Targeted Subsidy and Capital (Mis)Allocation

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Abstract

This paper investigates the welfare implications of targeted subsidy in a financially constrained economy. While such policy can relax the targeted firms' financial constraints, it may also cause misallocation. Moreover, the effects of an industry-specific policy are likely to spill over into the other industries through general equilibrium effects, and be propagated through production network. The first part of the paper develops a theoretical framework that captures the above channels. I build a dynamic model with heterogeneous firms and borrowing constraints and then extend it by incorporating production network. I use the model to illustrate the channels through which targeted subsidy generates both static and dynamic welfare implications. Guided by the model, I study an industrial policy in China in the second part of the paper. Using firm-level custom and survey data, I provide evidence that the compulsory import delegation on iron ore enforced by the Chinese government in 2005 was a *de facto* targeted subsidy favouring large steel producers. On the one hand, the policy led to fast debt accumulation and rapid expansion of the targeted firms, which turned out to be key to the spectacular growth of China's steel industry. On the other hand, the policy caused severe capital misallocation. I structurally estimate the model and find that the welfare losses caused by deteriorated misallocation dominate the welfare gains. Removing this policy would increase aggregate output by 0.93% in five years.

Keywords: Targeted Subsidy, Industrial Policy, Capital Misallocation, Financial Constraints

1 Introduction

Many firms in developing economies are financially constrained. Some governments adopt industrial policy to relax the financial constraints of prioritized firms in prioritized industries. For example, exporters in certain industries enjoyed preferential taxation from Singapore government in 1960s. Another well-known example is the Heavy-Chemical Industry Drive introduced by the South Korean government in the 1970s, which provided low-interest loans to promote six upstream industries. Chinese government also adopted various industrial policies to promote economic growth, from industry-specific export tax rebates, fiscal supports for R&D investment to various implicit subsidies disguised as regulations. All these policies share a common consequence that profits of the prioritized firms are increased because of the subsidy from governments and their financial constraints are relaxed. However, such practice may cause misallocation of resource between the targeted and non-targeted firms. Moreover, the effects of an industry-specific policy are likely to spill over into the other industries under general equilibrium effects, and might be propagated through production network. In this paper, I develop a theoretical framework that is rich enough to capture the above mechanisms through which industrial policy may affect an economy with financially constrained firms. Then, I use the framework to assess quantitatively the welfare implications of an industrial policy implemented in China's steel industry.

I start with a one-sector model where both wage and interest rates are exogenous. Each firm is run by an infinitely-lived entrepreneur who can only borrow up to a fraction of his net worth. Consistent with the facts from China, I assume all firms are in the transitional dynamics where their marginal products of capital are above the interest rate. Yet, the extent to which firms are financially constrained depends on their TFP and capital. Among the firms with the same TFP, for instance, larger firms are associated with lower marginal product of capital, and their financial constraints are less tight than those of smaller firms. In this economy, subsidizing any firm would increase the industry output by relaxing the firm's financial constraints. Despite its unambiguous effect on the industry output, the subsidy could alleviate or worsen misallocation in the industry, depending on the degree of financial constraints faced by the subsidized firm. If subsidy flows to the firms with relatively higher marginal product capital, it will alleviate capital misallocation. If the marginal product of capital of the subsidized firm is close to the interest rate, the subsidy would lead to worse resource allocation in the industry, and lower the industry TFP and capital returns.

To further investigate the macroeconomic consequences of the subsidy, I extend the above one-sector model to a multi-sector model and then incorporate it with production network. As a closed economy, the multi-sector model endogenizes wage and interest rates. This allows me to study the general equilibrium effects of the subsidy. Subsidizing some firms in one industry may extract resources away from the other industries associated with higher returns and worsen misallocation across industries. So, there is no guarantee for such subsidy to increase the aggregate output. What's more, the effects of the subsidy on the targeted industry may also spill over into the other industries through production network. The recent literature has shown that frictions will accumulate from downstream industries to upstream industries through demand linkages (Liu (2017)). As a result, subsidizing upstream industries are more likely to generate welfare gains.

To summarize, the model captures the following four channels through which targeted subsidy could affect welfare: (1) the direct effect by relaxing the targeted firms' financial constraints; (2) the effect on misallocation within the targeted industry; (3) the effect on sectoral misallocation; (4) the effect propagated through the production network. While the first effect is always positive, the other three effects are all ambiguous. The model can thus be used as a workhorse to assess quantitatively the welfare implications of targeted subsidy.

The second part of this paper studies a policy which is commonly known as compulsory import delegation on iron ore enforced by the Chinese government, which turns out to be an ideal case of studying the effects of targeted subsidy. I first document the facts from firm-level custom and survey data, supplemented by annual reports of some listed firms and business groups, which reveal the nature of the regulation as a targeted subsidy. In 2005, under the name of bargaining for a better import price, the Chinese government restricted the rights of importing iron ore to a selected group of firms, which are mainly large steel producers. While there is no evidence that the regulation helped to lower the iron ore import price, the licensed firms snatched sizable profits by reselling imported iron ore to the non-licensed firms. The estimated resale profits accounted for 38.07% of the operational profits of the licensed firms between 2004 and 2013. I also found that the licensed firms experienced much faster growth as opposed to the non-licensed firms. The expansion of the licensed firms was associated with much faster accumulation of debt and more dramatic decline in the marginal product of capital. Since the licensed firms had lower marginal product of capital before the enforcement of this policy, misallocation was deteriorated afterwards. Moreover, the debt-driven expansion of the licensed firms may crowd out investment of firms in the other industries, causing sectoral misallocation

through the general equilibrium effect. Finally, subsidizing steel producers as upstream suppliers may generate welfare gains through the production network. However, the deteriorated misallocation within steel industry impose larger welfare losses and eventually the welfare implications are negative. In summary, positive welfare implications of the policy can be found through the first and fourth channels and negative welfare implications come from the second to the fourth channel.

I structurally estimate the one-sector model by targeting a comprehensive set of empirical moments in the steel industry. I find that introducing the targeted subsidy with the magnitude observed in the data can account for nearly 19% and 45% of the increase in their sales and debt-sales ratio relative to that of the non-licensed firms and 37% of the widened gap of marginal product of capital between the licensed and non-licensed firms. The estimated model predicts that during the time of policy enforcement, the industry TFP and returns to capital go down by 8.77% and 8.15%, respectively. Extending the experiment to the multi-sector model calibrated to the Chinese economy and its Input-Output table in 2007 shows the quantitative importance of each of the four channels. While the direct effect increases steel output, the worsened misallocation within the industry and across industries would reduce the aggregate output by 0.15% in 5 years. The production network amplifies both the direct and misallocation effects. The counterfactual exercise shows that by incorporating the production network, aggregate output would increase by 0.05% from allocating more capital to steel industry and decrease by 0.98% from productivity decline of steel industry. Overall, the policy reduces aggregate output by 0.93% in the model.

This paper first contributes to the growing literature on resource misallocation. Restuccia and Rogerson (2008), Hsieh and Klenow (2009) and Bartelsman, Haltiwanger and Scarpetta (2013) study the macro outcome of micro level distortions. Typically, Hsieh and Klenow (2009) provide us a quantitative framework to understand how firm-level wedges affect aggregate productivity. Their paper finds that if the allocation efficiency in China can match that in US, her aggregate output will increase by 30% to 50%. Hsieh and Song (2015) apply this framework to analyze the reform in China's state-owned sector, and show that this reform has contributed 20% of aggregate productivity growth from 1998 to 2007. Song, Storesletten and Zilibotti (2011) use an dynamic model to capture the economic transition in China, where reallocating resources from unproductive units to more productive ones is a key to explains economic success. In this paper, I first provide micro foundation of capital misallocation, which is borrowing constraints during firm dynamics. With a clear source of capital misallocation, counterfactual tests of policy evaluation can be performed. Moreover, in the second part of this paper, I extend the model in Hsieh and

Klenow (2009) with CES production function to capture the substitutability of capital and labor in steel industry. When elasticity of substitution between inputs is non-unitary, factor productivity observed in data is no longer proportional to wedge. Instead, I show that when capital and labor are substitutes in production, the observed factor productivity will over report the true wedges.

