactual IVs based on the geographical distance between each mainland Chinese city and major Chinese coastal ports that are adjacent to Hong Kong and Macau, respectively. Columns 13 to 15 show the IV, first stage, and reduced form estimates using a new IV i.e. access to the 156 Projects. Column 16 shows the IV estimate by using two IVs together. The main IV refers to the distance to Jinmen. Standard errors are clustered at the county level. Standard errors are in parentheses. *** p < .01, ** p < .05, * p < .1.

Table 4 Impact of rural-urban migration barriers on the adoption of pay for performance

Variables	(1) OLS	(2) OLS	(3) IV	(4) First Stage	(5) Reduced
Rural-urban migration barriers	0.0989***	0.0920***	0.4080***		
	(0.0127)	(0.0112)	(0.0570)		
IV: Distance to Jinmen				-0.0214***	-0.0086***
				(0.0029)	(0.0009)
Observations	10843	10839	10839	10839	10938
R-squared	0.0159	0.0864	-0.0594	0.1576	0.0890
F-stat	60.8439	20.6479	11.5406	13.3601	22.0923
Weak IV test (F statistic)			55.2853		
Endogeneity test (p-value)			0.0000		
Control variables	NO	YES	YES	YES	YES

Variables	(6) Control likely channels	(7) IV	(8) New IV First Stage	(9) Reduced	(10) Two IVs
Rural-urban migration barriers	0.4542***	0.2763***			0.3257***
	(0.0914)	(0.0407)			(0.0373)
IV: Access to 156 Projects			-31.8092***	-8.9650***	
			(3.9333)	(1.1238)	
Observations	10839	10839	10839	10938	10839
R-squared	-0.0759	0.0369	0.1808	0.0842	0.0067
F-stat	9.3989	14.7992	14.1962	20.1765	14.0063
Weak IV test (F statistic)	25.8594	65.4022			53.8292
Endogeneity test (p-value)	0.0000	0.0000			0.0000
Hansen test (p-value)					0.0198
Control variables	YES	YES	YES	YES	YES

Notes: This table reports the impact of rural-urban migration barriers on the adoption of pay for performance. Columns 1 and 2 report the OLS results, with and without control variables, respectively. Columns 3 to 5 report the IV, first stage, and reduced form estimates. Column 6 controls for other likely channels through which the IV may affect pay for performance. Columns 7 to 9 show the IV, first stage, and reduced form estimates using a new IV i.e. access to the 156 Projects. Column 10 shows the IV estimate by using two IVs together. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5 Estimates of the mediation model

Mediating Variables	(1)
Panel A: Second Stage (Equation 5)	
β_Y^M	0.0176***
	(0.0060)
DE: β_Y^T	−0.0021***
	(0.0007)
F-Stat Instruments	67.424
Panel B: Model Parameters	
β_M^T	0.4079
IE: $\beta_M^T \cdot \beta_Y^M$	0.0071
TE	0.0051
IE+DE	0.0051
S=IE/TE	1.40
S=IE/(IE+DE)	1.40
Panel C: First Stage Equation (Equation 4)	
γ_M^Z	-0.0072***
	(0.0008)
γ_M^T	0.0698***
	(0.0110)
Observations	10839
R-Squared	0.0967

Notes: This table reports estimates of the mediation model. Panel A reports the second stage results, based on equation (4). Panel C reports the first stage results based on equation (3). Panel B reports main parameters of the mediation model. We use the STATA code *ivmediate* to estimate the main results above (Dippel, Ferrara, and Heblich 2020). Control variables are the same as those used in Table 1. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6 Heterogeneous impacts of rural-urban migration barriers on labor productivity over time

