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Market Structure, Resource Allocation, and Industry Productivity Growth: Firm-level Evidence from China's Steel Industry

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KEYWORDS Resource Reallocation; Market Structure; China's Steel Industry; Total Factor Productivity.

JEL Code D21, D24, F43

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ABSTRACT Regional monopoly limits market reforms from improving cross-firm resource allocative efficiency, but the underlying mechanism is not known. This paper develops a spatial competition model to examine how regional monopoly may prevent more productive firms from expanding, and test it by using a large panel dataset covering 11,136 steel firms in China for the 1998-2009 period. We show that market reforms in China's steel industry strengthen competition at the national level but do not improve within-province resource reallocation. The results shed light on the importance of removing regional monopoly for developing countries undergoing market reforms to improve resource allocative efficiency.

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1. Introduction

Developing countries' economies often are characterized by poor resource allocation efficiency and low productivity, which generally are caused by improper institutional arrangements, poor enforcement of contracts and property rights, and information frictions (Bhagwati 1971; Balassa 1988). However, in the course of these countries' economic development, if policy makers can launch market reforms by eliminating institutional barriers; liberalizing labor, capital, and product markets; investing in better infrastructure; and producing an economy characterized by more competition, aggregate productivity should rise. The notion that developing countries—with the right set of policies—can achieve aggregate productivity growth by reallocating resources from less- to more-efficient firms has been examined thoroughly in the literature on resource misallocation and market reforms (Olley and Pakes 1996; Baily et al. 1992; Foster et al. 2001, 2008; Hsieh and Klenow 2009; Bartelsman et al. 2013; Asker et al. 2014; Restuccia and Rogerson 2017).

Unfortunately, not all market reforms end up producing the intended higher aggregate productivity increases through improvement of resource allocation efficiency across firms. For the manufacturing industry (as a whole), Hsieh and Klenow (2009) showed that resource misallocation in India worsened during the 1987–1994 period when a policy that limited firms' entry into the manufacturing industry was being abolished. Bartleseman et al. (2013) also found that resource misallocation worsened in many Eastern European nations during their transitions to market economies in the 1990s, and that in the case of many of the region's manufacturing industries, gains in resource allocation efficiency were absent or (at best) modest. Other studies that focused on Southern Europe, Latin America, and Africa reported similar results (Gopinath et al. 2017; Oberfield 2013; Sandleris and Wright 2014; Kalemli-Ozcan and Sorensen 2016).

While the absence of improvements in resource allocation in the face of market reforms is well-documented in many countries, the precise reason why market reforms are not promoting more efficient resource reallocation across firms and yielding higher productivity levels is not always readily apparent. However, academic interest exists on this issue. Research teams in several recent studies have identified market monopoly power as an important factor that could undermine the impact of market reforms on resource reallocation (Hopenhayn 2014; Restuccia and Rogerson 2013, 2017). Considering that "a producer with monopoly power may produce less than the efficient level, but charge a higher markup" (Restuccia and Rogerson 2017, 154), market reforms that promote the free flow of resources across firms may fail to improve resource allocation efficiency because monopoly power held by the dominant firm might limit more-productive smaller firms from expanding their production. However, less attention has been paid to understanding how resource allocation across firms responds to market reforms when markets are fragmented by the existence of local monopolies, a phenomenon commonly observed in developing economies.

The present paper develops a theoretical model that produces testable hypotheses on why market reforms may fail to improve resource allocation efficiency across firms in a competitive national market characterized by strong local monopoly power. By incorporating the market structure characterized by monopolistic competition (with firms' monopoly power declining with transportation distance from the dominant firm) into a resource reallocation analysis, we investigated regional monopolies' (those caused by market fragmentation) role in affecting resource reallocation efficiency. A testable hypothesis was derived to examine whether regional monopolies prevent market reforms from reallocating resources from less- to more-efficient firms within the local market, as well as at the national level.

Given the theory-based prediction, in the next section, we empirically test the hypothesis using a firm-level set of panel data on China's iron and steel industry during the 1998–2009 period. Our empirical strategy followed three steps. First, we measured resource reallocation at the industry level in response to China's market reforms. The Olley-Pakes (OP) (1996) approach, modified by Melitz and Polanec (2016) and Collard-Wexler and De Loecker (2015), is used in the main empirical analysis. The estimated contribution of resource reallocation to aggregate productivity growth was compared with that of within-firm productivity growth (with the two components combined being equal to aggregate productivity growth). In doing so, we sought to find evidence on whether the market reforms were successful or failed to deliver intended efficiency gains from resource reallocation at the national level. In this part of our analysis, we expected more-productive firms to expand more quickly during the reform period, considering that the market at the national level became more competitive.

In the second step of our empirical analysis, we decomposed the industry-level resource reallocation effect into its "within-province" and "between-province" components using the methodology proposed by Collard-Wexler and De Loecker (2015). Considering that steel products selling to more remote markets face more intensive competition (there are more firms competing for a given market), but incur higher transportation costs, which weaken more-productive firms' advantage (as our theoretical model predicts), the comparison between the two resource reallocation effects can inform us as to whether local monopoly power weakens resource reallocation across firms within each province. The idea is that if no regional monopoly exists, we should expect that the within-province effects would be larger than the between-province effects, and vice versa.

In the third step, we performed a set of regression analyses to establish the link between the within-province resource reallocation effects and the strength of the local monopoly's power as measured by iron and steel firms' average markup at the province level. Evidence of a negative relationship between firms' average markup and the within-province resource reallocation effects would suggest that firms' monopoly power due to inter-provincial market fragmentation is one of the factors undermining market reforms' resource reallocation effects in the provincial market, as well as at the national level.

In this paper, we used data from China's iron and steel industry for several reasons. First, in the most general terms, the iron and steel industry provides a quasi-natural experimental context for us to test the theoretical hypotheses. Specifically, the nation's iron and steel industry has been the focus of its domestic market reforms since the late 1990s (Tang 2010; Holloway et al. 2010), so this makes it (meeting the first requirement) a case that allows us to study the impact of market reforms on resource reallocation across firms. In addition, vertically integrated technology dominates steel production in China and exhibits increasing returns to scale (Sheng and Song 2013; Brandt et al. 2020). Because of this, it was easy for large firms in many provinces (that historically were distributed across the country under the centrally planned economy) to obtain (or strengthen) local monopoly power during the reform period when the national market was starting to become more competitive.[1] Finally, iron and steel products are relatively homogeneous (Collard-Wexler and De Loecker 2015) and, on a per ton basis, relatively low value and sensitive to transportation costs. This characteristic of the industry makes it possible for us to use demand elasticity (or the firm's markup) as a proxy for the sample firms' monopoly power, considering that iron and steel products from different firms (i.e., large vs. small or state-owned enterprises [SOEs] vs. non-SOEs) tend to be perfect substitutes and independent of preferences (Syverson 2004). In this sense, firms only compete for price in the market, which is determined by production and/or sales costs.

In the environment in which China's iron and steel firms exist, our paper generates both theoretical and empirical findings. Theoretically, the analysis in the paper shows that regional monopolies caused by market fragmentation may prevent firms from selling products in the local market at marginal costs, thereby limiting more-productive firms from expanding (which weakens national-level resource reallocation

[1] This feature of market structure is particularly salient in a developing economy such as China, where local protectionism is rampant, often making markets regionally fragmented (see Wu 2000; Xu 2002; Sheng and Song 2013; Brandt et al. 2020).

effects). Consequently, market reforms strengthen competition at the national level (or at the industry-nation level) and help improve within-firm productivity growth, but may not facilitate resource reallocation from less- to more-efficient firms within the local market (and, thus, may undermine the contribution of resource reallocation to industry-level aggregate productivity growth).

After executing the empirical analysis, this study shows that the empirical evidence supports the theoretical predictions. Specifically, our empirical results demonstrate that the resource reallocation effect in China's iron and steel industry due to market reforms is surprisingly low during the 1998–2009 period. The absence of a substantial reallocation effect is found from rapid within-firm technological progress despite there being a substantial increase in the privatization of firms and marketization of the iron and steel industry overall. Between 1998 and 2009, on average, resource reallocation only accounted for 14% of industry-level total factor productivity (TFP) growth, which is one-sixth of within-firm productivity growth's contribution. However, SOEs' output share in the industry decreased from 80 percent in 1996 to 40 percent in 2009, while the share of the top 10 largest steel enterprises in the industry declined from 80 percent in 1998 to 50 percent in 2009. If there had been no local monopoly power caused by market fragmentation, we would have expected the resource reallocation effects to be comparable with (or almost equal to) within-firm productivity growth, with its impact on aggregate productivity growth being larger in the local market than in the remote market (as the local market is impacted less by transportation costs). However, our empirical results show that the resource reallocation effects within provinces are substantially lower than those between provinces, implying that the presence of market fragmentation (or market frictions) keeps more-productive firms from expanding within the province. Finally, we found that within-province resource reallocation effects are associated negatively with iron and steel firms' average markup. This result suggests that local monopoly power is an important factor undermining the within-province resource reallocation effects of market reforms in China's iron and steel industry.

The present paper contributes to the literature in two ways. First, we are the first to demonstrate the mechanism through which regional market monopolies may undermine resource reallocation across firms, even if the market reforms help intensify competition in the national market. In particular, we extend the literature (Hopenhayn 2014; Restuccia and Rogerson 2013, 2017) by showing that local monopoly power held by a small number of dominant firms may cause market fragmentation and limit more-productive firms from expanding. This provides an alternative explanation as to why market reforms may fail to deliver intended resource reallocation effects in many developing countries.

Second, in the context of a large, important industry (namely, China's iron and steel industry), we empirically examined the role of regional monopolies and their effects on resource reallocation across firms in developing countries. Syverson (2004, 2007) found that a monopolistic market structure could restrict resources from being reallocated from less- to more-efficient, dominant firms in the U.S. concrete industry. Collard-Wexler and De Loecker (2015) found that market monopolies of large, vertically integrated steel firms could dampen resource allocation effects in the U.S. steel industry. Despite the empirical evidence obtained in developed countries, little evidence has been found on the role of local market monopoly power in affecting cross-firm resource reallocation in developing countries. We fill the research gap by showing that a dominant firm's monopoly power in the local market can deteriorate within-province resource reallocation effects in China's steel industry. Finally, considering that a dominant firm needs to hold an overcapacity of production to maintain its monopoly power in the local market, our findings also may help explain the paradox of the increased overcapacity problem with China's iron and steel industry in a more competitive market (due to market reforms).

The rest of the paper is organized as follows. Section 2 summarizes the characteristics of China's iron and steel industry and the market reforms in the industry since the late 1990s. Section 3 develops a theoretical model that examines the size-productivity relationship when the market is characterized by spatial monopolistic competition. This section also produces our study's testable hypotheses. Section 4 describes the data and the empirical strategies used to test the hypotheses. Section 5 discusses the empirical results, and Section 6 provides several robustness checks. Section 7 concludes the paper.

2. China's Iron and Steel Industry: Market Reforms and Regional Monopoly

The iron and steel industry in China is one of the nation's key pillars of economic growth. In 2017, China's iron and steel industry produced 711 million metric tons of pig iron, 832 million metric tons of crude steel, and 33 million tons of alloy products. This production level accounted for more than half of global iron and steel production.