My paper is also closely related to literature on financial frictions and capital misallocation. Models with financial frictions pioneered by Kiyotaki and Moore (1997) implies that firm-level financial frictions are associated with capital misallocation. Buera and Shin (2013) provide a quantitative framework of TFP dynamics with financial frictions and use it to understand the process of economic development across countries. Banerjee and Moll (2010) build a model of capital accumulation with credit constraints to explain the persistence of capital misallocation. They find that although individuals may accumulate enough capital over time and marginal return of all agents would be equalized, the misallocation still exist because of some agents never get the chance to start capital accumulation. Moll (2014) further studies the capital misallocation with collateral constraints. This paper find that the persistence of idiosyncratic productivity shocks determines both the size of steady-state welfare losses and the speed of transitions. Only focus on the welfare losses in steady state will be misleading since financial frictions may generate larger misallocation during transitional dynamics. Midrigan and Xu (2014) indicate that financial frictions will distort firms' entry and technology adoption decisions, and generate dispersion in capital returns. Both effects from financial frictions will bring welfare losses. Liu, Wang and Xu (2017) investigate the interest rate liberalization in China and find that the embodied financial frictions in market will enlarge the capital misallocation towards state-owned firms, and lower the aggregate productivity. Gopinath et al. (2017) investigate a similar phenomenon in South Europe and find that interest rate decline will push capital towards to firms with higher net worth but not necessarily more productive, which eventually causes losses in aggregate productivity. Song, Storesletten and Zilibotti (2011) imply that the although private sector in China is more productive, their limited access to credit prevents them from utilizing more resources and relaxing borrowing constraint leads a faster TFP growth. Besides the financial frictions caused market imperfections, government policy in China is another important source of frictions. Wu (2018) finds that aggregate welfare losses caused by imperfections in financial market are relatively small in China, while policy has been playing a much bigger role in allocating capital. The exporting firms, upstream firms, politically connected to the Party are favorably treated by the policy. My paper differs to the literature in the following aspects. First,

as indicated by Moll (2014), most researches focus on the capital misallocation in steady state, which may under estimate the effect of financial friction. My study focus on the transitional dynamics of firms. Unlike Buera and Shin (2013) and Moll (2014), who study the transitional dynamics after some changes in financial frictions determinants, my paper assume that all firms are in shortage of capital, which is consistent to the situation in China, and the industry-specific policy will not change economic wide financial frictions determinants, which is also more realistic. Second, Wu (2018) already show that policy plays a role in capital misallocation in China. My paper provides a solid micro foundation to illustrate how the policy plays a role and quantify its effect. Third, unlike Kalouptsidi (2017) who detects industry-wide subsidy from the outcomes in China's ship building industry, I merge Custom data and Industrial Enterprise Survey data to clearly identify who have been favored by this policy and quantify the welfare implications.

Finally, this paper builds on the recent findings in the literature of economic performance and production network. Hulten (1978) first proposes that production network in the economy will amplify the effect of productivity change in one industry. Ciccone (2002) and Jones (2011) build up theoretical models to illustrate the multiplier coming from input output linkages. Besides the multiplier effect Acemoglu et al. (2012) show that micro level idiosyncratic shocks may lead to aggregate fluctuations under production network. Miranda-Pinto (2018) extends this framework and find that how industries are linked matters for the pass through of productivity shock. Bartelme and Gorodnichenko (2015) and Fadinger, Ghiglino and Teteryatnikova (2016) use data from OECD input output table to show that difference in sparsity of production network across countries can explain their income difference quantitatively. These two papers mainly focus on how the tax or frictions in goods transactions weaken the input output linkage in the economy, which eventually generates welfare losses for consumers. Liu (2017) shows that this argument is not comprehensive. Since market imperfections will accumulate through backward demand linkages, and distortions are largest in the most upstream sectors. A well behaved government will subsidize the upstream industries to promote economic growth. My paper builds on the framework in Liu (2017) but differ in the following aspect. In Liu (2017), he focus on the welfare implications from resource reallocation across industries caused by industrial policy and assume away other implications from the policy. My paper takes the within industry misallocation caused by industrial policy into account as well. Moreover, My paper clearly identifies a policy and quantify its implications under production network.

The rest of this paper is organized as follows. Section 2 describes theoretical framework. Section 3 applies this framework to evaluate welfare implications of compulsory import

delegation policy on iron ore imposed by Chinese government. Section 4 concludes.

2 Theoretical Framework

In this section, a firm dynamic model with heterogeneous agents and collateral constraints is developed to illustrate the welfare implications for the firm and industry and the underlying mechanism. Next, the above model is extended to a multi-sector model and then incorporate it with production network to evaluate the welfare implications under general equilibrium.

2.1 One-Sector Model

I start with a one-sector model where both wage and interest rates are exogenous. In the industry i, there are X firms indexed by $x = 1, ..., X$. Each firm is run by an infinitely-lived entrepreneur who can only borrow up to a fraction of his net worth. Firms produce differentiated products $Y_{ix,t}$ and their products are aggregated into industry level output $Y_{i,t}$ by a representative firm with CES technology in a perfectly competitive market.

$$Y_{i,t} = \left[\sum_{x=1}^{X} Y_{ix,t}^{\frac{1}{\eta}} \right]^{\eta} \quad (\eta > 1) \tag{1}$$

Problem of the representative firm in industry i is to maximize the profit by taking price of its output $P_{i,t}$ and each product $P_{ix,t}$ as given.

$$\max \ P_{i,t} Y_{i,t} - \sum_{x=1}^{X} P_{ix,t} Y_{ix,t} \tag{2}$$

The first order condition with respect to firm's output implies that each firm is faced with an iso-elastic demand.

$$P_{ix,t} = P_{i,t} Y_{i,t}^{\frac{\eta-1}{\eta}} Y_{ix,t}^{\frac{1-\eta}{\eta}} \tag{3}$$

$$P_{i,t} = \left[\sum_{x=1}^{X} P_{ix,t}^{\frac{1}{1-\eta}} \right]^{1-\eta} \tag{4}$$

The production function of each firms is featured by a constant return to scale technology in capital and labor inputs, and firms differ in their productivity $A_{ix,t}$ and firm size $K_{ix,t}$.

$$Y_{ix,t} = A_{ix,t} F(K_{ix,t}, L_{ix,t}) \tag{5}$$

Within this industry i, each firm x is operated by an entrepreneur who wants to maximize the lifetime utility U_{ix}. In each period, his utility is concave in consumption.

$$\max \ U_{ix} = \sum_{t=0}^{\infty} \beta^t U(C_{ix,t}) \tag{6}$$

$$C_{ix,t} + K_{ix,t+1} + RB_{ix,t} + AC_{ix,t} \leq P_{ix,t}Y_{ix,t} - WL_{ix,t} + (1-\delta)K_{ix,t} + B_{ix,t+1} \tag{7}$$

$$K_{ix,t+1} \leq \kappa E_{ix,t+1} \ (\kappa \geq 1) \tag{8}$$

$$AC_t = \frac{\theta}{2} \left(\frac{K_{ix,t+1} - K_{ix,t}}{K_{ix,t}} \right)^2 K_{ix,t} \tag{9}$$

At time t, the capital of entrepreneur is a composition of his equity $E_{ix,t}$ and borrowing $B_{ix,t}$, i.e. $K_{ix,t} = E_{ix,t} + B_{ix,t}$. When he smooths consumption over periods, he faces two constraints. The first is budget constraint. His consumption, investment and capital adjustment cost cannot exceed operational income and change in net borrowing. The second is collateral constraint. The capital stock at next period can only be leveraged at his net worth by κ. This setup in collateral constraints is widely used in literature (Banerjee and Moll (2010), Buera and Shin (2013), Moll (2014), Gopinath et al. (2017)). When κ goes to infinity, there will be no constraints. If $\kappa = 1$, all the newly installed capital must be financed by his saving. For simplicity, I rewrite this constraints by $B_{ix,t+1} \leq \phi K_{ix,t+1}$, where $\phi = \frac{\kappa-1}{\kappa}$. Consistent with the facts from China, I assume all firms are in the transitional dynamics where their marginal products of capital are above the exogenous interest rate. Yet, the extent to which firms are financially constrained depends on their TFP and capital stock. Among the firms with the same TFP, for instance, marginal

product of capital of larger firms is closer to the interest rate, and their financial constraints are less tight than those of smaller firms.

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^t U(C_{ix,t})$$
$$+ \sum_{t=0}^{\infty} \beta^t \lambda_{ix,t} [P_{ix,t} Y_{ix,t} - W L_{ix,t} + (1-\delta) K_{ix,t} + B_{ix,t+1} - C_{ix,t} - K_{ix,t+1} - R B_{ix,t} - A C_{ix,t}]$$
$$+ \sum_{t=0}^{\infty} \beta^t \mu_{ix,t} [\phi K_{ix,t+1} - B_{ix,t+1}]$$

First order condition implies that:

$$\frac{\partial \mathcal{L}}{\partial C_{ix,t}} : U'(C_{ix,t}) - \lambda_{ix,t} = 0$$

$$\frac{\partial \mathcal{L}}{\partial L_{ix,t}} : MRPL_{ix,t} = W$$

$$\frac{\partial \mathcal{L}}{\partial K_{ix,t+1}} : - \lambda_{ix,t} - \lambda_{ix,t} AC'_{ix,t} + \beta \lambda_{ix,t+1} MRPK_{ix,t+1} + \beta \lambda_{ix,t+1}(1-\delta)$$
$$- \beta \lambda_{ix,t+1} AC'_{ix,t+1} + \mu_{ix,t} \phi = 0$$

$$\frac{\partial \mathcal{L}}{\partial B_{ix,t+1}} : \lambda_{ix,t} - \lambda_{ix,t+1} \beta R - \mu_{ix,t} = 0$$

Here, marginal product of capital is defined as $MRPK_{ix,t+1} = \frac{\partial P_{ix,t+1} Y_{ix,t+1}}{\partial K_{ix,t+1}}$ and similar for the $MRPL$. Euler equation indicates that in the transitional dynamics, marginal product of capital of firm x is always larger than the user cost of capital $R - 1 + \delta$. Since the entrepreneur is always faced with collateral constraints during transitional dynamics, he cannot expand his capital to the optimal size immediately, where marginal product of capital equals the user cost of capital. Under the situation without collateral constraints $\kappa \to \infty \Leftrightarrow \phi = 1$, marginal product of capital will equal the user cost of capital immediately. In this constrained economy, when time moves on, the firm is approaching its steady state and its marginal product of capital is decreasing in t, i.e. $U'(C_{ix,t}) > U'(C_{ix,t+1})$. When $t \to \infty$, all firms will get rid of financial constraints and their user cost of capital will be equalized.