Variables	(1) Year1999	(2) Year2000	(3) Year2001	(4) Year2002	(5) Year2003	(6) Year2004	(7) Year2005	(8) Year2006	(9) Year2007
					Panel A: All firms				
Rural-urban migration barriers	0.0063***	0.0058***	0.0064***	0.0075***	0.0081***	0.0078***	0.0077***	0.0071***	0.0072***
	(0.0021)	(0.0022)	(0.0022)	(0.0022)	(0.0023)	(0.0024)	(0.0024)	(0.0023)	(0.0023)
Observations	25255	25363	25328	25333	25429	25410	25426	25401	25355
R-squared	0.2076	0.2161	0.1841	0.1447	0.1184	0.1137	0.1169	0.1278	0.1271
F-stat	94.9656	95.4085	83.1613	80.7108	69.0830	100.9563	79.2818	81.4649	78.5958
Weak IV test (F statistic)	33.9870	31.2134	33.1527	34.8444	31.0215	28.3517	30.0989	29.0164	28.5343
Firm-level variables	YES	YES	YES	YES	YES	YES	YES	YES	YES
					Panel B: Private Chinese firms				
Rural-urban migration barriers	0.0093***	0.0083***	0.0073***	0.0081***	0.0086***	0.0081***	0.0079***	0.0080***	0.0079***
	(0.0025)	(0.0025)	(0.0023)	(0.0021)	(0.0022)	(0.0022)	(0.0021)	(0.0022)	(0.0021)
Observations	12791	13170	13437	13668	13957	14158	14248	14438	14423
					Panel C: State-owned enterprises				
Rural-urban migration barriers	0.0052***	0.0048**	0.0064***	0.0070***	0.0088***	0.0093***	0.0090***	0.0086***	0.0100***
	(0.0020)	(0.0020)	(0.0020)	(0.0021)	(0.0022)	(0.0024)	(0.0024)	(0.0025)	(0.0026)
Observations	5058	4766	4432	4217	4016	3744	3683	3507	3433
					Panel D: Foreign-owned firms				
Rural-urban migration barriers	-0.0094	-0.0098	-0.0069	-0.0041	-0.0100	-0.0104	-0.0079	-0.0089	-0.0109
	(0.0082)	(0.0095)	(0.0071)	(0.0061)	(0.0112)	(0.0109)	(0.0086)	(0.0090)	(0.0116)
Observations	7406	7427	7459	7448	7456	7508	7495	7456	7499

Notes: This table reports the heterogeneous impacts of rural-urban migration barriers on labor productivity over time. Panel A reports estimates for all firms. Panel B reports estimates for private Chinese firms only. Panel C reports estimates for state-owned enterprises only. Panel D reports estimates for foreign-owned firms only. Columns 1 to 9 report the impact of rural-urban migration barriers on labor productivity from 1999 to 2007, respectively. Control variables are the same as those used in Table 1. The indicator of rural-urban migration barriers is constructed using China's population census in 1982. Firm-level variables come from the Chinese Annual Survey of Industrial Firms (1999–2007). Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Supplementary Appendix: Can Migration Barriers Save Productivity in a Developing Country?