The industry also has strong backward and forward industrial linkages. Iron and steel producers generate demand for upstream industries such as iron ore/coal mining and energy. For example, to produce the industry's output level, the industry consumed 1.15 billion tons of iron ore (CSDRI 2019). The industry also provided inputs for downstream industries, such as construction, machinery and equipment, automobiles, shipbuilding, etc.

Apart from feeding domestic demand, China's steel production also took the lead in global steel trade. According to World Steel Statistics (2018), China's steel exports accounted for 16.1 percent of global steel exports in 2017. The industry also accounted for around two-thirds of global iron ore trade (CSDRI 2019).

While originally (through the 1980s) a key sector of the economy that was heavily planned, a decade-long effort at market reform starting in the late 1990s changed the course of the Chinese iron and steel industry's development, enabling the industry to achieve two decades of double-digit annual growth. Historically, the iron and steel industry in China strictly followed the central government's planning (Jefferson 1990; Fisher-Vanden 1998), yielding low efficiency. These SOEs still were producing more than 80 percent of the industry's output in 1996. However, reform began in 1998 when a two-stage corporatization campaign was launched to introduce modern management systems and new types of ownership into the nation's iron and steel firms. Under the reforms, all SOEs were categorized into two groups: "key" firms and "local" firms. In the first stage, between 1998 and 2000, most "key" firms were turned into publicly listed companies, while the vast majority of small- and medium-size "local" firms remained unchanged (Wu 2000; Movshuk 2004).[2] During the second reform stage after 2000, "local" firms gradually were privatized. Simultaneously, both private and foreign direct investments were encouraged as part of the industry's reform package (Kim et al. 2006). By the end of the reforms in 2008, the industry had become more market-oriented, with the output share of private firms accounting for more than 60 percent of the industry's total output (CSDRI, various years).

The market reforms fundamentally changed the industry's operational environment, resulting in positive levels of within-firm technology progress. Figure 1 shows the changes in the total number of firms (Panel [A]), total employment (Panel [B]), total output (Panel [C]), and total assets (Panel [D]) between 1998 and 2014. During the 1998–2008 reform period, although total employment remained almost unchanged, the total number of firms, total output, and total assets increased substantially. This implies that the industry's average labor productivity increased as market competition intensified. Simultaneously, the increase in total assets (or the average capital-labor ratio) also suggests an increase in technology/innovation and equipment/capital investment. Consequently, the average vertical integration (VI) ratio for steel production in China—one of the most important indicators of production

[2] In general, "key" firms are big firms that are directly controlled by the central government and provincial or municipal authorities. "Local" firms are younger and smaller in size and are controlled by local governments (Steinfeld 1998).

technology in vertically integrated steel firms—increased from around 40 percent to more than 99 percent between 1998 and 2009.[3]

[Insert Figure 1 about here]

Apart from promoting within-firm productivity growth, the market reforms in China's iron and steel industry also were expected to improve the allocative efficiency of resources among firms. However, empirical evidence remains elusive on this. On one hand, although the industry suffered from a sharp decline in average profits, fixed-asset investments continued to build within the local regions over time.[4] In particular, most of the investments were targeted at low-end, old-technology products (such as rebar, wire rods, and plates) that already were in oversupply. Consequently, as China's overall production of crude steel soared from 115 million tons in 1998 to 512 million tons in 2008, the excess supply of crude steel reached 160 million tons (around 24 percent of the total production capacity).

During this same time frame, many studies found that the market reforms significantly improved the market share of "local" firms in China's iron and steel industry (Wu 2000; Kim et al. 2006; Sheng and Song 2013). Many of these newly entered private firms or privatized SOEs were small and, thus, not well-equipped with modern technology compared with the "key" firms. As additional evidence, Brandt et

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[3] The vertical ratio is technical terminology that is defined as the proportion of pig iron directly used for crude steel production. In practice, it is used to measure the efficiency of a vertical-integrated steel mill.

[4] According to a report by China Daily (August 1, 2013), in the first half of 2013, the profit of the 86 largest steel mills was a mere 2.27 billion Yuan (about US$ 0.33 billion), with an average profit margin of 0.13 percent. This is in sharp contrast to the two-digit rate of return earned in many other industries.

al. (2020) also found that no significant difference in productivity existed for private/privatized “local” firms in terms of ownership, even in recent years. Thus, such a change in the industrial structure implies that resource misallocation across firms worsened during the reform period.

Three distinct features of China’s iron and steel industry are useful in understanding the changes in resource allocation efficiency within the industry. First, China’s steel production relies on the use of open-hearth blast furnaces with the basic oxygen technique in vertically integrated facilities, compared with the rapid diffusion of electric arc furnaces and mini-mill technology in the U.S. and other developed countries. This production technology enables China’s iron and steel firms to obtain market monopoly power more easily by expanding operational scale because the production is characterized by increasing returns to scale. Second, most iron and steel firms in China produce homogeneous and low-end products because of the nature of downstream demand from the rapid expansion of the construction industry. For example, in 2017, the construction industry (including the real estate and infrastructure sub-industries) contributed 53 percent of the nation’s total domestic demand for steel products. Given that steel products are close substitutes, iron and steel firms in China must compete over price. Third, as a legacy of the centrally planned era, both “key” and “local” steel firms are sparsely distributed geographically across regions. In fact, most “key” firms usually command particular advantages given their connection to local governments, thereby restricting free market access and mergers and acquisitions (M&As) activities in the local market.

Given the three aforementioned distinct features, the market reforms in China's iron and steel industry have reduced the overall concentration ratio at the industry level, but have resulted in market fragmentation and regional monopoly by "key" firms in local regions (Tang 2010; Holloway et al. 2010). Figure 2 shows the change in production of pig iron, crude steel, and alloy products across the provinces between 1998 and 2009. The output share of the top 10 largest steel enterprises in China in 2009 declined to 50 percent (from 80 percent in 1998) compared with shares of 65 percent, 78 percent, and 83 percent in the U.S., EU, and Japan, respectively (Brandt et al. 2020). This implies that the nation's market reforms reduced the industry's average concentration ratio nationwide. However, when taking a closer look at provincial-level markets, the top steel producer in each province accounts, on average, for more than 60 percent of the local market, a concentration ratio that is comparable to that of the rest of the world. According to this analysis, the distinct market structure in China has incentivized the bigger key steel manufacturers to expand their production, often irrationally, to gain an advantage over their smaller competitors (Fung 2009), leading to the oversupply problem.

[Insert Figure 2 about here]

Two additional pieces of evidence indicate the existence of market fragmentation and regional monopoly in China's iron and steel industry. First, we observed substantial steel price dispersion across provinces, which persisted during the reform period. Figure 3 shows the price differences in the three categories of steel products (including all steel products, round steel, and line steel) across China's provinces over time. Between 1998 and 2009, the variance in the coefficients of average prices of all steel products increased, while round steel and line steel products' prices remained constant. For products as homogeneous as crude steel, the existence of a substantial price dispersion across provinces, along with a rapid increase in supply, clearly indicates the existence of regional market segregation.

[Insert Figure 3 about here]

Second, we used data from 86 major steel firms registered with the China Iron and Steel Association in 2008 to calculate the average sales radius for each firm (Figure 4). We obtained two findings from these firm-level sales data. First, most steel firms serve local consumers located within a radius of 200 kilometers from the selling entity. Second, within each province, large and small steel firms coexist. Large and small firms' sales radii overlap, with small firms usually distributed at the edge of large firms' sales radii. The two findings above offer further support for the observation that China's national iron and steel market actually comprises a set of fragmented markets and regional monopolies.

[Insert Figure 4 about here]

The characteristics of a regional monopoly and geographical market fragmentation have been viewed as an important factor that could undermine the role of market reforms in facilitating expansion at more-productive steel firms. However, to the best of our knowledge, neither formal modeling nor systemic empirical examinations have been conducted to identify the role of regional monopolies in affecting resource reallocation across firms and how they contribute to aggregate productivity growth. We attempt to overcome this shortcoming in the next section.

3. A Resource Reallocation Model in a Monopolistic Competitive Market

To provide a theoretical lens through which to examine the role of market fragmentation and the resulting effect of regional monopolies on the resource reallocation effects of market reforms, we developed a monopolistic competition model to link a market structure defined by spatial competition across firms with cross-firm resource reallocation effects (measured by using productivity-size covariance).

Suppose that the industry comprises N firms, and each firm, i, produces one type of good using log-linear production technology, such that

$$Q_i = A_i {I_i}^{\alpha} \quad (1)$$

in which Q_i is firm i's output and A_i is its TFP. I_i is the variable input used in production, which can be defined either as a single input, such as labor, or a composite input of labor, capital, and other intermediate inputs. The symbol α is the elasticity of output with respect to the variable input, such that $\alpha \in (0, +\infty)$.[5]

To organize production, firms need to pay both a sunk cost, $\bar{C}$, and a variable cost, $C'_i = W_i I_i$, in which W_i is the input price. Moreover, we assumed that the variable cost is proportional to input use and that factor markets are competitive. From these assumptions, it should be clear that all firms pay the same market price for inputs, $\bar{W}$,

[5] Where $\alpha < 1$ represents a decreasing return to scale, $\alpha = 1$ constant return to scale, and $\alpha > 1$ increasing return to scale.

such that $W_i = \bar{W}$. Thus, the total cost of production, C_i, is defined as: $C_i = C'_i + \bar{C} = \bar{W} I_i + \bar{C}$.

On the demand side, the utility function is assumed to take the form of a constant elasticity of substitution (CES) function, $U = [\sum_i \theta_i^{1-\rho} Q_i^{\rho}]^{1/\rho}$. Following from this assumption, the utility maximization problem can be written as:

$$\max_{U} [\sum_i \theta_i^{1-\rho} Q_i^{\rho}]^{1/\rho} \quad \text{s.t.} \quad \sum_i P_i Q_i = M \tag{2}$$

in which M is total expenditures, and P_i and Q_i are the price and output of firm i. θ_i is the adjustment coefficient for consumption of a particular product, and the elasticity of substitution $\rho < 1$ implies that the firms' products are substitutes.

Although steel products usually are viewed as relatively homogeneous goods in the market, we assumed that the products coming from different firms are imperfect substitutes because spatial competition exists across firms, and firms differ in their factories' distances from their final consumption markets, as explained in Syverson (2004). Specifically, because steel products are low value-added in wholesale markets, industrial consumers usually are sensitive to sales prices quoted by firms from different locations. In this sense, the shipment cost is not negligible because it adds more to the market price as the transportation distance increases. To incorporate this characteristic into the model, we assumed that the sale of steel products by each firm is subject to an iceberg transaction cost, i.e., to sell one unit of steel product to a distant place, the firm must ship $\tau_i \geq 1$ unit of product, with $\bar{\tau} \geq 1$.