$$MRPK_{ix,t+1} + (1 - \delta) + AC'_{ix,t+1} = R \left[(1 - \phi + AC'_{ix,t}) \frac{U'(C_{ix,t})}{U'(C_{ix,t+1})} + \phi \right] \quad (10)$$

The following equation gives the law of motion of capital (equity). The amount of capital installed at $t + 1$ depends on the operational profits, consumption decision, adjustment costs and level of collateral constraints. Holding other things constant, when ϕ increase a bit, which means that the collateral constraints get loosened, entrepreneur will be able to install more capital at next period.

$$K_{ix,t+1} = \kappa E_{ix,t+1} = \frac{P_{ix,t} Y_{ix,t} - W L_{ix,t}}{1 - \phi} + (1 - \delta) K_{ix,t} - R B_{ix,t} - C_{ix,t} - AC_{ix,t} \quad (11)$$

The law of motion of capital is important to understand how a targeted subsidy may change the firm dynamics and capital misallocation within industry i. Now, consider an industrial policy enforced by government to promote some firms in industry i. As mentioned above, although policies may appeared as preferential taxation, low interest rates, guaranteed market power, or soft budget constraints, they share a common feature that they are a subsidy paid to the firms. In this model, subsidy appears as a lumps-sum transfer from government firm, and increase firm owner's equity. The law of motion of capital (equity) then becomes:

$$K_{ix,t+1} = \kappa E_{ix,t+1} = \frac{P_{ix,t} Y_{ix,t} - W L_{ix,t} + (1 - \delta) K_{ix,t} - R B_{ix,t} - C_{ix,t} - AC_{ix,t} + S_{ix,t}}{1 - \phi}$$

$$(12)$$

Holding the consumption constant, the subsidy from government will raise the firm's capital stock by $\frac{S_{ix,t} - AC_{ix,t}}{1 - \phi}$, and as a result, its output will increase. Given the assumption that industrial policy will not change the exogenous wage interest rates, and output of the targeted industry is a CES aggregation of firms' products, any subsidy at firm level will be reflected by an increase of firm's output as well as industry level output. It is the first channel through which the targeted subsidy influence the economy.

To formalize this channel, I assume the production function to be linear in capital for simplicity, i.e. $Y_{ix,t} = A_{ix,t} K_{ix,t}$, and then map the firm dynamic model into the static accounting framework in Hsieh and Klenow (2009). At each point of time, denote the gap

between a firm's marginal product of capital and its steady state user cost of capital as the capital friction it faced with. The capital friction is a function of its current capital stock and productivity. The change in capital friction over time also depends on the collateral constraint and capital adjustment cost. I use the parameter $\chi_{ix,t}$ to summarize the capital friction of firm i at time t. When time goes on, the measured frictions will gradually decrease and become 1 eventually. This measurement not only captures the absolute level of distortion for each firm at different periods but also indicates relative level of frictions across firms. For firms with different capital stock and productivity, their measured capital friction could be different.

$$
\begin{aligned}
MRPK_{ix,t+1} &= R\left[(1 - \phi + AC'_{ix,t})\frac{U'(C_{ix,t})}{U'(C_{ix,t+1})} + \phi\right] - (1 - \delta) - AC'_{ix,t+1} \quad (13) \\
&= f(K_{ix,t+1}, A_{ix,t+1}) \cdot (R - 1 + \delta) \\
&= (1 + \chi_{ix,t+1})(R - 1 + \delta)
\end{aligned}
$$

When a firm x in industry i is subsidized by government, its marginal product of capital will decrease, because of the increase in capital stock (equity). The change of firm-level capital return in represented by $\tau_{ix,t+1}$. Meanwhile, its relative size, compared with others, will increase. The subsidy is good to the firm, as well as to the industry, as shown in the following equations. Firm-level implications will result in a decrease in aggregate marginal product of capital at industry level. Here, the industry level marginal product of capital is defined as the inverse of weighted sum of inverse marginal product of capital of each firm as in Hsieh and Klenow (2009). It means that no matter who get this subsidy, it will be reflected in the industry level as a decline in marginal product of capital. The policy will speed up industry level transition in the short run. In the long run, industry level capital return will equal to $R - 1 + \delta$, where any further subsidizing will not have effects. These features of targeted subsidy conclude the first channel:

$$
MRPK_{ix,t+1} = (1 + \chi_{ix,t+1} - \tau_{ix,t+1})(R - 1 + \delta) \quad (14)
$$

$$
\overline{MRPK_{i,t+1}} = \frac{1}{\sum_{x=1}^{X} \left(\frac{P_{ix,t+1}Y_{ix,t+1}}{P_{i,t+1}Y_{i,t+1}}\right)\frac{1}{MRPK_{ix,t+1}}} \quad (15)
$$

However, there are side effects hidden behind. Although the targeted firms and the industry get better off, the efficiency of subsidy depends on the characteristics of targeted

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firms. At each period t, firms $x = 1, ..., X$ in industry i have different marginal product of capital, depending on its current equity holding and borrowing constraints. In order to show the misallocation induced by the targeted subsidy, I need to write down the aggregate production of industry i. Total of resource at time $t + 1$ of industry i is $K_{i,t+1} = \sum_{x=1}^{X} K_{ix,t+1}$, and with this resource constraint, I can write down the aggregate production function of industry i at time $t + 1$ as a function of aggregate capital and industry productivity. Aggregate productivity is a weighted sum of each firm's productivity.

$$Y_{i,t+1} = TFP_{i,t+1} K_{i,t+1} \tag{16}$$

$$TFP_{i,t+1} = \left[\sum_{x=1}^{X} \left(A_{ix,t+1} \frac{\overline{MRPK_{i,t+1}}}{MRPK_{ix,t+1}} \right)^{\frac{1}{\eta-1}} \right]^{\eta-1} \tag{17}$$

Intuitively, given the same amount of capital stock in industry i, how much it can produce depends on its TFP, and government subsidy will change industry-level TFP. When productivity of each firm and the frictions at time t are jointly lognormally distributed, there is a closed form expression for industry level productivity and this gives the second channel.

$$\log(TFP_{i,t+1}) = (\eta - 1) \log \left(\sum_{x=1}^{X} A_{ix,t+1}^{\frac{1}{\eta-1}} \right) - \frac{1}{2} \frac{1}{\eta - 1} var(\log MRPK_{ix,t+1}) \tag{18}$$

If there is no policy intervention, the variance of marginal product of capital within industry i will become smaller over time. The reason is straightforward. Because all firms are moving towards steady states and firms with higher marginal product of capital have also higher rate of convergence, which narrows the gap between others. When all firms have reached steady state, the variance will be zero. Here, I reach result because all firms are assumed to be identical in accessing credit market and all have positive initial equity holding. Here, no further distortion is imposed on the firms. This model can be extended to a more general one that firms may operate under different lending rate R_{ix} or different sales tax. As long as all firms are in transitional dynamics, the value of $var(\log MRPK_{ix,t+1})$ will decrease, since more constrained firms are converging faster. But, the results will be differ in the steady state welfare level.

To be clear, the welfare implications for the industry is measured from the static aspect, i.e., I only focus the potential welfare implications from the reallocation of capital across

firms. In a dynamic model with capital adjustment cost, same amount of subsidy paid at time t may lead to different capital stock increase at $t+1$. Here, the welfare (total output) from the increase of total capital stock is not analyzed. Also, the capital adjustment cost associated with the subsidy is not included.

When government provides subsidy to some firms in industry i, the level of dispersion in capital return may change, depending on which firms are subsidized. I simulate 500 firms for 50 periods and assume that government pays subsidy from time 16 to 30. Both initial capital stock and productivity of each firm is drawn from a lognormal distribution. Parameters used in this simulation is shown in Table 1. Consider the following four scenarios: (1) no subsidy; (2) government always subsidizes 10% of firms with largest sales (3) government always subsidizes 10% of firms with highest productivity (4) government always subsidizes 10% of firms with highest $MRPK$. The subsidy paid to each firm is same in each period in all the four scenarios, which makes the subsidy comparable across those cases.

Figure 1 shows the aggregate MRPK of the industry. When some firms get subsidy from government, aggregate marginal product of capital will decrease, as the predictions in Channel 1. Figure 2 shows the welfare implication from subsidy, which testifies the prediction in Channel 2. The solid line shows the situation without subsidy; the circled line shows the implication from scenario (2); the diamonded line shows the implication from scenario (3) and the crossed line shows the implication from scenario (4). It is obvious that subsidizing firms with highest MRPK will lower the welfare loss most, and subsidizing firms with largest size will increase the welfare loss in the short run. It is interesting that if the government subsidizing firms with highest TFP, welfare loss will first decrease but become larger the case without subsidy. The reason is that when the firms with high productivity has been subsidized for some periods of time, they become less financially constrained that others, and subsidizing them will not improve the efficiency of capital allocation. If the subsidy goes to those firms with largest size, who are usually less financially constrained, the welfare loss from capital misallocation will increase. Under this scenario, the welfare loss begins to decrease before the subsidy ends, since those firms reaches steady state a few periods after they get the subsidy and stop accumulating capital. When all of those large firms have reached their steady state, the allocation efficiency of capital will be improved again, since other firms' are converging.