A1 Summary Statistics for Main Variables

Table A1 Summary statistics for main variables

Variables	N	Mean	Median	Std. Dev.	min	max
Sales per capita in log	11200.00	12.19	12.15	1.24	5.31	21.30
Percentage of piece rate wage plus bonuses (%)	10942.00	42.07	38.95	33.98	0.00	100.00
Percentage of piece rate wage (%)	10942.00	29.54	0.00	36.48	0.00	100.00
Percentage of bonuses (%)	10942.00	12.53	5.00	17.07	0.00	100.00
Percentage of fixed salary (%)	10942.00	46.91	50.00	35.17	0.00	100.00
Firm age	11195.00	13.76	9.00	13.64	3.00	140.00
State-owned firms (0/1)	11200.00	0.09	0.00	0.29	0.00	1.00
Non-State-owned firms (0/1)	11200.00	0.73	1.00	0.44	0.00	1.00
Foreign-owned firms (0/1)	11200.00	0.18	0.00	0.38	0.00	1.00
Total employment in log	11200.00	5.58	5.51	1.48	1.79	13.50
Total assets in log	11200.00	16.27	16.31	2.32	0.00	25.61
Percentage of workers with high school degree and above (%)	11198.00	48.97	49.00	27.47	0.00	100.00
Percentage of workers with college degree and above (%)	11198.00	17.80	12.00	17.19	0.00	100.00
General manager with master degree (0/1)	11200.00	0.15	0.00	0.36	0.00	1.00
General manager with undergraduate degree (0/1)	11200.00	0.42	0.00	0.49	0.00	1.00
General manager with college degree (0/1)	11200.00	0.28	0.00	0.45	0.00	1.00
General manager with high school degree or below (0/1)	11200.00	0.14	0.00	0.35	0.00	1.00
The distance between each mainland Chinese county in which firms are located and the coastline (km)	11200.00	399.85	293.58	401.38	0.04	2575.14
Total population (in 10,000 person)	11200.00	273.02	219.64	232.62	14.06	867.73
Foreign direct investment (in 10,000 dollars)	11200.00	1490.02	9.50	6761.35	0.00	58906.00
Total exports (in 10,000 dollars)	11200.00	16003.74	0.00	71023.94	0.00	546725.00
Percentage of heavy industry (%)	11200.00	53.01	55.53	19.04	2.08	91.71
Percentage of state-owned industry (%)	11200.00	73.36	79.69	16.13	29.62	98.73
Percentage of large-size industry (%)	11200.00	21.51	15.65	21.46	0.00	93.20

Number of subscribers of telephones	11200.00	20511.66	15281.00	20240.66	940.00	91191.00
Railway passenger traffic (in 10,000 person)	11200.00	592.92	337.50	813.60	0.00	4393.00
Highway passenger traffic (in 10,000 person)	11200.00	1720.37	1191.50	2057.00	0.00	16456.00
Number of scientists	11200.00	23029.19	14440.00	26188.91	765.00	144738.00
Number of social scientists	11200.00	16450.84	12381.00	15221.64	20.00	78963.00
Access to "156 projects" (0/1)	11200.00	0.23	0.00	0.42	0.00	1.00
Rural-urban migration barriers (1982)	11100.00	58.19	87.90	43.24	0.00	100.00
The geographical distance between each mainland Chinese city and Jinmen (km)	11200.00	1189.79	1139.95	613.16	35.65	3507.98
Distance to the capital of the PRC (km)	11200.00	1097.51	1028.35	554.67	55.25	2426.82
Number of universities and colleges in each mainland city in 1949	11200.00	1.13	0.00	2.45	0.00	13.00
Local severity of the Cultural Revolution	11200.00	0.02	0.01	0.04	0.00	0.49

Notes: Firm-level variables come from the Enterprise Survey in 2005.

A2 Robustness Checks

A2.1 Alternative Measures of Rural-Urban Migration Barriers

In our main analysis, we use the percentage of rural residents in the local population in 1982 to measure rural-urban migration barriers, given the fact that AH holders were not allowed to migrate to urban areas unless they successfully obtained NAH and that it was very difficult for AH holders to migrate to urban areas in early 1980s.[20] We use two different measures of rural-urban migration barriers for robustness checks. First, to reduce the concern that the percentage of rural residents in the local population may be different from the percentage of AH holders in the local population, we further use the percentage of AH holders in the local population in 1990, provided by the 1990 Chinese population census, to measure rural-urban migration barriers in 1990. Second, to reduce the concern that rural-urban migration barriers in 1982 may not fully capture rural-urban migration barriers exposed to local firms in 2005, we further use the percentage of AH holders in the local population in 2000, provided by the 2000 Chinese population census, to measure rural-urban migration barriers in 2000.[21] Results shown in **Table**

[20] According to the Chinese Population Census, less than 1% of the total population were living away from their registered places in 1982.

[21] In fact, the correlation between rural-urban migration barriers in 1982 and rural-urban migration barriers in 2000 is 0.675, suggesting the persistence of rural-urban migration barriers over time.

A2 do not reject our main findings.