For there to be no arbitrage opportunity, the output price of firm i must be equal to $P_i = \tau_i P$ and $P = \frac{M}{Q}$, in which $P = [\sum_{i=1}^{n} P_i^{\rho}]^{1/\rho}$ is the market price and $Q = \sum_i Q_i$

is the total output, such that $P_i = \frac{\tau_i M}{Q}$. Normalizing the unit expenditure, we derived the demand for each firm i's product from (2) as

$$Q_i = M\theta_i P_i^{-\varepsilon} \qquad (3)$$

in which $\varepsilon = \tau_i^{-\frac{\rho}{1-\rho}}/\delta_i$ is the price elasticity of demand $(\partial Q_i/\partial P)/(Q_i/P)$ -, which is a function of distance to market and is measured by iceberg transaction costs τ_i and market structure δ_i. Generally, three factors jointly determine the price elasticity of demand – including transportation distance, unit transportation/transaction costs, and market monopoly power – and it usually is greater than 1.

If firms have no monopoly power in the local market $(\delta_i = 1)$, the price elasticity of demand (ε) is likely to be lower the longer the shipping distance is between producers and consumers, such that $\frac{\partial \varepsilon}{\partial \tau} < 0$, as the transportation costs will add to the sales prices. However, if there is market segregation $(\delta_i > 1)$, firms' monopoly power will change the distribution of demand elasticity across space. Specifically, the price elasticity of demand (ε) will decrease in the local market, as we have $\frac{\partial \varepsilon}{\partial \delta_i} < 0$, but the impact from firms' monopoly power will be offset by increased transportation costs in more remote markets. Thus, price elasticity of demand under the assumption of a market monopoly power's presence could be lower in the local market than in the remote market.

Combining production and consumption, the firms' profits equal total revenue minus total costs:

$$\pi_i = P_i Q_i - \bar{W} I_i - \bar{C} \qquad (4)$$

In equilibrium, free entry condition drives firms' economic profit down to zero. Substituting (1) and (3) into (4), and taking the first order condition of (4), we have

$$I_i^{\alpha} = [\alpha\left(1-\frac{1}{\epsilon}\right)(M\theta_i)^{\frac{1}{\varepsilon}}\overline{W}A_i^{1-\frac{1}{\epsilon}}]^{\frac{\alpha\varepsilon}{\alpha+\varepsilon-\alpha\varepsilon}} \quad (5)$$

Combining (1) and (5), firms' output can be written as

$$Q_i = A_i I_i^{\alpha} = [\alpha\left(1-\frac{1}{\epsilon}\right)(M\theta_i)^{\frac{1}{\varepsilon}}\overline{W}]^{\frac{\alpha\varepsilon}{\alpha+\varepsilon-\alpha\varepsilon}} A_i^{\overline{\frac{\varepsilon}{\alpha+\varepsilon-\alpha\varepsilon}}} \quad (6)$$

Taking the logarithms of (6), we have the logarithm of the firm's output (or scale) being written as

$$lnQ_i = \mathrm{B} + \frac{\varepsilon}{\alpha+\varepsilon-\alpha\varepsilon} lnA_i \quad (7)$$

in which $B = \frac{\alpha\varepsilon}{\alpha+\varepsilon-\alpha\varepsilon}\ln[\alpha\left(1-\frac{1}{\epsilon}\right)(M\theta_i)^{\frac{1}{\varepsilon}}\overline{W}]$. If the idiosyncratic technological shock affects a firm's total factor productivity (TFP) randomly, we can assume that firms' productivity in logarithm takes the form of a normal distribution, such that $lnA_i \sim \mathcal{N}(\mu, \sigma^2)$ and $E[(lnA_i)^2] = \sigma^2 + \mu^2$; thus, we have

$$lnQ_i \sim \mathcal{N}(\mathrm{B} + \frac{\varepsilon}{\alpha+\varepsilon-\alpha\varepsilon}\mu, (\frac{\varepsilon\sigma}{\alpha+\varepsilon-\alpha\varepsilon})^2).$$

The resource reallocation effects, expressed as the covariance of the logarithm of firm size and productivity (when $\alpha = 1$, or constant return to scale), can then be written as:

$$COV[lnQ_i, lnA_i] = E[lnQ_i * lnA_i] - E[lnQ_i]E[lnA_i] = \varepsilon\sigma^2 \quad (8)$$

Proposition 1: The resource reallocation effects, as measured by size-productivity covariance, increase with price elasticity of demand (ε) and decrease with the transportation distance (τ_i) if firms operate in a competitive market (see Appendix A for proof).

An implication from the above proposition is that in the absence of market monopolies, firms will increase their output in response to an idiosyncratic technology shock (that raises within-firm productivity), yet the extent of the output response to productivity shock will decrease with the distance over which their output must be sold. This result exists because increased transportation costs erode more-productive firms' production cost advantages in remote markets. As a result, the resource reallocation effects become smaller in the remote market, even under the assumption of a competitive market. However, if a market monopoly power exists, the situation will change.

Proposition 2: The resource reallocation effect, as measured by the size-productivity covariance, decreases with a firm's markup (or monopoly power, δ_i) in local markets that dominant firms monopolize (see Appendix A for proof).

Proposition 2 shows that the resource reallocation effect will be undermined by the presence of a firm's monopoly power, particularly the power that the firm exerts in the local market. On one hand, dominant firms will restrict their output in response to productivity shocks to maximize their profits. On the other hand, dominant firms' local monopoly power will limit more-productive, but relatively smaller, firms from expanding. However, both effects should be much stronger in the local market, considering that the role of dominant firms' market power in affecting resource reallocation effects across all the local firms will be weakened by increased transportation costs in more remote markets.

Based on the above discussion, we arrived at two testable hypotheses: a) In a competitive market, resource reallocation effects within provinces will be larger than those between provinces, and b) if a dominant firm monopolizes the local market (thereby limiting more-productive firms from expanding), the resource reallocation effects in the local market should be associated negatively with firms' average markup (as they are dominating the local market).

4. Data and Empirical Strategy

In this section, we present the data and methodology used for empirically testing the two hypotheses derived from the monopolistic competition model described in the previous section. The empirical model will test the results from the model that describes the theoretical relationship between the resource reallocation effects and monopoly power of firms in both local and remote markets.

4.1 Data Collection and Firm-Level TFP Estimates

The data used in the present study mainly came from the Chinese Industrial Enterprise Database (CIED) provided by China's National Bureau of Statistics (NBS). The data cover the 1998–2009 period.[6] Iron and steel firms in the study were defined as those registered with the industry and engage in "smelting and pressing of ferrous metals" (namely, Category 32 of the two-digit Chinese Industrial Classification [CIC] Code). The set of the included firms includes four four-digit sub-sectors based on the

[6] Although the global financial crisis started in 2008, it is not until late 2009 that the iron and steel industry in China was affected when the total output of the industry dropped because of the slack in demand (Fung 2009).

steel production process: sintering/iron making; steel making; rolling and pressing; and alloy making.[7] The CIED database includes all state-owned and private enterprises above a designated size (those with annual sales of at least RMB 5 million).

Using these data provided a large sample base upon which to reflect on how China's iron and steel firms grew during the sample period. Dropping the observations with incomplete information left us with a sample of 33,778 firm-year observations. The sample ranged from 1,654 firms in 1998 to 4,929 firms in 2009.

The summary statistics on the major variables are listed in Table 1. The firms included in our sample account for more than 90 percent of the total number of firms in China's iron and steel industry. The combined output and asset shares accounted for around 96 percent of the total output/asset shares of the nation. Compared with the data used in the literature, our sample was more representative because it covered not only all SOEs, including both large and small firms, but also many private firms, which helped alleviate any potential selection bias problem.

[Insert Table 1 about here]

The output and intermediate input quantities at the firm level were derived by dividing total sales revenue and expenditures on the intermediate inputs by the corresponding firm-level product and intermediate input prices, respectively. Firm-

[7] Steel manufacturing is the process of producing steel using iron ore and coking coal as the major input. The process involves four steps: the first is iron making, or iron ore is transformed into pig iron in a blast furnace; the second is steel making, or the molten pig iron and recycled steel scrap are fed into a converter to produce steel; the third and fourth step is rolling/pressing, which refers to when the output crude steel is refined and cast into steel products such as slab, billet and bloom, or other alloy products.

level product and intermediate input prices were estimated using product-level price data collected at the factory gate (see below). *Capital* was defined as a firm's net fixed assets deflated by the industry-level price index for investments specific to the iron and steel industry. *Labor* was defined as the number of employees (*zaigang* workers, which exclude redundant workers such as those laid off or already retired). The level of human capital (or labor quality) was adjusted by taking into account the sample firms' average wages.

We collected detailed product prices for both the outputs and intermediate inputs from the price surveys conducted by the National Development Research Center (NDRC). The NDRC price database provides the monthly prices for all manufacturing and mining products measured at the factory gate in 130 major cities between 1989 and 2012. For this study's purposes, we matched these price data with the top three products of each firm and their major inputs. Data on the weights for price aggregation were collected from the internal reports for representative firms of the China Iron and Steel Association by region.

Using the regression method to estimate firm-level TFP has long been discussed in the literature (Olley and Parks 1996; Levinsohn and Petrin 2003; Ackerberg et al. 2007; Collard-Wexler and De Loecker 2015). Here, two issues need to be addressed to help describe our approach. The first is that we corrected for potential price variations across firms and over time for both the outputs and inputs, which reduced the effects from different output and input structures on output prices across firms and over time. The second issue that we sought to account for was the potential correlation between capital use and unobserved productivity level, which, in principle, helps resolve the endogeneity problem in the estimation of production functions.[8]

4.2 Empirical Strategy to Test the Hypotheses

Our empirical strategy contained three steps. The first was to decompose aggregate industry-level TFP into the within-firm productivity effect and the resource reallocation effect across firms in China's iron and steel industry in response to market reforms during the 1998–2009 period. We used the aforementioned OP decomposition approach, as proposed by Olley-Pakes (1996) and modified by Melitz and Polanec (2016) and Collard-Wexler and De Loecker (2015). This approach measures the resource reallocation effect by using the covariance between firm size and productivity. Compared with the BHC and FHK approaches, the OP measure offers the advantage of tracking specific moments of the distribution of productivity and market share (Melitz and Polanec 2016; Bartelsman et al. 2009; Collard-Wexler and De Loecker 2015).[9] Meanwhile, the OP measure also was connected directly to our theoretical prediction on the resource reallocation effect (see Equation [8] above).

In the standard OP estimation, industry-level productivity can be decomposed into unweighted average firm-level productivity and the sum of the covariance between firm-level productivity and the firm's market share:

$$\Omega_t = \overline{\omega_t} + \sum_i (\omega_{it} - \overline{\omega_t})(s_{it} - \overline{s_t}) \quad (9)$$

[8] The detailed procedures that we used to estimate the sector-level production function (thus the firm-level TFP) are provided in Appendix B.

[9] The estimate of resource reallocation effects by using the BHC and FHK approaches are also provided in Table C3 in Appendix C as a robustness check.

in which Ω_t is industry-level productivity, ω_{it} is firm-level productivity, and s_{it} is the total output share of firm i. $\overline{\omega_t}$ and $\overline{s_t}$ are the unweighted means of firm-level productivity and the firm's output share, respectively. The decomposition result obtained from (9) will inform the analysis of how resource reallocation may contribute to industry-level productivity growth and/or sector productivity growth relative to within-firm technology progress.