In the welfare implication from the subsidy, I do not include the effects from capital adjustment cost and change in capital stock. But here, with the figures, I briefly discuss the welfare implications from these two aspects. Figure 3 shows the change in aggregate

output from subsidy. From the figures, we can see that although all kinds of subsidy will lower MRPK and increase aggregate output anyway, it will affect the welfare from the aspect of speed of convergence. We can see that subsidizing firms with highest MRPK will speed up the transition of the industry. If the government subsidizes firms with highest productivity, the welfare implications will be second to the latter scenario. If the subsidy goes to firms with largest firm size (sales), the welfare gain will be lowest. In the long run, the target of subsidy matters, since the speed of transition would be affected by subsidy. But in the short run, welfare implications from the view of transition is different. Since firms with highest MRPK may also have smaller firm size, implying higher capital adjustment cost, and subsidizing them is associated with higher loss from adjustment compared to others. That is why in the very short run, the aggregate output increase from subsidizing high MRPK firms is lower.

In the long run, such policy intervention will have zero effect in capital allocation since all firms have reached steady states. Intuitions behind the mathematical expression can also be interpreted in this way. At time t, government provides $S_t = \sum_{x=1}^{X} S_{ix,t}$ $(S_{ix,t} \geq 0)$ extra pledge to industry i, which allows it to install $K'_{i,t+1} = \kappa S_{i,t}$ more capital than the situation without policy intervention (under the situation of linear utility and zero capital adjustment cost). No doubt, extra capital generates positive changes in industry's output. However, the size of welfare gains depend on where the subsidy goes to. Since entrepreneurs are faced with an iso-elastic demand function for their products, marginal return is decreasing in capital stock. If 1 unit of subsidy flows to the firm with high marginal return, its welfare gains will be larger than allocating it to a low marginal return firm. This intuition is embodied in the expression $var(MRPK_{ix,t+1})$, which determines the size of welfare gains.

To summarize, in an industry with heterogeneous firms who are in their transitional dynamics toward steady states, a relaxation on financial constraints will increase targeted firms' capital installation, generating positive welfare implications at firm level. Same results apply to the industry level output. Given that targeted subsidy does not change market lending rate and aggregate output of the targeted industry is a CES aggregation of each firm's products, any positive welfare implication at firm level will be reflected as an increase of industry level output. Beside the positive welfare implications for targeted firms and industry, there are also two hidden effects. First, industry level marginal return to capital will be brought down by the targeted subsidy. Second, industry level productivity in the targeted industry will change, and its direction depends on the relative financial constraints of firms who get subsidized. If the subsidy helps firm who are more constrained,

its effect will be reflected as a narrowing dispersion of marginal product of capital, implying an improvement in productivity of the targeted industry. On the contrary, if the policy helps those less constrained firms, it will generate lower welfare improvement, which will be shown as a deteriorating misallocation.

2.2 Multi-Sector Model

The effect of subsidy does not only stopped in one sector, and it will spill over into other industries under general equilibrium effects. Promoting firms in one industry means suppressing others, since total resources in a closed economy is constrained. I extend the one-sector model into a multi-sector model where wage and interest rates are endogenously determined. In this closed economy, I show that subsidizing one industry might cause sectoral misallocation, and the effects would be propagated through production network.

2.2.1 General Equilibrium Effect

In this closed economy, there are M industries, producing intermediate output, and there is a final goods producer, producing final goods by aggregating intermediate outputs from all industries with Cobb-Douglas production technology in a perfectly competitive market.

$$Y = \Pi_{i=1}^{M} y_i^{\beta_i} \tag{19}$$

When the final goods producer makes decision, it takes price from each intermediate output producer as given and maximize the aggregate output, where the price of final goods is normalized to 1.

$$\max \Pi_{i=1}^{M} y_i^{\beta_i} - \sum_{i=1}^{M} p_i y_i \tag{20}$$

First order condition implies that expenditure share on each intermediate output is a constant, which is the preference parameter β_i.

$$\beta_i = \frac{p_i y_i}{Y} \tag{21}$$

In each industry i, there are X_i firms producing output and there is a representative firm who aggregates their outputs. Same as the one-sector model, this representative firm i aggregates each firms' output with CES technology and operates in a perfectly competitive market.

In this economy labor is provided by the representative household and receive wage W_t from proving 1 unit of labor at time t. Capital is accumulated by entrepreneurs, and rent to each other. If a firm owner finds that its marginal return of capital is lower the market interest rate, he will choose to be a firm owner and a lender. The firm owner would maintain the capital stock, which make sure its marginal return equals market interest rate, and lend the rest of the assets out, which receives the rental from other firm owners. Consider the following case, one firm has huge amount of equity that if it puts all of the equity in to production, its marginal return is closed to zero. Another firm has some equity and would have a much higher marginal capital return. As a result, firm with excessive equity will not turn all of the equity into capital stock, but choose to lend some out. Eventually, the two firm will have same marginal product of capital, which also equals to market lending rate. The collateral constraint κ may vary across industries and firms to make sure capital market is clearing.

The government imposes a lump-sum tax T on household (and firm owners) to finance its consumption and subsidy. The budget constraint for government is $T = G + \sum_{i=1}^{M} S_i$. Under this setup, total capital stock at time $t + 1$ is predetermined by the saving (equity) of all entrepreneurs at time t and government subsidy paid at time t. This feature helps to turn the dynamic welfare analysis into a static one. The welfare implications for the whole economy is evaluated only from the aspect of capital allocation efficiency. The government subsidy will affect the welfare from two aspects. The first is from changing capital stock of the economy. The second is from capital reallocation. If some firms in certain industries have more equity, it will be borrow more from the market and install more capital at time $t + 1$. Here, as in the one-sector model, welfare implications from the change in aggregate capital stock is not included in the welfare evaluation.

In this economy, sectoral capital allocation is a function of industry-level marginal product of capital and preference parameter. Here, the production function is assumed to be linear in capital for simplicity. In the first-best situation, marginal product of capital of each industry shall be equalized to maximize the aggregate output. In reality, the marginal product of capital is different because of various reasons.

$$\frac{K_i}{K} = \frac{\frac{\beta_i}{\overline{MRPK_i}}}{\sum_{i=1}^{M} \frac{\beta_i}{\overline{MRPK_i}}} \tag{22}$$

Now, the government will intervene the economy with subsidy. It paid subsidy S_i to some firms in industry i, which comes from its lump-sum tax T. Intuitively, industry i will expand and its marginal capital return will be lower than before. The effect of subsidy is measured by the change in relative marginal product of capital τ_i^K. When the relative MRPK of industry i goes down, its relative capital stock level will increase. As a result, both market clearing rental rate and sectoral capital allocation will change. Industry i will be able to rent more capital from the market, and this extra amount of capital comes from other industries, which is the source of sectoral capital misallocation.

Combined with the implication from one-sector model, I show the implications for the aggregate output in the multi-sector model, which gives the third channel. Here the production technology at firm level is assumed to be linear in capital for simplicity.

$$\log(Y) = \sum_{i=1}^{M} \beta_i \log(TFP_i) + \sum_{i=1}^{M} \beta_i \log(K_i) \tag{23}$$

The targeted subsidy will influence aggregate output from two aspects. First, as shown in Channel 2, it will change within industry capital misallocation and affect industry-level productivity TFP_i. If the subsidy brings marginal product of capital of each firm in industry i together, industry-level productivity will increase. Second, it will change sectoral capital misallocation. If the subsidy helps to bring industry-level capital allocation to its first-best case, it will alleviate sectoral capital misallocation, which will increase aggregate output. Otherwise, it may have negative impact on aggregate output.

2.2.2 General Equilibrium Effect with Production Network

In the general equilibrium model, subsidy will change capital allocation across industries and if subsidy brings excessive capital stock to one industry, it will cause welfare loss from misallocation. However, in a recent paper Liu (2017), an interesting conclusion has been made that in an economy with vertical linkage in production, subsidizing upstream industries would bring welfare gains from a better allocation of resources under certain conditions. Based on this model, I extend the multi-sector model to incorporate production

and evaluate the welfare implications from government subsidy.

The model setup is modified in the following aspects. First, in production side, there is one representative firm in each industry j, producing with capital and intermediate inputs from other industries $i = 1, ..., M$, and operating in a perfectly competitive market. A_j represents the physical productivity of this representative firm in industry j, and m_{ij} represents the quantity of intermediate goods from industry i used to produce output in industry j. Here, the production technology is constant return to scale, which implies $\sum_{i=1}^{M} \sigma_{ij} = \sigma_j$. The output of each industry can be used as inputs by others or used for final good production, which generate market clearing condition of output. In order not to get confused by notations, I use Q_i to represent industry level output and y_i to represent output for final usage. Second, how distortions in the economy work is also changed accordingly. There are two kinds of distortions in the economy. The first kind is called market imperfections, creating wedges when firms using inputs. They are denoted by χ_{ij} and χ_i^K. χ_i^K, the wedge between marginal product of capital and market lending rate r, indicates industry-level frictions in using capital. The representative firm need to pay $(1 + \chi_i^K) r K_i$ when it rents capital from the market. The other kind of distortion is government interventions, which is characterized as subsidy paid to firm i when using inputs. They are denoted by τ_{ij} and τ_i^K. For example, the subsidy S_i^K is paid in terms of final goods which makes the implicit price of capital faced by representative firm i becomes $1 + \chi_i^K - \tau_i^K$. Third, capital is provided by the households and the analysis is conducted in the static model. I assume that household owns capital and rent them in the market. This modification will only shut down the welfare implications from the change in aggregate capital stock, but not change the welfare implications from capital reallocation. Same as it in the model without production network, total capital stock at time $t+1$ is predetermined at time t. Analyzing the welfare implications from capital reallocation alone does not need the dynamics in aggregate capital stock (in transitional dynamics). Moreover, the change in industry-level production technology and distortions will not change the capital allocation form as it in the model without production network. Capital allocation across industries follows the overall frictions it has faced, besides the frictions from capital market. The rest of settings are the same as it in the general equilibrium model without production network. Final goods are produced by a final goods producer with Cobb-Douglas technology, and government collect lump-sum tax to finance its consumption and subsidy.