Table A2 Estimates of the mediation model using alternative measures of rural-urban migration barriers

Mediating Variables	(1)	(2)
	Migration barriers (1990)	Migration barriers (2000)
Panel A: Second Stage (Equation 5)		
β_Y^M	0.0134**	0.0251***
	(0.0059)	(0.0078)
DE: β_Y^T	-0.0023***	-0.0049**
	(0.0008)	(0.0015)
F-Stat Instruments	65.581	44.281
Panel B: Model Parameters		
β_M^T	0.6010	0.5309
IE: $\beta_M^T \cdot \beta_Y^M$	0.0080	0.0133
TE	0.0057	0.0084
IE+DE	0.0057	0.0084
S=IE/TE	1.413	1.581
S=IE/(IE+DE)	1.413	1.581
Panel C: First Stage Equation (Equation 4)		
γ_M^Z	-0.0071***	-0.0058***
	(0.0008)	(0.0008)
γ_M^T	0.0824***	0.1421***
	(0.0120)	(0.0166)
Observations	10,448	10,640
R-Squared	0.0908	0.0984

Notes: this table reports estimates of the mediation model using alternative measures of rural-urban migration barriers. Panel A reports the second stage results, based on equation (4). Panel C reports the first stage results based on equation (3). Panel B reports main parameters of the mediation model. We use the STATA code *ivmediate* to estimate the main results above (Dippel, Ferrara, and Heblich 2020). Control variables consist of age, skill composition of general managers, ownership dummies, 2-digit industry dummies, the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. The rural-urban migration barriers variable in Column (1) is constructed using China's population census in 1990. The rural-urban migration barriers variable in Column (2) is constructed using China's population census in 2000. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** p < .01, ** p < .05, * p < .1.

A2.2 Alternative Measures of Incentive Pay

In our main analysis, we use the percentage of bonuses and piece-rate wages in total compensation among permanent workers to measure the intensity of incentive pay. We use four different measures of incentive pay for robustness checks. The first one is the percentage of bonuses in total compensation (excluding piece-rate wages) among permanent workers. The second one is the percentage of piece-rate wages in total compensation (excluding bonuses) among permanent workers. The third one is the percentage of bonuses and piece-rate wages in total compensation among all workers (including temporary workers). Finally, we use a dummy variable on whether the

general manager's annual income is directly related to the company's performance to measure firms' intensity of incentive pay. Results shown in **Table A3** do not reject our main findings.

Table A3 Estimates of the mediation model using alternative measures of incentive pay

Mediating Variables	(1) Bonuses	(2) Piece-rate wages	(3) All employees	(4) General manager
Panel A: Second Stage (Equation 5)				
β_Y^M	0.0347***	0.0214***	0.0208***	1.5330***
	(0.0115)	(0.0080)	(0.0077)	(0.5430)
DE: β_Y^T	-0.0009*	-0.0030***	-0.0024***	-0.0006
	(0.0005)	(0.0011)	(0.0009)	(0.0005)
F-Stat	35.330	38.086	56.022	57.541
Instruments				
Panel B: Model Parameters				
β_M^T	0.1767	0.3823	0.3615	0.0037
IE: $\beta_M^T \cdot \beta_Y^M$	0.0061	0.0081	0.0075	0.0057
TE	0.0051	0.0051	0.0050	0.0050
IE+DE	0.0051	0.0051	0.0050	0.0050
S=IE/TE	1.204	1.607	1.482	1.132
S=IE/(IE+DE)	1.204	1.607	1.482	1.132
Panel C: First Stage Equation (Equation 4)				
γ_M^Z	-0.0036***	-0.0059***	-0.0060***	-0.0000***
	(0.0006)	(0.0009)	(0.0008)	(0.0000)
γ_M^T	0.0044	0.1044***	0.0768***	-0.0001
	(0.0073)	(0.0118)	(0.0105)	(0.0001)
Observations	10,215	10,823	10,839	10,970
R-Squared	0.0333	0.1396	0.1278	0.0434