In the second step, we split size-productivity covariance between in-local and in-remote markets to examine the change in resource reallocation effects in space (or comparing resource reallocation effects between local and remote markets). Using the approach proposed by Melitz and Polanec (2016) and Collard-Wexler and De Loecker (2015), we decomposed the resource reallocation effect at the industry level into "within-group" and "between-group" components, such that

$$COV = \sum_i (\omega_{it} - \overline{\omega_t})(s_{it} - \overline{s_t}) = \sum_k [\Omega_{kt}(\phi) - \overline{\Omega_t}(\phi)][s_{kt}(\phi) - \overline{s_t}(\phi)] + \sum_k s_{kt}(\phi)\{\sum_{i\in k}[\omega_{ikt}(\phi) - \overline{\omega_{kt}}(\phi)][s_{it}(\phi) - \overline{s_{kt}}(\phi)]\} \quad (10)$$

Equation (10) contains the two components. Specifically, when firms are categorized by type ϕ (e.g., by province and ownership), one can treat each type of firm as a unit such that aggregate productivity can be written as the unweighted productivity of these firm groups, *k*, and their size-productivity covariance (or "between-group" decomposition):

$$\Omega_t = \overline{\Omega_t}(\phi) + \sum_k [\Omega_{kt}(\phi) - \overline{\Omega_t}(\phi)][s_{kt}(\phi) - \overline{s_t}(\phi)] \quad (11)$$

in which $\overline{\Omega_t}(\phi)$ is the unweighted productivity of type ϕ firms across its k groups, $\Omega_{kt}(\phi)$, and $\overline{s_t}(\phi)$ is the average market share of type ϕ firms across its k groups, $s_{kt}(\phi)$.

Thus, the aggregate productivity of type ϕ firms in group k, $\Omega_{kt}(\phi)$, can be decomposed into the unweighted productivity of type ϕ firms in group k and the covariance between these firms' size and productivity (or "within-group" decomposition):

$$\Omega_{kt}(\phi) = \overline{\omega_{ikt}}(\phi) + \sum_{i \in k}[\omega_{ikt}(\phi) - \overline{\omega_{kt}}(\phi)][s_{ikt}(\phi) - \overline{s_{kt}}(\phi)] \quad (12)$$

in which $\overline{\omega_{ikt}}(\phi)$ is the unweighted productivity of firm *i* in group *k* at time *t* by type ϕ, $\omega_{ikt}(\phi)$, and $\overline{s_{kt}}(\phi)$ is the average output share of firm *i* in group *k* at time *t* $s_{ikt}(\phi)$ and $\sum_i s_{ikt}(\phi) = 1$.

In comparing the resource reallocation effect between firms obtained from (11) and (12), we retrieved the change in resource reallocation effect in space. Specifically, we measured the within-province resource reallocation effect by using (Equation 11) and the between-province effect by using (Equation 12). The comparison of the two effects will inform us as to whether the resource reallocation effect decreases (or increases) with the distance over which each firm's output must be sold (Hypothesis 1). If the within-province resource reallocation effect is relatively larger than that of the between-province effect, the market is deemed more competitive (and vice versa).

In addition, we also defined firm type by ownership (i.e., SOEs vs. non-SOEs) to examine how resources shift between and within firms with different types of ownership. In doing so, we had an *a priori* expectation that SOEs typically are viewed as dominant firms in the local market. This exercise allowed us to test this idea empirically and seek supportive evidence for the presence (or not) of the nature of the monopoly power of the dominant firm(s).

In the third step, we examined the relationship between the within-province resource reallocation effect and average firm-level markup because the impact of a regional market monopoly as measured by average firm-level markup, decreases as the sales distance expands beyond the provincial level. To test this second hypothesis, we regressed the within-province resource reallocation effect on average firm-level markup while controlling for other potential determinants, such that

$$COV_{rst} = \alpha + \beta MKP_{rst} + \gamma Z_{rt} + u_s + v_t + \varepsilon_{rst} \qquad (13)$$

in which COV_{rst} denotes the within-province OP covariance, and *r*, *s*, and *t* denote province, sector, and year, respectively. MKP_{rst} is the average markup of steel firms in province *r* at year *t*, which captures the degree of monopolistic competition. Z_{rt} represents a set of control variables.

In these regressions, we added control variables to account for the factors that could affect cross-firm resource reallocation beyond factors associated with local firms' monopoly power. These factors included the number of iron and steel firms by sector in the local market, a firm's average export share, and the average level of fixed-asset investment within the province (e.g., Jefferson 1990). The purpose of adding these variables was to account for the impact from the sector-level market concentration level, each firm's export orientation, and vintage effects, respectively, on cross-firm resource reallocation within the local market. In addition, we also accounted for the provincial cluster effects (u_s) and included a year dummy (v_t), which takes 1 for the period after China's accession into the WTO.

When estimating the coefficient of interest, β, in Equation (13), we risked encountering potential endogeneity concerns resulting from either the omitted variable or the issue of reverse causality. We addressed this concern in two ways. First, we included the province-sector fixed effects to account for the impact from time-invariant factors that may affect both the resource-reallocation effect and monopoly power.

In addressing the issue of potential endogeneity, we also applied an instrumental variables (IV) approach to deal with the potential reverse causality concern (considering that it is possible that resource misallocation may strengthen the monopoly power further). In implementing the IV approach, we used two different instrumental variables. One is the maximum sale distance of the top steel firm in each province, a variable that seeks to exploit the exogenous variation in a firm's location distance to the market. The other variable, following Syverson (2004), is the total housing area under construction, which is relevant because rapid growth in the construction industry (as well as the level of public infrastructure investment in a region's downstream industries) can drive market demand for iron and steel products (Fung 2009; Tang 2010; Holloway et al. 2010). For example, in 2008, the construction industry consumed about 55 percent of China's steel (Fung 2009). Both instruments are associated with firms' local monopoly power, but are not related directly to size-productivity covariance.

5. Empirical Results

In this section, we will discuss the results from the tests of the two hypotheses based on the proposed empirical estimation strategy and the data described in Section 4. The related results are shown in Tables 2–6.

5.1 Industry TFP Growth and Resource Reallocation

As discussed in Section 4, industry-level TFP growth can be decomposed into within-firm productivity growth and resource reallocation effect. As shown in Table 2, annual industry-level TFP growth during the 1998–2009 period was, on average, 5.34 percent per year. According to our analysis, within-firm productivity growth accounts for 86 percent of overall annual industry-level TFP growth (or 4.59 percent per year). The resource reallocation effect, as measured by annual growth in OP covariance, was 0.74 percent per year and accounted for only 14 percent of overall annual industry-level TFP growth.

[Insert Table 2 about here]

Our results present clear declining trends in resource reallocation effects during the sampled time frame. When we split the whole period into three subperiods—1998–2001, 2002–2005, and 2006–2009—annual growth in OP covariance (a measure of resource reallocation effects) declined from 2.42 percent a year during the 1998–2001 period to -1.39 percent a year during the 2006–2009 period. However, during this same period, annual within-firm productivity growth increased from 2.13 percent to 4.27 percent per year. Such trends are somewhat surprising because market reforms during this period led to a substantial increase in the privatization of steel and iron industry firms, as well as the marketization level in the industry. In other words, during a time when the resource reallocation effect was deteriorating, China was in the middle of implementing a set of market reforms that elicited a reduction in market share of SOE firms in the industry, from 80 percent in 1996 to 40 percent in 2008. Simultaneously, the market share of the top 10 largest firms in the industry fell from 80 percent in 1998 to 50 percent in 2009. In such an environment, one might have expected to see a more positive resource allocation effect resulting from the relatively rapid levels of within-firm technological progress.

[Insert Table 3 about here]

Our analysis is also clear in showing that the pattern of productivity changes is not confined to the overall/aggregated sector. In examining the four subsectors of China's iron and steel industry, the results do not indicate a significant positive resource reallocation effect in any subsector. As shown in Table 3, the OP covariance term grows at the rate of less than 1 percent per year in three out of the four subsectors, which is far less than the 3.68–4.32 percent-per-year growth found in annual within-firm productivity. Although the OP covariance term in the sintering/iron-making subsector increases slightly (1.46 percent a year), its contribution to sub-sectoral-level TFP growth remains relatively small (only about 25 percent).

5.2 Resource Reallocation Between and Within Province

Could the unintended resource reallocation effect due to market reforms in China's iron and steel industry during the 1998–2009 period be related to geographical market fragmentation? To answer this question, we decomposed the industry-level resource reallocation effect into two components: the *within-province* and *between-*

province effects. As discussed in the methods section above, the purpose of doing this is to test the first hypothesis: The presence (or absence) of a local market monopoly can be shown by comparing the within-province resource reallocation effects with the between-province resource reallocation effects. Following Proposition 1, if there was a nationwide competitive iron and steel market, the resource relocation effect would be larger in the local market. Thus, we expect *between-province* resource reallocation effects to be lower than *within-province* resource reallocation effects.

Table 4 shows the decomposition results for the four subsectors. As shown in Column (3) of Table 4, in three out of the four subsectors, resource reallocation *between provinces* positively contributes to industry-level TFP growth. However, and relevant to our results, the magnitude of these TFP shifts is small. On average, the change in the OP covariance *between provinces* only accounts for 5.52 percent, 8.22 percent, and 18.64 percent of industry-level TFP growth in the sintering/iron making, steel-making, and alloy-making sectors, respectively. Such results are consistent with what should be expected. The between-province effect should be small, considering that transportation costs would be expected to undermine the impact from productivity growth of more-productive steel firms and keep them from being able to expand their market share into more remote regions.

[Insert Table 4 about here]

Interestingly, despite there being small *between-province* productivity effects, the *within-province* resource reallocation effects generally are not significantly larger than the *between-province* resource reallocation effects. Specifically, in the case of the sintering/iron-making and steel-making sectors, the *within-province* resource reallocation effect is 36.45 percent and 37.5 percent of the already small *between-province* resource reallocation effect, respectively. As for alloy making, the *within-province* and *between-province* resource reallocation effects are 0.45 percent and 0.37 percent per year, respectively, i.e., similar in magnitude. The findings on the insignificant *within-province* resource reallocation effect relative to the *between-province* resource reallocation effect contradict the hypothesis that a nationwide competitive market exists. Therefore, based on this finding, one begins to hypothesize that either market fragmentation characterizes China's iron and steel market and/or dominant firms impose monopoly power within provinces (which, in turn, could limit more-productive firms from expanding into local markets).[10]

In the literature, iron and steel market fragmentation usually is attributed to local protectionism associated with the presence of large SOEs and the privileges that they enjoy, including prioritized access to various resources and close ties with local governments (Sheng and Song 2013; Brandt et al. 2020). According to the literature, SOEs are significant in generating GDP growth, employment, and tax revenue, thereby contributing to improving the performance indicators that are important to local policy makers. However, because SOEs share the same administrative system as local governments and state-owned banks, they historically have enjoyed preferential treatment in land use and bank loans compared with their private counterparts (Song

[10] The only exception is the rolling/pressing industry, which by its very nature is dominated by many small- and medium-sized firms.

and Liu 2012). Given the difference in the economic status between SOEs and non-SOEs compared with local governments, it may be hypothesized that local protectionism could help SOEs establish their market power.