$$Q_j = A_j K_j^{1-\sigma_j} \Pi_{i=1}^M m_{ij}^{\sigma_{ij}} \tag{24}$$

$$Q_i = y_i + \sum_{j=1}^M m_{ij} \tag{25}$$

The problem of representative firm in industry j is to maximize its income by choosing capital, intermediate input when prices and distortions are given.

$$\max \; p_j Q_j - (1 + \chi_j^K - \tau_j^L) r K_j - \sum_{i=1}^M (1 + \chi_{ij} - \tau_{ij}) p_i m_{ij} \tag{26}$$

First order condition implies:

$$(1 - \sigma_j) p_j Q_j = (1 + \chi_j^K - \tau_j^K) r K_j \tag{27}$$

$$\sigma_{ij} p_j Q_j = (1 + \chi_{ij} - \tau_{ij}) p_i m_{ij} \tag{28}$$

The competitive equilibrium with distortion in this economy is a collection of quantities $\{K_i\}_{i=1}^M$, $\{Q_i\}_{i=1}^M$, $\{y_i\}_{i=1}^M$, $\{\{m_{ij}\}_{i=1}^M\}_{j=1}^M$, prices r, $\{p_i\}_{i=1}^M$, frictions $\{\{\chi_{ij}\}_{i=1}^M\}_{j=1}^M$, $\{\chi_i^K\}_{i=1}^M$, and government interventions $\{\{\tau_{ij}\}_{i=1}^M\}_{j=1}^M$, $\{\tau_i^K\}_{i=1}^M$.

1. $\{y_i\}_{i=1}^M$ solves the profit maximization problem final good producer in perfectly competitive market with $\{p_i\}_{i=1}^M$ given.

2. $\{K_j, \{m_{ij}\}_{i=1}^M\}_{j=1}^M$ solves the profit maximization problem of representative firm in industry j in perfect competitive market with $\{p_i\}_{i=1}^M$ and τ_j as given.

3. Market clearing condition implies

   (a) r clears capital market that $K = \sum_{i=1}^M K_i$

   (b) p_i clears goods market in industry i that $Q_i = y_i + \sum_{j=1}^M m_{ij}$ for $i = 1, \cdots, M$

Denote $\frac{p_i m_{ij}}{p_j Q_j} = \omega_{ij}$ and the matrix of supply share is Ω. Similarly, the output elasticity is σ_{ij}, and the corresponding matrix is Σ. Domar weight is defined as $\gamma_i = \frac{p_i Q_i}{Y}$ which is the sales of each industry over total consumption. In vector form, it is $\gamma = (I - \Omega)^{-1}\beta$. Define $\mu' = \beta'(I - \Sigma')^{-1}$ as the influence vector of the economy, which captures the impact of change in productivity on aggregate output. If there are no frictions in the economy,

the sales vector and influence vector are equal. Define the vector $\xi = \mu/\gamma$ as distortion centrality, which captures the difference between first best industry size and actual industry size.

In the competitive equilibrium, there is a closed form expression between aggregate output Y, industry level productivity $\{A_i\}_{i=1}^{M}$, level of market imperfections and frictions. Here, a is a vector of log productivity for all industries and σ is a vector of capital output elasticity of all industries. χ^K and τ^K represents the vector of capital frictions and subsidy respectively. χ and τ represents the matrix of frictions and subsidies on intermediate inputs respectively. The welfare implications for the whole economy are determined by the vector a and $(1 - \sigma) \log(1 + \chi^K - \tau^K)$.

$$\log(Y) = \beta'(I - \Sigma')^{-1}[a - (1 - \sigma) \log(1 + \chi^K - \tau^K) - \Sigma' \cdot [\log(1 + \chi - \tau)]'] + \cdots \quad (29)$$

First, when government subsidizes some firms in industry i, the industry level productivity A_i will change, depending on which firms get subsidy. If the subsidy makes productivity in industry i increase 1%, there will be a $\mu_i\%$ increase in final goods output. If the industry level productivity has been deteriorated by this policy, there will be negative welfare implications for the whole economy.

Second, when government subsidizes some firms in the targeted industry i, the marginal product of capital at industry level will decrease, and this decline is captured by τ_i^K. When the marginal product of capital of industry i decreased by 1%, the aggregate output will increase by $\mu_i(1 - \sigma_i)\%$. Here, the assumption is that this subsidy comes from outside of the economy. However, in a closed economy, government provide subsidy by cutting its consumption, holding the lump sum tax T constant. When the current level of subsidy is zero and hold the lump sum tax T constant, welfare implication of marginal intervention is comparing the increase in aggregate output and cost of government subsidy:

$$\frac{\partial Y/\partial \tau_i^K}{\partial S/\partial \tau_i^K} \Big|_{\tau=0,\ T\ constant} \quad (30)$$
$$= \frac{Y \mu_i(1 - \sigma_i)}{(1 + \chi_i^K - \tau_i^K)rK_i}$$
$$= \frac{\mu_i}{\gamma_i}$$

Given the level of frictions, as long as $\frac{\mu_i}{\gamma_i} > 1$, the subsidy will increase the aggregate

output, which means it will bring more increase the households consumption than the decrease in government consumption. This result is generated because of following two parts. First, in order to finance such subsidy $S_i^K = (1 + \chi_i^K)rK_i - (1 + \chi_i^K - \tau_i^K)rK_i$, the cost is $\tau_i^K rK_i$. Second, the log increase in aggregate output from such subsidy is given by $\mu_i(1 - \sigma_i)\log(1 + \chi_i^K - \tau_i^K)$. As long as the industry is constrained, that $\mu_i > \gamma_i$, the welfare gains from a capital subsidy will overcome the cost. In the economy with market imperfections, frictions will accumulate through backward demand linkages, and the most upstream industry becomes the sink of all distortions. Thus, if government helps upstream industries by lowering capital cost, there will be positive welfare implications for the whole economy.

Based on the two effects brought by government subsidy, the overall effect can be decomposed in the two parts: welfare change from productivity decrease, welfare change from subsidy, which conclude the fourth channel.

$$\Delta \log Y = \mu_i \Delta \log(A_i) + (\mu_i - \gamma_i)\omega_i^K \tau_i^K \tag{31}$$

To summarize, welfare implications for the whole economy depends on two conditions. First, it depends on which industry is targeted by government. If the industry is upstream, a capital subsidy paid to it will generate positive welfare implications for the whole economy. Second, it depends on which firms in the industry get subsidized. If the fund flows to those who are relatively more constrained, the industry level productivity will get improved, which generates positive welfare implications. If the subsidy flows to those who are already less constrained, misallocation in the industry will increase, which will deteriorate industry level productivity and generate welfare losses for the whole economy.

3   Application

Chinese government has adopted various industrial policies to promote economic growth, from industry-specific export tax rebates, fiscal supports to R&D firms to implicit subsidies disguised as regulations. In this paper, I evaluate the welfare implications of a disguised industrial policy: compulsory import delegation regulation on iron ore imposed on steel industry between 2005 and 2013.

There are several reasons of picking up steel industry as the example. First, steel industry in China is large and upstream. Any impact on it will generate sizable influence to

the whole economy. Figure 4 shows the position of steel industry in production network. It serves as important intermediate inputs for many other industries. Second, steel industry in China expanded fast during 2005 to 2013. Figure 5 whos the quantity of steel output in China and its position in the world. In 2004, China only produced 26% of global steel output, but in 2013, half of steel in the world was produced in China. The output growth during this period in China even exceeded the global increase. In the same period, Chinese firms contributed 95% of global export growth. Third, along with the fast expansion in steel production, misallocation in steel industry increased. Moreover, many large firms are in trouble nowadays. For example, between 2014 and 2017, Dongbei Special Steel Group defaulted on 7 billion RMB corporate bond, which accounted for 10% of total defaults in Chinese bond market. Eventually, this company went bankruptcy and was over taken by Shagang Steel Group. Wuhan Steel Group, who was the third largest steel producer in China, experienced huge losses from 2014 to 2016, and was merged into Baosteel Group to avoid bankruptcy. Ansteel Group, who was the 5th largest steel producer in China, faced consecutive losses since 2011, and in 2013, it had to decorate its financial statement by change depreciation scheme of fixed assets to avoid being delisted. Bohai Steel Group, whose output rank 8th in China, defaulted on 192 billion RMB bank loans and this issue is still not solved yet. Last, I can clearly identify which firms were targeted by this policy with a match firm-level data from custom and industrial enterprise survey.

3.1 Institutional Background

Steel industry in China experienced a prosperity in the first decade of the 21 century as shown in Figure 5. The massive steel production required huge amount of raw material: iron ore. However, neither the quantity nor the quality of domestic supply can satisfy the demand. China only has 13.5% of world's iron ore storage. Moreover, quality of iron ore produced in China is much lower than world's average level. Compared with the 50% of global steel production in 2013, iron ore output only accounted for 15% of global output. As a result, constraints in natural resource pushed Chinese steel companies to international markets, seeking for iron ore.