Notes: this table reports estimates of the mediation model using alternative measures of incentive pay. Panel A reports the second stage results, based on equation (4). Panel C reports the first stage results based on equation (3). Panel B reports main parameters of the mediation model. We use the STATA code *ivmediate* to estimate the main results above (Dippel, Ferrara, and Heblich 2020). Control variables consist of age, skill composition of general managers, ownership dummies, 2-digit industry dummies, the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. Columns (1) to (4) use the percentage of bonuses in total compensation (excluding piece-rate wages) among permanent workers, the percentage of piece-rate wages in total compensation (excluding bonuses) among permanent workers, the percentage of bonuses and piece-rate wages in total compensation among all workers (including temporary workers), a dummy variable on whether the general manager's annual income is directly related to the company's performance, to measure firms' intensity of incentive pay, respectively. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** p < .01, ** p < .05, * p < .1.

A3 The Reforms of Wage Payment System in China

China's transformation into a more market-oriented economic system is accompanied with substantial changes in wage payment system over the past four decades. The reforms of wage payment systems started with the introduction of the Household Responsibility System (HRS) to the agricultural sector. After the massive collective

movement in the 1950s, China's agricultural sector worked under the production team system for about 20 years. Under this system, agricultural workers got work points for the jobs they performed every day. At the end of each year, the net income of production team was distributed based on the work points that each one earned during the year. Although various systems of work points had been adopted to reflect the quality and quantity of work performed by each worker, it is extremely difficult to supervise agricultural work because of the nature of agricultural production. An agricultural worker received fixed work points for a day's work regardless of his work output. Consequently, the incentive to work was low, and productivity was stagnant (Lin 1988).

The HRS was introduced to deal with problems associated with the collective system of the late 1970s. Under the new system, the individual peasant, rather than the production team, became the basic decision-making unit for agricultural production. The HRS involves contracts signed between the production team and each household, which regulate the taxes and delivery quotas payable to the state, and the welfare and investment funds payable to the team. Any production above the delivery quota is retained by the household, which can sell it and receive the proceeds. Some significant studies have assessed the effectiveness of the HRS (McMillan, Whalley, and Zhu 1989; Lin 1988; 1992; Wen 1993). These studies consistently provide evidence that introducing the HRS significantly increases agricultural productivity through changing wage payment systems.

The second stage introduces the "managerial responsibility system" to state-owned firms in the industrial sector, which transferred the responsibility of production decisions from the state to the firm and increased the fraction of profits that the firm could retain. As a result, firm managers respond to these increases in autonomy by strengthening workers' performance incentives, such as paying more in bonuses and hiring more workers on fixed-term contracts. A number of studies have confirmed that introducing the "managerial responsibility system" significantly increases productivity of the state-owned firms through increased bonuses (Groves et al. 1994; Li 1997).

The third stage is the prevalence of the non-state-owned firms in the industrial sector since the late 1990s. Since non-state-owned firms adopt more flexible wage payment systems than their state-owned counterparts, the increased proportion of non-state-owned firms significantly alters the wage payment systems of the industrial sector. For example, while state-owned firms used to recruit permanent (contract) workers, it

is very common for non-state-owned firms to recruit temporary (contract) workers. As a result, more flexible wage payment systems such as piece rates have been adopted intensively by non-state-owned firms than their state-owned counterparts.

A4 Effects of Rural-Urban Migration Barriers on Other Outcomes

In order to highlight the management technology channel, we further analyze the effects of rural-urban migration barriers on other firm-level outcomes such as capital-labor ratio, skill composition of employees, and technological adoption in terms of computer use. **Table A4** shows the main results.