To investigate the potential link between resource reallocation effects and market structure caused by SOEs' presence in China's local markets, we further classified the iron and steel firms by ownership and decomposed the industry-level resource reallocation effect into components among SOEs and non-SOEs, and between the two types of firms. We expect that resource reallocation should be larger among non-SOEs rather than among SOEs (and also somewhat higher between SOEs and non-SOEs). This expectation is confirmed in our empirical results. As shown in Table 5, the average annual change in OP covariance terms between SOEs and non-SOEs is estimated to range from -0.08 to -0.29 percent in three out of the four subsectors (including steel, rolling and pressing, and alloy production). When examining average annual change in OP covariance terms among non-SOEs, it is clear that they are all positive. Similarly, the average annual change in OP covariance terms among non-SOEs is also much larger than those among SOEs. Because both SOEs and non-SOEs have experienced similar within-productivity growth during the reform period, our findings suggest that SOEs, which have been shown to receive local protection (and, thus, command local monopoly power), are less likely to be part of a process that allows resource reallocation across firms in response to productivity shocks. In addition, the presence of locally supported SOEs also may limit other more-productive firms from being able to expand.

[Insert Table 5 about here]

5.3 Regional Monopoly and Resource Reallocation

The decomposition analysis above shows that low levels of resource reallocation effect at the industry level may derive from the fact that weak resource reallocation exists within provinces. The results are consistent with an explanation that weak resource reallocation within provinces could be related to SOEs' reluctance to participate in (or allow) resource reallocation. It also could be a lack of interaction between SOEs and non-SOEs during the reform period; however, in the literature, no direct evidence so far indicates a link between low resource reallocation effects within a province and large and dominant SOEs' monopoly power in the local market. In this section, we test the second hypothesis by examining the relationship between within-province OP covariance and firms' monopoly strength in the local market, both visually (see Figure 4 and the discussion below) and by the estimated coefficient from the fixed effect model with instrumental variables. We expected that the within-province resource reallocation effect would be correlated negatively to the local monopoly power of dominant firm(s).

We start by illustrating the relationship between the within-province OP covariance and dominant firms' local monopoly power for the four subsectors by province and over time. In this analysis, we measured the local market monopoly power of firms by using the average markup of steel firms for each province.[11] As shown in

[11] We define the variable as the primary sales revenue divided by the primary sales costs for the four subsectors, following Collard-Wexler and De Loecker (2015). Please refer to Collard-Wexler and De

Figure 4, the within-province OP covariance is correlated negatively with the average markup of steel firms. Consistent with the prediction from Proposition 2 (above), our findings imply that resources are reallocated across iron and steel firms relatively slowly in the provinces where dominant firms have relatively strong market power.

[Insert Figure 4 here]

We further performed regressions to examine the relationship between the within-province OP covariance and average markup of steel firms formally. Table 6 reports the regression results from the fixed effect (FE) and fixed effect with instrumental variables (FEIV) regressions. From the baseline fixed effect regressions, as reported in Columns (1) and (3), we found a significant negative relationship between firms' local monopoly power and the within-province resource reallocation effect in China's overall iron and steel industry.[12] Our preferred FEIV regressions confirm the results, as shown in Columns (2) and (4). The estimated coefficients for the average firm-level markup also are negative and significant at the 1 percent level after taking into account the effect from other control variables. In particular, the results obtained from the FEIV regressions are -1.00 and -1.47, respectively, which are much smaller than those obtained from the FE regressions (-0.34 and 0.47), suggesting that omitted variables may be correlated negatively with steel firms' market power.

Loecker (2015) for the details of how to derive of this mark-up as a measure of the monopoly power of local firms.

[12] Note that we have two instrumental variables, each of which are run a separate fixed effects regression, as shown in Columns (1) and (3), and fixed effects with an IV regression, as shown in Column (2) and (4) in Table 6, respectively.

The findings associated with the regression in Columns (2) and (4) imply that a 1 percent increase in average firm-level markup is associated with a reduction in within-province resource reallocation of 1.00 to 1.47 percent. Such a finding is consistent with our theoretical model's prediction that the monopoly power held by a market's dominant firm might limit more-productive firms from expanding their production. The finding, which is consistent with the finding by Syverson (2004) in the U.S. concrete industry, suggests that the noncompetitive market structure that exists in some local markets in China is an important factor that is undermining the impact of the market reforms on resource reallocation in China's iron and steel industry.

[Insert Table 6 about here]

To sum up, in this section, we empirically demonstrated that market reforms in China's iron and steel industry have not delivered the intended resource reallocation effects across firms during the 1998–2009 period. In fact, resource reallocation worsens over time despite the fact that the reforms significantly increased privatization and marketization levels, as well as facilitated within-firm productivity growth. According to the findings, the within-province resource reallocation effect is particularly weak. The measured within-province effect generally is smaller compared with the between-province resource reallocation effect. Finally, our results also show that the weak within-province resource reallocation effect is likely to be related to the local monopoly power of the dominant firm(s) in local markets.

6. Robustness Check

In this section, we conduct several sensitivity tests to check the robustness of our empirical results. First, there might be concerns that our findings on the weak resource reallocation effect in China's iron and steel industry during the market reform period could be related to the OP decomposition method (which we used). Nishida et al. (2013) showed that one would get different measures of the resource reallocation effect when the analyst used different decomposition methods. To deal with this concern, we re-measured the resource reallocation effect by using the other two popular approaches: the BHC approach, proposed by Baily et al. (1992), and the FHK approach, proposed by Foster et al. (2001, 2008). The decomposition of the industry-level TFP growth obtained from using the BHC and FHK approaches confirms our finding that the resource reallocation effect is still weak compared with the within-firm productivity growth during the reform period (see Table C2 in Appendix C).

Second, our measures of the products' prices could be an important factor that affects the estimation of the resource reallocation effect across firms because firms may make their input/output choices based on profitability rather than productivity growth. We used the quantity-based TFP measure for our main exercise, but we also used alternative approaches as a robustness check, such as the revenue-based TFP measure. The findings derived from using the revenue-based TFP measure also are generally consistent with our initial results—except for the fact that the resource reallocation effect at the industry level during the sample period becomes a bit larger. In fact, this result is what should be expected, considering that it is consistent with the literature, which suggests that firms are more likely to choose resources in response to profit shocks, rather than productivity shocks, even though the two indicators are positively correlated strongly in the long run.

Third, the entry and exit decisions that firms made may have asymmetric impacts on resource reallocation across firms. Between 1998 and 2009, the average annual rates of firm entry into and exit from China's iron and steel industry were 16 percent and 33 percent, respectively. Although we accounted for the impact from firms' entry and exit in our main exercise, we did not separate the entering and exiting firms from the ongoing firms. To examine our results' sensitivity to this assumption, we examined the impact of market reforms on resource reallocation across firms, examining firms that are entering or exiting separately. Using the method proposed by Melitz and Polanec (2016), we show that the impact of market reforms on resource reallocation effects on firms that are entering or exiting resembles our original findings (which examined the impact of the market reforms on resource reallocation effects across ongoing firms).

Fourth, we sought to understand how our theoretical prediction on changes in resource reallocation effects across space will be consistent with our original findings, when we used alternative measures/definitions to define the local market (e.g., region rather than province). To answer this question, we split the iron and steel market in China into seven regions and re-decomposed the aggregate resource reallocation effect into the within-region and between-region effects. These regions, which we defined using the definitions embodied in the state plan from the national strategy for market integration of steel production, include the following: northeast; north; northwest; east;

south; middle; and southwest. As is shown in descriptive statistics (earlier in the paper), the market concentration level in the industry within each region declined, on average, by 10 to 20 percent during the reform period (1998-2009). Both within-region and between-region markets can be viewed as relatively more competitive. When using these new region divisions, the data suggest that when we compare resource reallocation effects within-region and between-region, the within-region resource reallocation effect is significantly larger than the between-region resource reallocation effect (see Table C3 in Appendix C). This finding generally is consistent with our theoretical predication (Proposition 1), such that resource reallocation effects across firms will decrease in a remote, but competitive, market.

Fifth, our regression results in Section 5.3 also could be sensitive to using the average firm-level markup by sub-sectors at the provincial level as the only measure of regional monopoly. To address this concern, we also used the total markup of all steel firms in all four sub-sectors at the provincial level and the largest firm's markup as alternative measures of market monopoly power, and we re-did the regressions. Consistent with the results using the average firm-level markup by sub-sector as the measure of regional monopoly, the markup of firms generally is associated negatively with the within-province size-productivity covariance, suggesting that our results are not sensitive to any particular measure of monopoly power.

Taken together, the finding of a negative relationship between market power firms and within-province resource reallocation effects in China's iron and steel industry is robust to alternative measures of firm productivity and markup, output prices, firms' entry and exit, level of aggregation of regions, and alternative regression methods.

7. Concluding Remarks

Policy makers in developing countries have launched market reforms to address resource misallocation issues across firms to raise productivity growth at the aggregate level. It is a common perception that by launching market reforms, more-productive firms are likely to expand their output in a more competitive (or privatized) market in response to more rapid within-firm productivity growth. The assumption is that this will lead to an improvement in aggregate productivity, but a growing body of literature examining how resources are reallocated across firms often has found puzzling evidence that market reforms could fail to deliver intended resource reallocation effects across firms.

In the current paper, we developed a monopolistic competition model to explain why market reforms may not improve resource reallocation efficiency in a more competitive overall market (but one characterized by strengthened local monopoly power). We show that locally dominant firms' regional market monopolies will limit more-productive firms and keep them from expanding their output. Because of this, market reforms that help improve overall market competitiveness may fail to deliver the intended resource reallocation effects in response to the within-firm productivity growth in the local market, and it is possible that this will lead to a deterioration of overall resource reallocation efficiency. In this paper, the theoretical prediction is put to the test empirically by using firm-level data for China’s iron and steel industry during the 1998–2009 reform period. We found evidence that the within-province market monopoly (particularly that of the local dominant firm) will undermine resource reallocation from less- to more-efficient steel firms.

Finally, dominant firms’ monopoly power in local markets also has been shown to be one of the causes of steel production over-capacity. Specifically, our findings shed light on explaining the paradox of oversupply of low-end iron and steel products as the Chinese market became more competitive (due to market reforms). The phenomenon has been observed widely in other industries in China as well, such as the concrete and energy industries (European Chamber 2016; Lin et al. 2016; Shi et al. 2018) in recent years, and it also applies to other developing countries that are in the process of implementing market reforms. A direct policy implication is that there should be a policy priority of removing regional protection and market segregation at the provincial level to facilitate more efficient resource reallocation across regions under market reforms.