At the end of 2004, the skyrocketing volume of import and its price attracted attention of Chinese government and it responded to this situation with the compulsory import delegation policy of iron ore. Endorsed by Bureau of Commerce, China Chamber of Commerce of Metals, Minerals & Chemicals Importers & Exporters (CCCMMC henceforth) and China Iron and Steel Association (CISA henceforth), jointly announced that from since 2005, the right to directly import iron ore from foreign countries would be restricted

to some licensed firms. The red-tape, entitled with Qualifications of Iron Ore Trade Companies and Applying Process of Import License, set some criteria for firms, among which firms size is the most important one. For steel producers, they need to produce at least 1 million ton of crude steel in 2004 in order to apply for this license. For trading companies, they should at least import 0.3 million ton of iron ore in 2004. Eventually, only large firms survived in the import market. There were 118 licensed firms, among which 70 were large steel producers, who accounted for 84% of iron ore import in China. Although this license system seemed to be built overnight, its prelude was played at the beginning of 2004. CISA suggested small steel producers to purchase iron from large ones and claimed this deal has benefited both sides. With such a success in hand, CISA pushed this baby version license system into an industry-wide regulation.

Purpose of government by introducing this policy is quite simple: it wanted to pursue a favorable import price for Chinese buyers. Since 1980, the majority of iron ore was traded at long-term contract price, which was a yearly price same for all buyers with contracts in hands. In 2004, 85% of imports in China was conducted at this price. Long-term contract price was the outcome of bargaining between large steel producers and mining companies, and at the end of 2003, Baosteel Group was invited to join this price bargaining. Chinese government was seeking a favorable price of its steel producers and wanted to utilize this regime of price bargaining. It argued that, if CISA becomes the largest importer in Asia, foreign mining companies will yield to its huge purchasing power and offer a better price. However, there too many small importers in the market and their behavior was had to control. Those small traders had to be cleared out of market in order to protect this power. Based on this argument, CISA introduced this compulsory import delegation regulation. On the one hand, CISA cleared small steel producers and trade companies out of market. On the other hand, it set a special department to handle the price bargaining, which was led by Baosteel Group. Whether the target has been achieved was in doubt. The long-term contract price increased year over year after the policy enforcement. Moreover, the price bargaining for 2009 humiliated CISA with a big failure. This policy was ended in July 2013. Due to changes in trade regime in 2011 that mining companies were no longer sell iron ore at a yearly price but follow the spot market one, this policy lost its foundation and was eventually ceased.

Although the effectiveness of this policy on price bargaining was in doubt, its influence on import market was obvious. It has two effects on the importers. Figure 6 shows the change in import market share by firm type. First, it cleared small buyers out of import market. I calculate the share of small traders, large traders and steel producers. Here,

small traders refer to those who did not get the import license after 2005. Between 2006 and 2011, import amount of the firms who did not get license at 2005 was zero. Second, this policy stopped competitor for those steel producers on enter this market. Before 2004, the market share of small traders kept increasing and eroding the business of steel producers. During this time, the business of large traders was not affected, since they are usually firmly attached to final users. After this regulation was enforced, small traders disappeared, and large traders and manufacturers jointly maintained a stable market share for several years. [1] In 2011, when the contract price trade regime of iron ore collapsed, some new steel producers and traders got the import license and the market share of large steel producers was further eroded. A big jump in small traders' market can be observed in 2013, that when compulsory import delegation was ended, small steel producers turn to traders but not large steel producers for material.

Unlike the quick response of import market, domestic iron ore market almost did not react to this policy. Figure 7 shows the comparison between market prices from 2003 to 2017. To make the price across markets comparable, I pick up two kinds of ore fines which are always used as benchmark products in the market. The domestic one is ore fines with 66% ferro content sold in Tangshan, and the imported one is Carajas sold in Qingdao port. The contract price includes the shipping cost, and either one is the price faced by end user. Before 2009, contract price was adjusted yearly. In 2010 and 2011, the price was first adjusted at quarterly basis and later at monthly basis. At the end of 2011, this contract price became history, and it was replaced by spot market price. The price gap between domestic spot market price and contract price was not affected by this policy. [2] An explanation to this phenomenon is that domestic market is a segmented market and when the policy was introduced, market share of small traders was too little to influence the domestic price. Transportation of iron ore is costly, and firms usually use water or railway to do long range shipping. The rivers and railway are already overcrowded in

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[1]The market share in 2009 was an outlier. In first half of 2009, CISA was not satisfied with the outcome of price talk and required steel producers to cease importing. As a result, their import volume was affected. But it does not mean their total import decreased as large as the data shows. From Jinan Steel Group's year book, I find that its total purchasing in 2009 did not decrease, but part of its import was conducted through some trade agencies. It explains the big drop in import market share in 2009 and the recovery in 2010.

[2]I tested whether the price gap between contract price and domestic spot market price has been changed associated with enforcement of this policy with the method by Bai and Perron (2003). If the mean of price gap has changed, this method will report that there is a structural break. Two structural break points are suggested by this method. The first break happened in September 2008 and the second happened in March 2012. Neither one appeared at the time of policy implementation. The first break point seemed to be associated with the global financial crisis and the second one appeared around the time when contract price regime was totally ended.

China which further lowers inter region free flow of iron ore. Under such situation, the iron ore market is a segmented and non-competitive market. In each region, the local market is controlled by some giant local suppliers. Figure 8 shows the import share of three largest firms in each city for 2004 and 2008. Before and after the policy was implemented, the import share of was highly concentrated around 1. This policy only increased the agglomeration a little. What's more, during the same time, government even take actions to stop the formation of a competitive local iron ore market. In 2009, under the name of further strengthening import delegation policy, the newly built iron ore exchange center in Rizhao was shut down just after one-month operation. By doing so, firms in one region cannot freely attach suppliers near by and they must obey the rules in a monopolized local market. However, those local giant iron ore suppliers cannot charge a markup too high, since competitors will penetrate their market if they can overcome entry costs. As a result, although small traders were cleared out and their market share was replaced by new supplier, this shift does not change the non-competitive feature of iron ore market in China.

To summarize, this compulsory import delegation policy was introduced to bargain for a favorable price for Chinese steel producers. Although whether the original purpose of government has been achieved was in doubt, it has impact on the domestic market. Small traders disappeared after 2005 and the market share of large steel producers was protected. Eventually, it become a policy that help large steel producers to do the resale business and protect their benefits.

3.2   Data

In order to further analyze the impact of this policy, I mainly rely on two data sets. The first is China Custom Trade Data, and the other is China Industrial Enterprise Data. The rest information is collected from yearbooks of steel industry and large business groups.

China Custom Trade Data conveys two kinds of messages. The first part is detailed information of a firm, such as firm's Chinese name, address and registration number in custom. The second part is detailed information of each transaction, such as product in 8-digit HS code, origin ore destination country, value and quantity of the deal, and transportation method. The unit price of imported iron ore includes the FOB price and transportation cost, which is the final suer price and is comparable to iron ore price in domestic market. Table 2 shows import quantity and firm number by ownership and firm type. Since policy was announced at March 2005 and terminated at July 2013, the firm

number from 2006 to 2012 can show its real influence. There were 523 firms imported iron ore at 2004, and the number fell to 231 in 2006. [3] Column 3 in Table 2 show a very interesting phenomenon. When the license was issued in 2005, three quarters of the non-SOE traders were squeezed out of the market, and when the license was terminated in 2013, the number immediately tripped. Meanwhile, the influence on those state-owned traders is relative smaller. Although a lot of traders were kicked out of market after 2005, only a few firms engaged in this business after 2013. The share of import quantity in Table 2 further shows how this policy shapes the market. Although the majority imports were dominated by the state-owned steel producers, the non-state-owned firms did not fall behind. The policy may block some small private steel producers from importing directly, but it did protect the benefit of those large private manufacturers. However, the same story cannot be applied to the traders. Before 2005, a lot of non-state-owned traders noticed the opportunity of fortune and rushed into this market. However, this trend stopped, and they failed to grab the benefit from those state-owned traders. Only after 2011, when the price regime fully collapsed, the market share of those private owned traders began to increase. In 2013, the change was so dramatic that the import of private traders even exceeds that of state-owned firms when the license system was abolished. In Custom data, firms report quantity and value of import without specifying price regime. I back out whether the transaction is billed at contract or spot market price from its unit price. Baosteel Group imports all its iron ore at contract price; so, I set Baosteel Group as the benchmark firm, and treat all its imports are billed at contract price. The variation of its price within year comes from the fluctuation in transportation cost. If other companies also import at contract price, their price shall fall in this range. Here, the underline assumption is that all firms import similar kinds of iron ore, and my focus is the end user price of imported iron ore. Since the shipping cost faced by importers were different, and usually higher than Baosteel Group, the estimated share will not over report the quantity traded at contract price. Table 3 shows the share of quantity purchased at contract price and spot market price. The number after 2011 is not provided since the contract price regime has ended. Column 2 and 3 demonstrate the import quantity of iron ore conducted at contract price as a fraction of total imports of steel producers and trade agencies. I can find that, most imports were billed at contract price before 2009, and steel producers bought majority of them. [4] For the steel producers, this share was quite stable

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[3]The license was issued at group level, and a group may use its several affiliations to conduct the import. As a result, total firm number shown in Custom Trade Data exceeded 118.

[4]The only data about the share of imports at contract price was published in the journal titled China Steel on September 2005. The article mentioned that a survey of the 20 largest manufacturer importers showed that 135 out of 155 million ton of iron ore they purchased was at contract price in 2005, which is

from 2000 to 2008. It became lower afterwards because of the big fall in spot market price, and the price at spot market was even cheaper at first several month in 2009. Clearly, the main features of Chinese imports are that majority of transactions is billed at contract price and steel producers conducted most imports.