Table A4: Effects of rural-urban migration barriers on other outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Capital-labor ratio		College and above (%)		High school and above (%)		Computer use (%)	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Rural-urban migration barriers	0.0001	-0.0000	-0.0597***	-0.0893***	-0.0667***	-0.0604*	-0.0472***	0.0087
	(0.0006)	(0.0019)	(0.0058)	(0.0246)	(0.0084)	(0.0337)	(0.0065)	(0.0311)
Observations	11095	11095	11093	11093	11093	11093	11095	11095
R-squared	0.1265	0.1264	0.2303	0.2253	0.2130	0.2129	0.1828	0.1680
F-stat	34.5117	34.3765	52.6513	49.6108	64.9628	65.1069	41.2225	39.0833
Weak identification test (Cragg-Donald Wald F statistic)	.	57.3129	.	57.2014	.	57.2014	.	57.3129
Endogeneity test of endogenous regressors (p-value)	.	0.9336	.	0.2348	.	0.8525	.	0.0392

Notes: this table reports the effects of rural-urban migration barriers on other outcomes. Column (1) and (2) show the effect of rural-urban migration barriers on capital-labor ratio (in log). Columns (3) and (4) show the effect of rural-urban migration barriers on the percentage of employees with college education or above. Columns (5) and (6) show the effect of rural-urban migration barriers on the percentage of employees with high school education or above. Columns (7) and (8) show the effect of rural-urban migration barriers on the percentage of employees who regularly use computers. Columns (1) (3) (5) (7) and (9) report OLS estimates. Columns (2) (4) (6) (8) and (10) report IV estimates. Control variables consist of age, skill composition of general managers, ownership dummies, 2-digit industry dummies, and the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. The rural-urban migration barriers variable is constructed using China's population census in 1982. The instrumental variable refers to the geographical distance between each mainland Chinese city and Jinmen. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** p < .01, ** p < .05, * p < .1.

A5 Effects of Rural-Urban Migration Barriers on Total Factor Productivity

In order to check whether or not migration barriers optimize the use of other inputs within firms, we examine the impact of migration barriers on total factor productivity using similar empirical approaches.

Table A5: Impact of migration barriers on total factor productivity

Variables	(1) OLS	(2) OLS	(3) IV	(4) First Stage	(5) Reduced
Rural-urban migration barriers	-0.0002	-0.0002	0.0025**		
	(0.0003)	(0.0003)	(0.0012)		
IV: Distance to Jinmen				-0.0217***	-0.0001**
				(0.0029)	(0.0000)
Observations	10844	10839	10839	11095	10936
R-squared	0.0001	0.0414	0.0289	0.1606	0.0418
F-stat	0.3115	10.7419	10.3220	13.8274	11.0876
Weak IV test (F statistic)	.	.	56.0436	.	.
Endogeneity test (p-value)	.	.	0.0227	.	.
Control variables	NO	YES	YES	YES	YES

Notes: This table reports the impact of rural-urban migration barriers on total factor productivity. Columns 1 and 2 report the OLS results, with and without control variables, respectively. Columns 3 to 5 report the IV, first stage, and reduced form estimates. Control variables consist of firm-level variables such as age, skill of the general manager, ownership dummies, 2-digit industry dummies, the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A6 Effects of Rural-Urban Migration Barriers on Firms' Probability of Experiencing Labor Shortage

In order to confirm the persistence of early migration barriers experienced by current firms, we examine the impact of migration barriers on the probability of experiencing labor shortage among manufacturing firms.

Table A6: Impact of migration barriers on firms' probability of experiencing labor shortage

Variables	(1) OLS	(2) OLS	(3) IV	(4) First Stage	(5) Reduced
Rural-urban migration barriers	0.0002**	-0.0001	0.0008**		
	(0.0001)	(0.0001)	(0.0004)		
IV: Distance to Jinmen				-0.0217***	-0.0000**
				(0.0029)	(0.0000)
Observations	11100	11095	11095	11095	11195
R-squared	0.0007	0.0872	0.0772	0.1606	0.0877
F-stat	4.1357	22.3514	18.8745	13.8274	23.0143
Weak IV test (F statistic)	.	.	57.3129	.	.
Endogeneity test (p-value)	.	.	0.0059	.	.
Control variables	NO	YES	YES	YES	YES

Notes: This table reports the impact of rural-urban migration barriers on firms' probability of experiencing labor shortage. Columns 1 and 2 report the OLS results, with and without control variables, respectively. Columns 3 to 5 report the IV, first stage, and reduced form estimates. Control variables consist of firm-level variables such as age, skill of the general manager, ownership dummies, 2-digit industry dummies, the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A7 Effects of Rural-Urban Migration Barriers on Firms' Management Technology Adoption

In order to the mitigate the concern that the pay for performance variable may be insufficient to capture management technology adoption, we resort to the principle component analysis to construct a measure of 'management technology', which considers management practices such as pay for performance, promotion and demotion.