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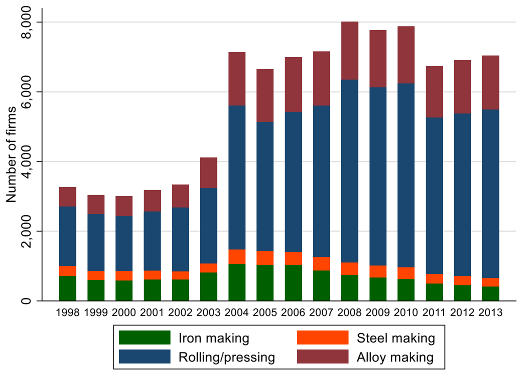
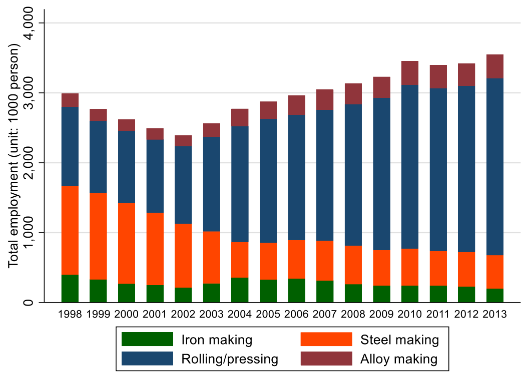
Figure 1. China's Iron and Steel Industry: 1998-2013

(A) Number of Firms



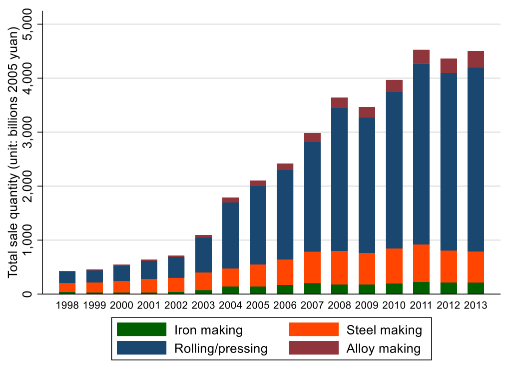
(B) Total Number of Employed Workers

(unit: 1000 persons)



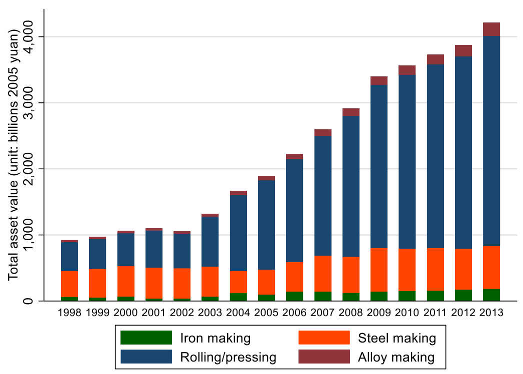
(C) Total Sales

(unit: billions yuan at 2005 price)



(D) Total Asset Value in real term

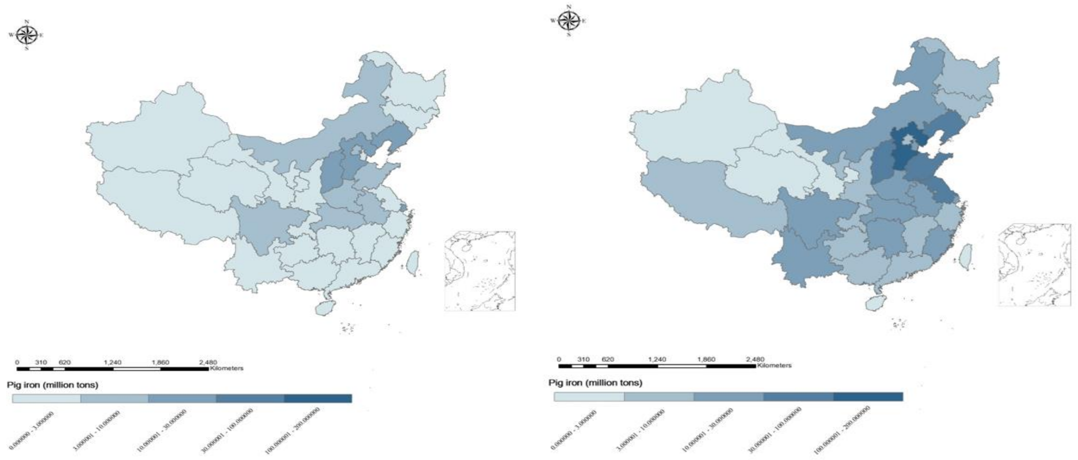
(unit: billions yuan at 2005 price)



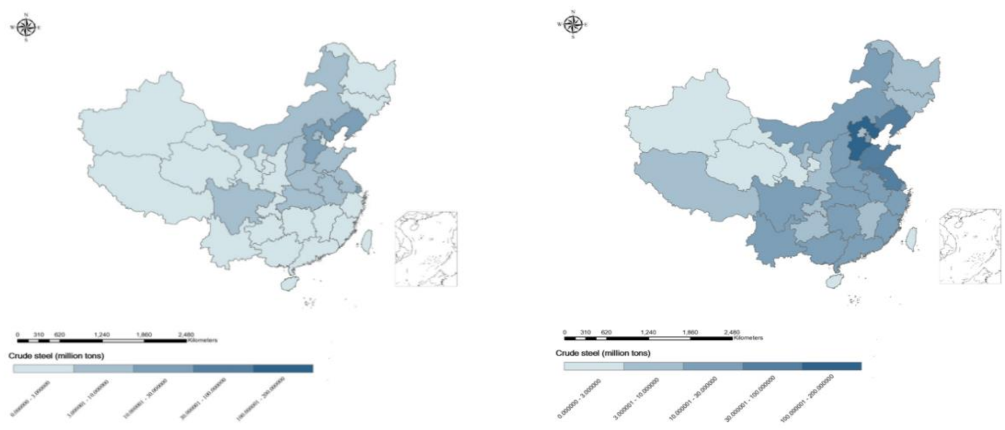
Source: the data are obtained from China Iron and Steel Statistical Yearbook, various years, which is available at the CEIC database.

Figure 2. Distribution of pig iron, crude steel and finished steel production in China

Panel (A) pig iron production: 1998 vs. 2009



Panel (B) crude steel production: 1998 vs. 2009



Panel (C) finished steel production: 1998 vs. 2009

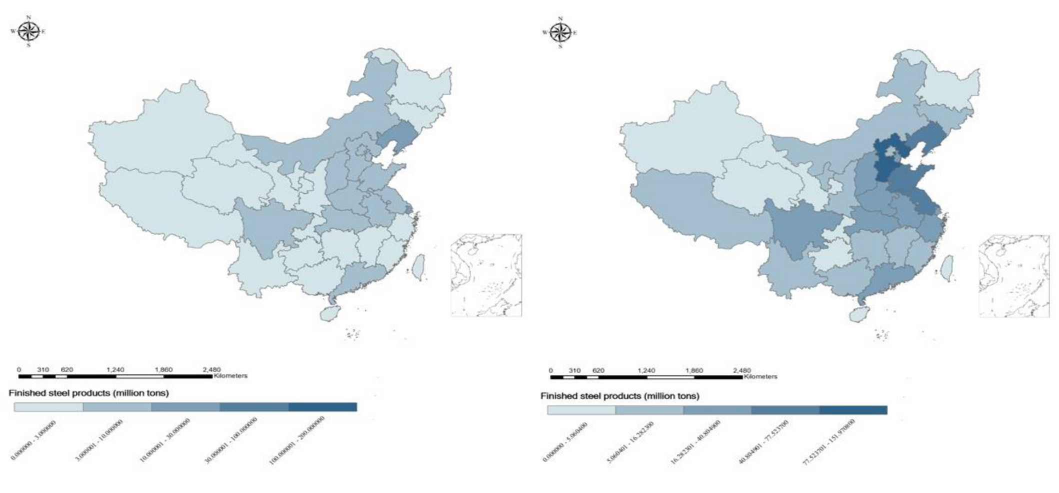
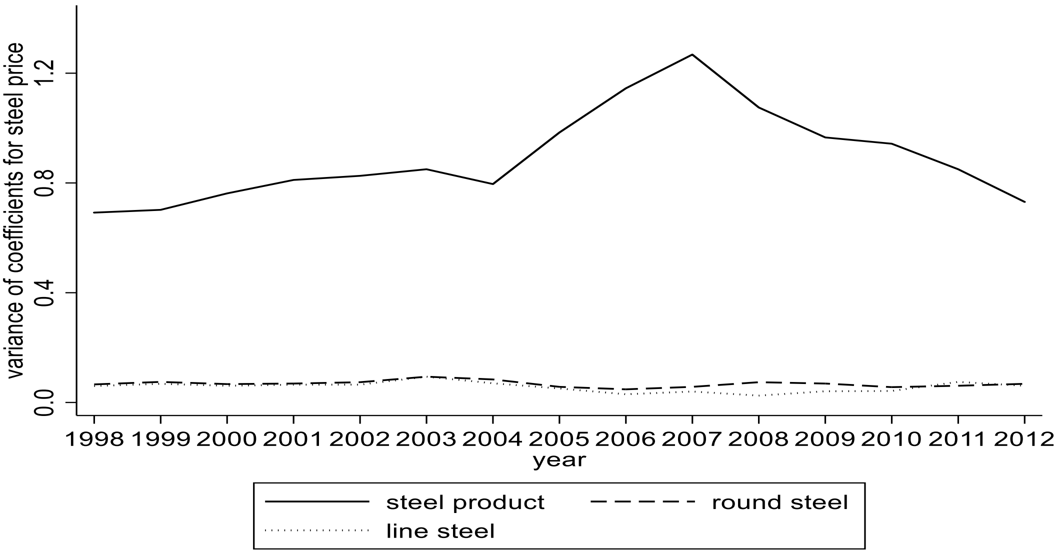
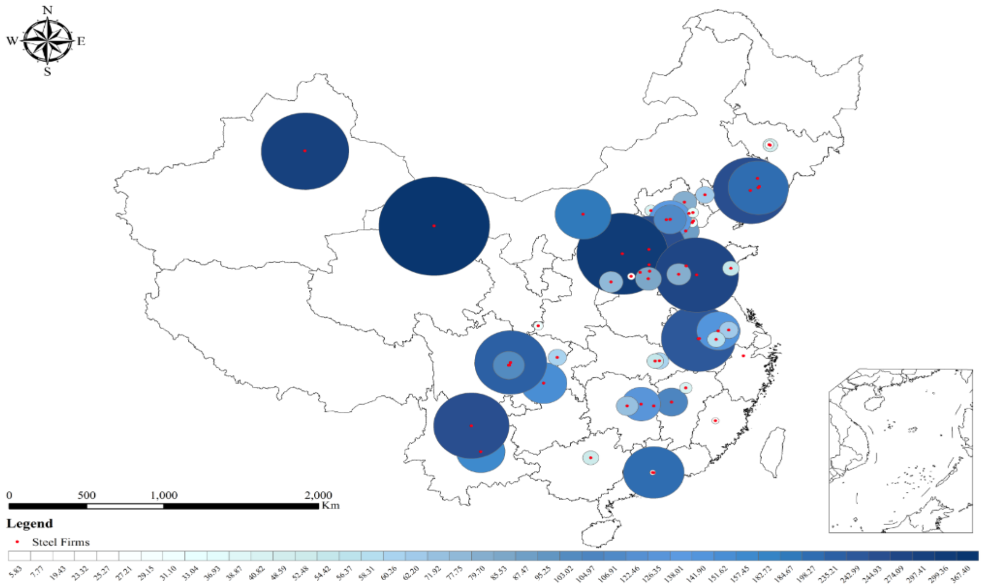