Industrial enterprise data mainly tells firm's financial statements and production formation. The classification includes steel industry defined in this paper is called Ferro Metal Producing and Processing, which has pig iron production, crude steel production, steel rolling and processing, and iron-alloy production. In this paper, firms registered in the first three sub-categories are considered as steel producers. In order to validate this definition, I look at those steel producers with import license, and find that all, expect few small subsidiaries, fall in those three sub-categories. Typically, Baosteel Limited Company and Jiangsu Shagang Steel Limited Company who are the largest state-owned and private owned steel producers both register under the category of steel rolling and processing. Within the steel industry 20% of firms registered under pig iron production, 8% registered under crude steel production, and the rest, which is the majority register themselves as steel rolling and processing firms. What's more, I find that the firms collected by China Steel Yearbook all fall into these three subcategories.

By utilizing the Chinese name in custom data, I recover the name list of firms with license. If one firm use its subsidiaries to conduct the import, the ultimate owner will be regarded as the license holder. Same work has been performed on the industrial enterprise data. All the subsidiaries of firms with license have been identified. The two data sets are connected by the Chinese name of license holder. The information is extended to 2000, which means, during 2000 to 2004, the importers were those who showed up in custom data, and after 2005, the importers were license holder and their affiliations. It is interesting to find that, before and after the license was introduced, the number of manufacturer importer does not change a lot. From 2004 to 2006, I have identified 8 manufacturers who did not get the license, and, only 2 of them were consistent importer before 2005, and others only showed up in 2004. In 2013, the newly showed manufacturer importer was much fewer than trade agencies, and I only locate one firm who has imported iron ore before 2005. It seems that under the pure spot market price regime, directing importing and import through a intermediary does not make too much difference for small steel producers. Across years, there are about 200 affiliations in steel industry belongs to those license holders.

Following Perkins and Rawski (2008), the real capital stock of each firm is calculated

87.5%.

with perceptual inventory method. Efficient unit of labor is measured at wagebill and use average year of schooling as a robustness check. Both measurements give the same time pattern. Sales and value added are deflated by the output deflater provided by the national bureau of statistics. As pointed out by Qian and Zhu (2012), labor share is under reported in Chinese data. I follow Hsieh and Klenow (2009) strategy and raise the wagebill by 1.667 during the following analysis. Neither material input nor value added of firms is not reported after 2008 and I follow the method provided by NBS that using value added rate to predict firm's value added.

3.3 Stylized Facts

With the data in hands, I show how large the profits of resale business and the firm dynamics of steel producers.

For the firms with import license after 2005, the most direct impact is that they engaged deeply in resale business. In order to estimate how much iron ore was sold by them, I calculate output share of steel products and control of iron ore by those privileged firms. Table 4 shows the results. Total iron ore controlled by those firms with import license includes total imports and their domestic output, where the quality is adjusted to match the imported one. Before 2002, the amount they produced and purchased can only fulfill their own needs. After the policy was implemented, their resale business was ever increasing.

With a large market share, how much profits can be snatched from it? Since the contract price was set at the year beginning, it cannot reflect the market situation for the whole year, which remains huge room for rent seeking. When the economy is booming faster than expected, the price in spot market will be higher than the contract price. Also, the iron ore market is segmented, which allow them to maintain a high markup. This is what happened from 2003 to 2011, except a few months in 2008 and 2009. This part of profits cannot be observed directly. One reason is that resale profits was counted at group level. The affiliations who conducted the import and resale may not be able to write these profits into their financial statements. I surveyed the yearbook of all available yearbooks of steel business groups, and only locate two companies clearly state how large their business was. [5] In order to estimate this part of profits, I rely on the price gap

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[5]Jinan Steel Group not only reports how many iron ore it sold in each year but also records average import and resale price. From 2005 to 2011, one thirds of its import was resold and majority profits were hided in financial statement at group level. Another example is Beijing Shougang Steel Group. In its yearbook, I find that from 2005 to 2009, 40% of its import was resold. However, from 2002 to 2006, this

between contract price and domestic market price, and the total resale quantity in each year. Table 5 shows the monetary value of import license. Column 2 shows the quantity of resale, and the following two columns tell the average price gap between contract price and domestic spot market price. The next column shows the resale profits in each year. The big decline in 2009 should be a misleading number. But without better source of data, I cannot adjust this figure with confident. The last column shows total reported operational profits of those manufacturers, which including profits from selling steel, iron ore, and other business. From 2004 to 2013, the profit from resale equals at least 38.07% of operational profits net of iron ore. Besides the overall benefit, value of this license can be inferred from specific firms. One example is Tangshan Ruifeng Steel Company. This firm was founded in 2002 but did not get license on March 2005 at first place. However, it managed to get the license in the end of 2007. One directly effect was that its profitability, which is total profit over sales, shoot up to 12% in 2008 and stayed at that level, while before 2007, its overall profitability was just around 4%. Moreover, its sales in 2011 was three times larger than that in 2007.

How did the profits from resale may benefit the firms with license? Although those firms were mainly large state-owned firms, their capital return was higher than market lending rate. Figure 9 shows the capital return of steel producers in 2004 and 2013. In find that in 2004, the firms got import license were financially constrained that their capital return was higher than lending rate. However, in 2013, their capital return was much more closer to the lending rate. Figure 10 shows the relative of firm size and capital stock between firms with and without import license. Here, the firms without license are taken as benchmark and their size is normalized to unity. The firm here refers to the firm in industrial enterprise data set, which has independent legal person code. For example, Baosteel Group have many subsidiaries, such as Baosteel Limited, Shanghai Pudong Steel Co. and etcetera. The firms shown up in data is Baosteel Limited and Shanghai Pudong Steel Co. In the following analysis, firm or manufacturer all refer to affiliations. Before the manufacturers were entitled with monopoly power in iron ore resale business, their relative firm size decreased. Only after 2004, their relative firm size began to increase, in terms of sales, employment and fixed assets. Three messages can be taken away from this figure. First, at initial place, firms with import license were already larger than others on average. Second, before CISA created such a conglomerate of interests, their relative

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part of profit in income statement of Shougang Steel Limited, who is the major affiliation, was 0. This number became 200 million, 400 million and 200 million between 2007 and 2009, which contributed half of its total profits. In 2008, the profit from selling material even over weighted the losses from main business. For other steel groups like Hangzhou Steel Group, they only mention in their yearbook that they are doing resales business, but do not record it size.

firm size was decreasing in terms of all aspects. Third, their expansion coincided with the enforcement of compulsory import delegation. At the same time, the expansion of firm size was at the cost of capital efficiency and debt, which is conveyed from Figure 11. Before the license was introduced, capital productivity and debt sales ratio of privileged firms were converging to others. The corresponding institutional background during this period of time is that, those large steel conglomerates were restructured or corporatized under state-owned enterprise reform. Their leverage decreased, and capital return increased. However, this trend is reversed along with the enforcement of this policy. Their relative capital productivity began to decrease, and debt sales ratio began to increase. Compared with others, in order to generate one more unit of sales, the firms with import license need to input more capital and the capital is financed by debt.

Eventually, this compulsory import delegation on iron ore turned out to be an industrial policy (targeted subsidy), which have brought sizable profits to steel producers with import license. Moreover, the stylized facts indicate that, for those financially constrained steel producers, the extra profits may lead to a debt-driven expansion, which is the same as the model prediction. In the next section, I will use the model to quantify to what extent, the observed phenomena can be explained by this policy.

3.4 Quantifying Welfare Implications

First, I evaluate the welfare implications for steel industry. Suggested by the literature (Grieco, Li and Zhang (2016), Berkowitz, Ma and Nishioka (2017)), elasticity of substitution between inputs may be non unitary. I plot the log labor share and log capital labor ratio for steel producers in 2004 and show the pattern in Figure 12. The log labor share and log capital labor ratio show negative correlation, indicating that capital and labor are substitutes in production. Then I modify the production into a CES one. The rest of model are consistent with the one-sector model in the theoretical part. The production function of a producer in steel industry at time t becomes:

$$Y_{x,t} = A_{x,t} \left[\alpha K_{x,t}^{\frac{\sigma-1}{\sigma}} + (1-\alpha) L_{x,t}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{32}$$

The industry indicator i is omitted here since I only focus on steel industry. σ if the elasticity of substitution between capital and labor. The problem of each firm owner is to rent capital and hire worker and to maximize the period profits.

$$\max \ \pi_{x,t} = P_{x,t}Y_{x,t} - (1 + \chi^K_{x,t})RK_i - (1 + \chi^L_{x,t})WL_i \tag{33}$$

First order condition with respect to capital implies:

$$(1 + \chi^K_{x,t})R = \frac{\alpha}{\eta} \frac{P_{x,t}Y_{x,t}}{K_{x,t}} \left[\alpha + (1 - \alpha) \left(\frac{K_{x,t}}{L_{x,t}} \right)^{\frac{1-\sigma}{\sigma}} \right]^{-1} \tag{34}$$

The left-hand side is marginal cost of capital for each firm. The capital rental price is R, and firm may face a distorted price $(1 + \chi^K_{x,t})R$. The wedges in market represents the static frictions for each firm. The right-hand side represents the marginal revenue product of capital. This term is composed of capital productivity and capital labor ratio. When the elasticity of substitution between capital and labor is not unitary, the marginal revenue product of capital can no longer be stated as a constant fraction of capital productivity.