Table A7 Estimates of the mediation model

Mediating Variables	(1)
Panel A: Second Stage (Equation 5)	
β_Y^M	0.5129***
	(0.1920)
DE: β_Y^T	−0.0010*
	(0.0005)
F-Stat Instruments	54.807
Panel B: Model Parameters	
β_M^T	0.0118
IE: $\beta_M^T \cdot \beta_Y^M$	0.0061
TE	0.0051
IE+DE	0.0051
S=IE/TE	1.20
S=IE/(IE+DE)	1.20
Panel C: First Stage Equation (Equation 4)	
γ_M^Z	-0.0002***
	(0.0000)
γ_M^T	0.0003
	(0.0003)
Observations	10228
R-Squared	0.0864

Notes: This table reports estimates of the mediation model. Panel A reports the second stage results, based on equation (4). Panel C reports the first stage results based on equation (3). Panel B reports main parameters of the mediation model. We use the STATA code *ivmediate* to estimate the main results above (Dippel, Ferrara, and Heblich 2020). Control variables are the same as those used in Table 1. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

A8 Effects of Rural-Urban Migration Barriers on Sales to Other Cities and Countries

Table A8 Impact of rural-urban migration barriers on sales to other cities and countries

Variables	(1) OLS	(2) OLS	(3) IV	(4) First Stage	(5) Reduced
Rural-urban migration barriers	0.0573***	0.0791***	0.3919***		
	(0.0132)	(0.0108)	(0.0575)		
IV: Distance to Jinmen				-0.0217***	-0.0084***
				(0.0029)	(0.0010)
Observations	11099	11094	11094	11095	11194
R-squared	0.0060	0.1284	-0.0327	0.1606	0.1337
F-stat	18.8543	25.3976	15.7133	13.8274	26.9192
Weak IV test (F statistic)	.	.	57.3421	.	.
Endogeneity test (p-value)	.	.	0.0000	.	.
Control variables	NO	YES	YES	YES	YES

Notes: This table reports the impact of rural-urban migration barriers on percentage of sales to other cities and countries. Columns 1 and 2 report the OLS results, with and without control variables, respectively. Columns 3 to 5 report the IV, first stage, and reduced form estimates. Control variables consist of firm-level variables such as age, skill of the general manager, ownership dummies, 2-digit industry dummies, the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A9 Effects of Rural-Urban Migration Barriers on Sales to the Government and SOEs

Table A9 Impact of rural-urban migration barriers on sales to the government and SOEs

Variables	(1) OLS	(2) OLS	(3) IV	(4) First Stage	(5) OLS
Rural-urban migration barriers	-0.1373***	-0.0793***	-0.3634***		
	(0.0162)	(0.0112)	(0.0572)		
IV: Distance to Jinmen				-0.0217***	0.0078***
				(0.0029)	(0.0011)
Observations	11100	11095	11095	11095	11195
R-squared	0.0293	0.2052	0.0923	0.1606	0.2082
F-stat	71.9100	53.0901	36.8478	13.8274	56.6419
Weak IV test (F statistic)	.	.	57.3129	.	.
Endogeneity test (p-value)	.	.	0.0000	.	.
Control variables	NO	YES	YES	YES	YES

Notes: This table reports the impact of rural-urban migration barriers on percentage of sales to the government and SOEs. Columns 1 and 2 report the OLS results, with and without control variables, respectively. Columns 3 to 5 report the IV, first stage, and reduced form estimates. Control variables consist of firm-level variables such as age, skill of the general manager, ownership dummies, 2-digit industry dummies, the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A10 Effects of Rural-Urban Migration Barriers on Firm Employment