Figure 3. Variance of Coefficient of the Price of Selected Steel Products in China: 1998-2012



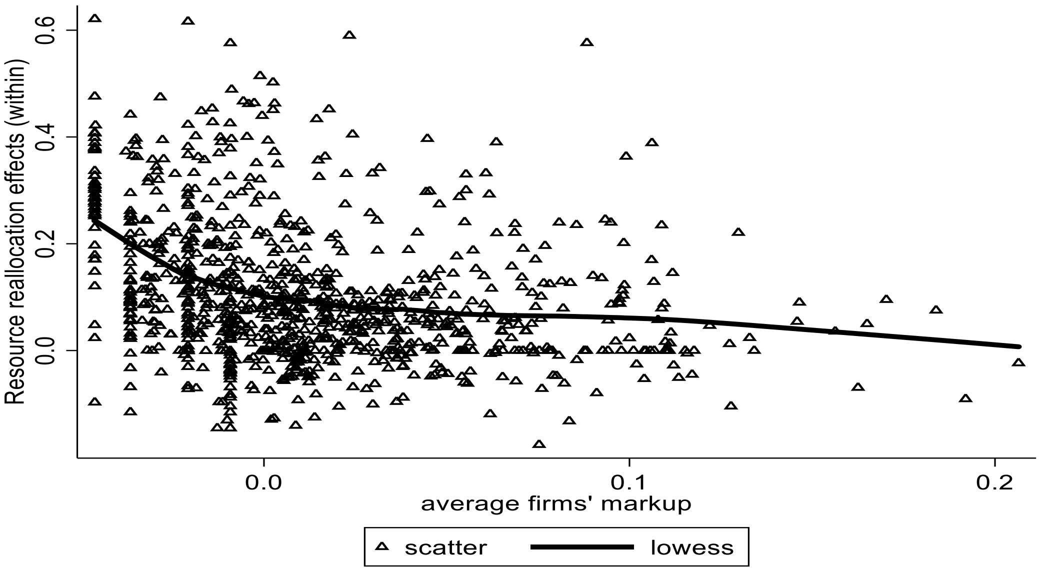
Source: Authors' estimates by using the product-level prices of major steel products in 300 cities, obtained from NDRC China.

Figure 4. The Sales Radius of Major Chinese Iron and Steel Firms: 2008



Source: Authors' calculations using data from China Iron and Steel Association in 2008, China.

Figure 5. Relationship between the Within-province Resource Reallocation Effecct and Firms' Local Monopoly Power: 1998-2009



Note: The vertical axis denotes the within-province OP covariance used to measure the resource reallocation effects within provinces, while the horizontal axis denotes the average farms' mark-up at the province level used to measure the local monopoly power.

Source: Authors' calculations.

Table 1. The Summary Statistics on China's Iron and Steel Firms between 1998 and 2009

	Sintering/Iron making	Steel making	Rolling/pressing	Alloy making	Average
Output value at current price (billion yuan)	1.691	17.442	4.610	0.885	4.046
	(9.054)	(63.528)	(29.335)	(2.456)	(27.173)
Employment (person)	405.19	3384.70	602.92	201.02	633.00
	(1356.49)	(12752.82)	(3544.13)	(382.65)	(4066.04)
Workers' annual wage (1000 yuan)	10.21	14.39	14.89	11.19	13.28
	(17.91)	(14.40)	(22.43)	(11.95)	(19.63)
Fixed asset value (billion yuan at 2000 price)	0.337	7.430	1.661	0.154	1.433
	(1.773)	(35.595)	(15.196)	(0.801)	(14.233)
Intermediate inputs (billion yuan)	1.292	13.096	3.589	0.665	3.116
	(7.287)	(43.446)	(21.840)	(1.910)	(19.814)
Export value (million yuan)	36.439	834.087	284.553	82.243	232.190
	(405.323)	(7037.639)	(3410.599)	(582.477)	(3080.286)
Entity share of SOEs (%)	26.13	30.14	19.71	21.03	21.67
	(41.66)	(47.52)	(37.58)	(39.02)	(39.33)
Number of observations	6882	2275	25581	9081	43819

Source: Authors' calculations using the China Industrial Enterprise Database.

Table 2. Contribution of Resource-Reallocation to the Industry-level TFP Growth (%): 1998-2009

	TFP Growth	Unweighted Average	OP Covariance
1998-2001	4.55	2.13	2.42
2002-2005	8.38	6.76	1.61
2006-2009	2.88	4.27	-1.39
1998-2009	5.34	4.59	0.74

Note: We adopt the OP (Olley and Pakes 1996) to measure the contribution of resource reallocation to TFP growth. Results from alternative approaches (i.e. FHK and BHC) are reported in Appendix C.

Table 3. Decomposition of TFP Growth and Its Components by Sectors (%): 1998-2009

	TFP Growth	Unweighted Average	OP Covariance
Sinister/iron making	5.74	4.28	1.46
Steel making	4.35	4.02	0.33
Rolling/pressing	4.56	4.32	0.24
Alloy making	4.50	3.68	0.82

Note: "Sinister/iron making" refers to China Industry Classification (CIC) Code 3210; "Steel making" refers to CIC 3220; "Rolling/pressing" refers to CIC 3230; "Alloy making" refers to CIC 3240.

Table 4. Comparing the Resource-Reallocation Effects across Regions: Between-province vs. Within-province (%): 1998-2009

	Between Province			Within Province		
	TFP	Unweighted Average	OP Covariance	TFP	Unweighted Average	OP Covariance
Sinister/iron making	5.74	4.67	1.07	4.67	4.28	0.39
Steel making	4.35	4.11	0.24	4.11	4.02	0.09
Rolling/pressing	4.56	5.37	-0.81	5.37	4.32	1.04
Alloy making	4.50	4.13	0.37	4.13	3.68	0.45

Note: "Sinister/iron making" refers to China Industry Classification (CIC) Code 3210; "Steel making" refers to CIC 3220; "Rolling/pressing" refers to CIC 3230; "Alloy making" refers to CIC 3240. "Within province" refers to resource reallocation within province, while "Between province" refers to resource reallocation effects between provinces.

Table 5. Comparing the Resource-Reallocation Effects across Ownerships: Between ownership vs. Within ownership (%): 1998-2009

	Between SOEs/Non-SOEs			Within SOEs			Within Non-SOEs		
	TFP	Ave	COV	TFP	Ave	COV	TFP	Ave	COV
Sinister/iron making	5.74	4.47	1.26	3.35	4.33	-0.98	5.6	4.11	1.49
Steel making	4.35	4.61	-0.26	4.6	4.49	0.11	4.62	4.33	0.29
Rolling/pressing	4.56	4.65	-0.08	4.28	4.86	-0.59	5.01	4.12	0.89
Alloy making	4.50	4.78	-0.29	5.06	3.76	1.31	4.51	3.42	1.09

Note: "Sinister/iron making" refers to China Industry Classification (CIC) Code 3210; "Steel making" refers to CIC 3220; "Rolling/pressing" refers to CIC 3230; "Alloy making" refers to CIC 3240. "Within SOEs" refers to resource reallocation among SOEs, "Within Non-SOEs" refers to resource reallocation among non-SOEs, and "Between SOEs/Non-SOEs" refers to resource reallocation between SOEs and non-SOEs.

Table 6. Market Monopoly Power and the Resource Reallocation Effect within Provinces: 1998-2009

	Sales Radius (IV1)		Construction Area (IV2)	
	Fixed Effect	Fixed Effect with IV	Fixed Effect	Fixed Effect with IV
	(1)	(2)	(3)	(4)
Dependent variable: within-province covariance (ln)				
Average firms' markup	-0.344*	-0.999***	-0.474**	-1.468***
	(0.132)	(0.145)	(0.137)	(0.533)
Total crude steel production (ln)	-0.015	-0.028**	0.000	0.004
	(0.014)	(0.013)	(0.008)	(0.008)
Export share of output	-0.003	-0.123	-0.010	-0.173
	(0.307)	(0.330)	(0.286)	(0.152)
Number of steel firms	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Fixed asset investment (ln)	0.008**	0.004***	0.010**	0.009***
	(0.002)	(0.001)	(0.002)	(0.003)
Constant	0.191	-	0.102	-
	(0.085)	-	(0.048)	-
Dummy for WTO accession	Yes	Yes	Yes	Yes
Province*Sector FE	Yes	Yes	Yes	Yes
Province*Sector cluster effects	Yes	Yes	Yes	Yes
Number of observations	933	933	1,059	1,059
R-squared	0.036	-	0.060	-
Number of province X sector	99	99	117	117

Note: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The first-stage F-test for IV are 57.97 and 14.45 respectively. The first-stage results for FEIV models are reported in Table C1 of Appendix C.

Appendix A. Proof of Propositions

This appendix provides proofs of Propositions 1 and 2.

Proposition 1: Resource reallocation effects, as measured by the size-productivity covariance, is increasing with the price elasticity of demand (ε) and thus decrease with the transportation distance (τ_i) if firms are operating in a competitive market.

Proof: Taking the first order condition of (8) with respect to ϵ, we have $\frac{\partial COV[lnQ_i, lnA_i]}{\partial \varepsilon} = \sigma^2 > 0$. Moreover, if there is no monopoly power, the elasticity of demand ε is only determined by transportation costs and thus likely to decline with the shipping distance between producers and consumers. QED

Proposition 2: Resource reallocation effects, as measured by the size-productivity covariance, is decreasing with firms' markup (or monopoly power, δ_i) if firms operate in a local monopoly market.

Proof: From (3), we have $\frac{\partial \varepsilon}{\partial \delta_i} < 0$. Substituting this into (8), we have $\frac{\partial COV[lnQ_i, lnA_i]}{\partial \delta_i} < 0$. Since the monopoly power of firms are usually stronger in the local market, resource reallocation effects are more likely to be weaken by firms' monopoly power in the local market. QED

Appendix B. Estimating firm-level total factor productivity

This appendix provides a brief description on how firm-level total factor productivity is measured based on the gross output model when using the regression method.

Output and input price correction

To estimate firm-level productivity, we need to derive quantities of output and inputs from data on revenue and expenditures. In doing so, firm-specific prices for output and inputs need to be constructed to deflate the corresponding values. By assuming input allocation across products have the same share as output, Collard-Wexler and De Loecker (2015) suggest using the average of product prices with product-specific sales share as weights to approximate firm-level output prices. This is a simple method, but it is biased due to the strong assumption of proportional allocation of all inputs to different outputs.

We propose to use a transitive Fisher index to aggregate product-specific prices using real output of each firm as weights. Specifically, we assume firms at each time period are independently observed. A direct Fisher index between any two observations can be written as

$$P_{it,ks}^{F} = \left(\sum_j p_{jt} q_{ijt} \,/\, \sum_j p_{js} q_{ijt}\right)^{1/2} \left(\sum_j p_{jt} q_{kjs} \,/\, \sum_j p_{js} q_{kjs}\right)^{1/2} \qquad \text{(B1)}$$

where p_{jt} and p_{js} are the price of product j at time t and s, and q_{ijt} and q_{kjs} are the quantity of product j manufactured by firms i and k at time t and s. Now, choosing a firm at any time as a base (bb), the EKS formula (Elteto and Koves 1964 and Szulc 1964) is used to derive the transitive price index, $P_{it,bb}$, of firm (i) at time t relative to the base as follows

$$P_{it,bb} = \prod_{ks} P_{it,ks}^{F} P_{ks,bb}^{F}. \qquad \text{(B2)}$$

Defining $Q_{it}^{j} = R_{it}^{j}/P_{it,bb}$, output quantity can be written as

$$\frac{R_{it}^{j}}{P_{it,bb}} = F_{\varphi t}^{j}(L_{it}, K_{it})\exp(\omega_{it}^{j}) \tag{B3}$$

where R_{it}^{j} is the revenue of firm i's product j k at time t while Q_{it}^{j} is the corresponding quantity. ω_{it} is firm-level productivity. L_{it} and K_{it} are labor and capital inputs respectively.

A similar method can be applied to derive price deflators for various inputs. Following Collard-Wexler and De Loecker (2015), we group all inputs into three categories: labor, capital and intermediate inputs. For labor, the number of workers (or hours worked) L_{it} at the firm level are observed but quality differences need to be accounted for. We use the firm-level average wage (W_{it}) to construct a quality adjustment index and combine it with the number of workers to account for differences in workers' skills across firms. For capital, we use firm-level financial information to estimate their financial costs (r_{it}) for investment to correct the capital stock series.

There are many intermediate inputs used in steel firms, and these can be quite different across firms using different production technologies. To simplify the comparison, we group them into four categories: fuel and electricity, coking coal, iron ores and scrap steel, and others. Firm-specific price indexes ($P_{it,bb}^{M}$) for intermediate inputs, relative to the same base, are estimated using Equations (B2) and (B3). Prices for each group of intermediate inputs are calculated using commodity prices, while the shares of each group of intermediate input in total expenditure are used as weights.

Finally, assuming a Cobb-Douglas production technology, we estimate the production function using our constructed output and input price deflators and revenue and expenditure data as follows

$$ln\left(\frac{R_{it}^{j}}{P_{it,bb}}\right) = \beta_l \ln\left(\frac{L_{it}}{W_{it}}\right) + \beta_k \ln\left(\frac{K_{it}}{r_{it}}\right) + \beta_m \ln\left(\frac{M_{it}}{P_{it,bb}}\right) + \omega_{it} + \varepsilon_{it} \quad \text{(B4)}$$

where lower case indicates the logarithm of deflated variables. ε_{it} is residual, which is used to absorb measurement errors in output and prices.

Treatment of endogeneity

However, there is a potential endogeneity concern when using Equation (B4) to estimate firm-level productivity, since unobserved productivity could be correlated with input use. Several approaches are used in the literature to deal with the endogeneity problem, for example, Olley and Parkes (1996); Levinsohn and Petrin (2003); Ackerberg et al. (2015); Wooldridge (2009).

Following Ackerberg et al. (2015) and Wooldridge (2009), we adopt a two-stage procedure in the estimation. Specifically, the first stage is to regress output $q_{it} = ln\left(\frac{R_{it}^{j}}{P_{it,bb}}\right)$ on a flexible function of inputs (l_{it}, m_{it}, k_{it}) (where $l_{it} = \ln\left(\frac{L_{it}}{W_{it}}\right)$, $m_{it} = \ln\left(\frac{M_{it}}{P_{it,bb}^{M}}\right)$ and $k_{it} = \ln(\frac{K_{it}}{r_{it}})$) so as to use the information of investment (i_{it}) or other external instruments to identify productivity.

$$q_{it} = \varphi_{\varphi,t}(l_{it}, m_{it}, k_{it}, i_{it}) + \varepsilon_{it} \quad \text{(B5)}$$

where firm-level productivity is estimated as

$$\omega_{it} = \widehat{\varphi_{\varphi,\iota t}} - f_{\varphi t}(l_{it}, m_{it}, k_{it}, i_{it}; \beta) \quad \text{(B6)}$$

Using Equations (B5) and (B6) for productivity estimation requires the use of the process that determines productivity movements over time. In this case, we use an exogenous Markov process such that

$$\omega_{it} = g_{\varphi}\left(\omega_{i,t-1}, \widehat{X_{\iota t}}\right) + v_{\varphi it} \quad \text{(B7)}$$

where firm-level productivity and its movements vary across different production technologies.

Estimation of the production function coefficients β relies on assumptions about how firms change input use in response to random productivity shocks over time $v_{\varphi t}$. When various inputs are assumed to adjust with productivity shocks at different speed, the identification conditions can be quite different. We allow firms to dynamically choose both labor and capital but adjust the use of intermediate inputs only when productivity shocks arrive. This assumption can be summarized in a moment condition as follows

$$E\left[v_{\varphi it}(\beta)\begin{pmatrix} l_{it} \\ m_{it-1} \\ k_{it} \end{pmatrix}\right] = 0 \qquad \text{(B8)}$$

The condition in Equation (B8) is flexible and allows for a variety of production functions with different assumptions about the variability of inputs and the use of instruments.

Table B1. Production Function Estimates based on the Gross Output Model by Sectors

	All 4 Sectors				Iron making				Steel making				Rolling/pressing				Alloy making			
	OLS	FE	LP	ACF	OLS	FE	LP	ACF	OLS	FE	LP	ACF	OLS	FE	LP	ACF	OLS	FE	LP	ACF
Dependent variable: real gross output in logarithm																				
Ln_L	0.087***	0.108***	0.075***	0.049***	0.073***	0.100***	0.061***	0.021**	0.034***	0.042***	0.026***	0.0090	0.086***	0.110***	0.065***	0.046***	0.088***	0.113***	0.085***	0.037***
	(0.005)	(0.007)	(0.002)	(0.003)	(0.013)	(0.015)	(0.023)	(0.009)	(0.010)	(0.010)	(0.002)	(0.009)	(0.007)	(0.010)	(0.003)	(0.004)	(0.009)	(0.011)	(0.009)	(0.008)
Ln_W (Human Capital)	0.038***	0.056***	0.039***	-0.030***	0.041***	0.060***	0.039***	-0.026*	-0.009	-0.001	-0.017***	-0.084***	0.032***	0.051***	0.030***	-0.027***	0.052***	0.063***	0.058***	0.018
	(0.004)	(0.006)	(0.000)	(0.007)	(0.010)	(0.010)	(0.009)	(0.015)	(0.012)	(0.011)	(0.001)	(0.025)	(0.006)	(0.008)	(0.004)	(0.010)	(0.009)	(0.010)	(0.007)	(0.021)
Ln_K	0.026***	0.033***	0.016***	0.040***	0.030***	0.034***	0.010	0.030***	0.009	0.011	0.017	0.026***	0.030***	0.040***	0.020***	0.046***	0.017***	0.017***	0.039	0.031***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.006)	(0.006)	(0.122)	(0.007)	(0.007)	(0.007)	(0.054)	(0.009)	(0.0040)	(0.005)	(0.006)	(0.003)	(0.004)	(0.005)	(0.031)	(0.006)
Ln_M	0.881***	0.844***	0.907***	0.852***	0.879***	0.841***	0.923***	0.881***	0.956***	0.942***	0.955***	0.955***	0.881***	0.838***	0.915***	0.829***	0.879***	0.848***	0.846***	0.873***
	(0.007)	(0.010)	(0.005)	(0.003)	(0.016)	(0.020)	(0.181)	(0.007)	(0.010)	(0.012)	(0.064)	(0.011)	(0.010)	(0.016)	(0.009)	(0.003)	(0.011)	(0.014)	(0.054)	(0.006)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prov. Cluster	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Multinomial Terms	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes
Constant	1.027***	1.199***	-	2.102***	1.087***	1.251***	-	2.477***	0.730***	0.829***	-	1.238	0.996***	1.202***	-	2.363***	1.110***	1.283***	-	3.678***
	(0.029)	(0.044)	-	(0.191)	(0.073)	(0.093)	-	(0.544)	(0.062)	(0.072)	-	(1.014)	(0.046)	(0.069)	-	(0.258)	(0.059)	(0.078)	-	(0.784)
Returns to Scale	1.032	1.041	1.037	-	1.023	1.035	1.033	-	0.989	0.993	0.980	-	1.028	1.039	1.029	-	1.035	1.040	1.028	-
Num. of Obs.	43,255	43,255	43,255	32,004	6,824	6,824	6,824	4,932	2,119	2,119	2,119	1,544	25,379	25,379	25,379	18,936	8,933	8,933	8,933	6,592
R squared	0.968	-	-	0.972	0.961	-	-	0.966	0.991	-	-	0.992	0.969	-	-	0.973	0.947	-	-	0.955
Number of firms	11,134	11,134	11,134	11,134	1,871	1,871	1,871	1,871	560	560	560	560	6,391	6,391	6,391	6,391	2,312	2,312	2,312	2,312

Note: following Nishida et al. (2013), we control for workers' average wage to account for change in human capital. Meanwhile, the returns to scale (RTS) for production function is not reported as it will involve multi-polynomial terms.

Appendix C

Table C1. The First-stage Estimation Results for the FEIV Regression

	FEIV1	FEIV2
Dependent variable: Average firms' markup		
Sales Radium (ln)	0.114***	-
	(0.015)	-
Construction area (ln)	-	-0.006***
	-	(0.002)
Total crude steel production (ln)	-0.013***	0.005*
	(0.003)	(0.003)
Export share of output	-0.161*	-0.166***
	(0.083)	(0.017)
Number of steel firms	-0.000	0.000***
	(0.000)	(0.000)
Fixed asset investment (ln)	-0.005***'	-0.001**
	(0.001)	(0.000)
Dummy for WTO accession	-0.008*	-0.010***
	(0.005)	(0.002)
Kleibergen-Paap rk LM statistic	32.12	14.35
Cragg-Donald Wald F statistic	55.12	5.27
Kleibergen-Paap Wald rk F statistic	57.97	14.35

Note: Robust standard errors in parentheses, *, **, *** denotes level of significance at 10%, 5% and 1% respectively.

Table C2. The Contribution of Resource Reallocation to the Industry-level TFP Growth: the BHC and FHK approaches

	TFP Growth	With-firm Growth	RE_Con.	COV	Net EE
BHC	5.70	4.23	-1.04	0.06	2.45
FHK	5.58	4.23	0.14	-	1.21

Note: BHC refers to the approach proposed by Baily et al. (1992), while FHK refers to the approach proposed by Forster et al. (2001, 2008).

Table C3. Comparing the Resource-Reallocation Effect across 7 Regions: Between-region vs. within-region (%): 1998-2009

	Between Region			Within Region		
	TFP	Unweighted Average	OP Covariance	TFP	Unweighted Average	OP Covariance
Sinister/iron making	5.735	5.166	0.569	5.166	4.276	0.890
Steel making	4.354	4.612	-0.259	4.612	4.021	0.592
Rolling/pressing	4.560	5.128	-0.568	5.128	4.325	0.803
Alloy making	4.499	4.204	0.295	4.204	3.675	0.529
Average	5.337	5.464	-0.128	5.464	4.594	0.870

Note: The seven regions are defined on geographical attributes, which include North-East China, North China, North-West China, East China, South China, Middle China and South-China