Table A10 Impact of rural-urban migration barriers on firm employment

Variables	(1) OLS	(2) OLS	(3) IV	(4) First Stage	(5) OLS
Rural-urban migration barriers	-0.0021***	0.0011**	0.0092***		
	(0.0007)	(0.0005)	(0.0025)		
IV: Distance to Jinmen				-0.0217***	-0.0002***
				(0.0029)	(0.0000)
Observations	11100	11095	11095	11095	11195
R-squared	0.0038	0.2602	0.2091	0.1606	0.2620
F-stat	9.8123	73.6784	63.4336	13.8274	75.0057
Weak IV test (F statistic)	.	.	57.3129	.	.
Endogeneity test (p-value)	.	.	0.0029	.	.
Control variables	NO	YES	YES	YES	YES

Notes: This table reports the impact of rural-urban migration barriers on firm employment. Columns 1 and 2 report the OLS results, with and without control variables, respectively. Columns 3 to 5 report the IV, first stage, and reduced form estimates. Control variables consist of firm-level variables such as age, skill of the general manager, ownership dummies, 2-digit industry dummies, the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A11 Effects of Rural-Urban Migration Barriers on New Firm Creation

Table A11a Impact of rural-urban migration barriers on the probability of new firm creation (i.e., created within the past three years)

Variables	(1) OLS	(2) OLS	(3) IV	(4) First Stage	(5) OLS
Rural-urban migration barriers	0.0003***	0.0002***	0.0002		
	(0.0001)	(0.0001)	(0.0003)		
IV: Distance to Jinmen				-0.0217***	-0.0000
				(0.0029)	(0.0000)
Observations	11095	11095	11095	11100	11195
R-squared	0.0028	0.0182	0.0180	0.1576	0.0166
F-stat	19.4960	10.4629	10.6245	13.1731	11.3653
Weak IV test (F statistic)	.	.	57.0871	.	.
Endogeneity test (p-value)	.	.	0.7449	.	.
Control variables	NO	YES	YES	YES	YES

Notes: This table reports the impact of rural-urban migration barriers on probability of new firm creation (i.e., created within the past three years). Columns 1 and 2 report the OLS results, with and without control variables, respectively. Columns 3 to 5 report the IV, first stage, and reduced form estimates. Control variables consist of firm-level variables such as age, skill of the general manager, ownership dummies, 2-digit industry dummies, the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A11b Impact of rural-urban migration barriers on the probability of new firm creation (i.e., created within the past five years)

Variables	(1) OLS	(2) OLS	(3) IV	(4) First Stage	(5) OLS
Rural-urban migration barriers	0.0005***	0.0003**	0.0006		
	(0.0001)	(0.0001)	(0.0005)		
IV: Distance to Jinmen				-0.0217***	-0.0000
				(0.0029)	(0.0000)
Observations	11095	11095	11095	11100	11195
R-squared	0.0022	0.0441	0.0432	0.1576	0.0433
F-stat	14.3991	512.2129	534.1065	13.1731	371.3001
Weak IV test (F statistic)	.	.	57.0871	.	.
Endogeneity test (p-value)	.	.	0.4640	.	.
Control variables	NO	YES	YES	YES	YES

Notes: This table reports the impact of rural-urban migration barriers on probability of new firm creation (i.e., created within the past five years). Columns 1 and 2 report the OLS results, with and without control variables, respectively. Columns 3 to 5 report the IV, first stage, and reduced form estimates. Control variables consist of firm-level variables such as age, skill of the general manager, ownership dummies, 2-digit industry dummies, the logarithm of the distance between the mainland Chinese county in which firms are located and the coastline, and the logarithm of the distance between the mainland Chinese county in which firms are located and Beijing. The rural-urban migration barriers variable is constructed using China's population census in 1982. Firm-level variables come from World Bank's Enterprise Survey in 2005. Standard errors are clustered at the county level. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.