$$(\widetilde{1 + \chi^{K'}_{x,t}}) = \left(\widetilde{\frac{P_{x,t}Y_{x,t}}{K_{x,t}}} \right) + \frac{\sigma - 1}{\sigma} \frac{(1 - \alpha)(\frac{K_{x,t}}{L_{x,t}})^{\frac{1-\sigma}{\sigma}}}{\alpha + (1 - \alpha)(\frac{K_{x,t}}{L_{x,t}})^{\frac{1-\sigma}{\sigma}}} \left(\widetilde{\frac{K_{x,t}}{L_{x,t}}} \right) \tag{35}$$

The above equation is log linearizion of the first order condition of capital. It shows that when capital wedge increases and other things unchanged, capital labor ratio will decrease, and in turn, capital productivity will increase even more. On the other hand, if the capital wedge decreases a little, the capital labor ratio will increase, eventually results in an even larger decrease in capital productivity. As a result, any changes imposed on capital wedge will make the capital labor ratio and capital productivity to change in different directions. If two firms only differ in capital wedge, their difference in capital productivity is not proportional to the difference in capital wedge, and this difference in capital productivity will over report the difference in capital wedge. If the production technology follows Cobb-Douglas, then the second part on the right-hand side will be zero, since $\sigma = 1$. Only under this case, the change in wedges equals change in factor productivity. Capital labor ratio is also enlarged by σ from the factor price difference. When other things are not changed, an increase in rental price of capital will result in an even larger change in capital labor ratio in opposite direction. Again, only under Cobb-Douglas case, the change in capital labor ratio is identical to change in factor price

difference.

The productivity can be expressed as a function of capital, labor and value added as in Hsieh and Klenow (2009).

$$A_{x,t} = \left(\frac{P_{x,t}Y_{x,t}}{P_{i,t}Y_{i,t}}\right)^{\eta} Y_{i,t} \frac{1}{\left[\alpha K_{x,t}^{\frac{\sigma-1}{\sigma}} + (1-\alpha)L_{x,t}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}} \tag{36}$$

Parameters are estimated using method in Grieco, Li and Zhang (2016). With the estimated parameters, I calculate the wedges and physical productivity of each firm in steel industry and conduct a counterfactual test. As indicated in the analysis above, the observed factor productivity will under estimate capital wedge and over report labor wedge, if the substitution between capital and labor is allowed. The capital wedge of firms with license is not as low as the observed capital productivity, and their labor wedge is not as high as observed labor productivity. The same results can also be generated if the efficient unit of labor is measured by year of schooling. Figure 13 shows the capital and labor wedges. From 2000 to 2004, the labor wedge faced by large firms were catching up with others, indicating the allocation efficiency in labor is increasing. However, after 2004, this improvement stopped and labor wedge maintain until 2007. For capital productivity, its trend follows capital productivity, but its actual level is not that bad. With the productivity and wedges of each firm, the welfare losses can be calculated from a counterfactual exercise. The first best case is defined as all firm faces the same capital and labor price, which means the wedges are equalized across firms. Under the assumption that total capital and labor are fixed in each year, redistributing of capital and labor according to physical productivity and common capital and labor price across firms generates the outcome of first best case. Figure 14 shows welfare implication estimated by comparing first best case and actual situation. Before the policy was implemented, welfare losses, measured by distance between first best case and actual one, were decreasing. After 2004, this trend was totally reversed. This result can be expected from the above analysis. Before 2004, the large firm's capital and labor wedge are converging with others. Meanwhile, their physical productivity was increasing. Under this situation, the allocation efficiency was improving which resulted the decreasing in welfare losses. After the policy came into force, the capital wedge of those large firms began to diverge from others and improvement on labor wedge stopped. Although their physical productivity was decreasing during this time, the force from capital wedge was so large that their firm size still increased. As a result, resources were over allocated to those privileged firms and resulted in the deteriorating misallocation.

Quantitatively speaking, until 2013, which is the end of compulsory delegation policy, allocation efficiency within steel industry has decreased by 38%, compared with it in 2004.

Within such a big deteriorating misallocation from 2004 to 2013, how much can be explained by the compulsory import delegation policy? I quantify this dynamic misallocation with the firm growth model. The model set up is generally the same as it in theoretical part with the following exceptions. First, there are only two types of agents, entrepreneurs with license and without license. Meanwhile, they are differing in productivity, initial firm size and faced with different distortions. Second, the utility function of them is linear, and the purpose is to simplify the analysis. Third, I characterize a representative household in the industry, who provides 1 unit of labor inelastically in each period and they are hand to mouth workers. The modified problem for firm owner becomes:

$$\max \ U_{ix} = \sum_{t=0}^{\infty} \beta^t C_{x,t} \tag{37}$$

$$C_{ix,t} + K_{ix,t+1} + RB_{ix,t} + AC_{ix,t} \le (1 - \tau^Y)P_{ix,t}Y_{ix,t} - WL_{ix,t} + (1 - \delta)K_{ix,t} + B_{ix,t+1}$$

$$K_{ix,t+1} \le \kappa E_{ix,t+1} \ (\kappa \ge 1)$$

$$AC_t = \frac{\theta}{2}\left(\frac{K_{ix,t+1} - K_{ix,t}}{K_{ix,t}}\right)^2 K_{ix,t}$$

$$C_{x,t} \ge 0$$

Again, for simplicity, replace credit constraints by $B_{x,t+1} \le \phi K_{x,t+1}$, where $\phi = \frac{\kappa - 1}{\kappa}$. When the firm owner makes decision, he or she takes the wage rate, initial capital stock and debt holding as given, and choose level of employment and next period of capital stock and debt level. When the credit constraint is binding and utility on consumption is linear, he or she will save all the income and invest it in next period production and borrow up to the limit. Here, the market wage rate will change according to the demand for labor, while lending rate is exogenously set at R.

Under CES production function, there is no closed form solution for capital stock and employment. As a result, parameters of the model are estimated by simulated method of moments. The initial state is chosen at year 2003, when it was not affected by the policy. Number of affiliations with import license accounts for 6% of total firms.

Part 1 of Table 6 shows the predetermined and estimated parameters. Here, the firms without import license are considered as benchmark, and their productivity and sales

subsidy are normalized to unity. Markup, distributional parameter, and elasticity of substitution between capital and labor are the estimates from the static model above. Here, I do not try to infer these two parameters with the highly simplified model, and instead, directly use the estimates from literature specialized in estimating production function. Time discount factor β and capital adjustment cost θ are picked up from literature. Depreciation rate is set at 10% per year. The parameters left to be estimated are initial capital stock K_0, financial frictions ϕ, relative productivity $1 + \tau^A$ and relative sales subsidy $1 - \tau^Y$.

The estimation is performed by minimizing the distance between data and model, where ϖ refers to the parameters and $g(\cdot)$ is the moments from model and $d(\cdot)$ is moments from data. The optimal weighting matrix W is calculated by bootstrapping. I keep the moments conditions from the 1000 bootstrapped samples and calculate their variance covariance matrix. The inverse of this matrix is served as the optimal weighted matrix. The intuition of this method is that I shall put more weights on the moments with smaller variations, since these moments are more robust in data.

$$\hat{\varpi} = \operatorname*{argmin}_{\varpi} \left[g(\varpi) - d(\cdot) \right]' \hat{W} \left[g(\varpi) - d(\cdot) \right] \tag{38}$$

The rest of Table 6 shows the moment conditions and estimated parameters. As long as the initial difference in capital stock is determined, those parameters can be estimated. The initial difference in firm size is measured by difference in capital stock that $\log(k_{wl}/k_{nl}) = 4.3$. At first place, capital stock of firms with license were much larger than those who did not get license to import later. The first three moments was targeted on the statistics of firms without license. In this model, they are treated as the benchmark firms and parameters measuring levels are estimated according to their moments. The rest 5 moments measure the relative status of two types of firms. Their difference in labor productivity, firm size, leverage, and factor productivities provides enough information to estimate parameters in the model. The capital share is estimated from the first moment, and borrowing constraint is inferred from the third one. Relative sales subsidy and productivity difference are jointly estimated by firm size gap and labor productivity gap. The parameters can be just identified by these 4 moments, and rest moments help to utilize more information from the data.

The policy is characterized as an additional pledge of the firms with license. As mentioned above, the profits from resale is collected by the business group and the

affiliations benefit from the extras profits indirectly. The affiliations receives the extra profits as transfers and use them as collateral to relax the financial constraint. It works the same way as the government's targeted subsidy that the financial constraints get relaxed with more collateral. The quantity of iron ore resold by those privileged firms accounts for about 10% of total usage in China during the ten years. In a model without uncertainties, profits from selling iron ore should proportional to the size of steel industry. Here, operational profits of those firms with license is used as a proxy of the size of steel industry, so I set $\varphi = 38.50\%$ which match the share of profits from resale in total operational profits.

$$S_{x,t} = \varphi[(1 - \tau^Y)P_{x,t}Y_{x,t} - W_{x,t}L_{x,t} - RB_{x,t} + (1 - \delta)K_{x,t}] \tag{39}$$

Figure 15 shows the implications for steel producers. I compare the predictions of this model and firm dynamics in data. Qualitatively, after a import delegation system if formed, the relative firms size of firms with license began to increase. The relative capital labor ratio, capital productivity and debt sales ratio also followed up. The predictions of this model fit patterns observed in data. When the policy brings extra pledge for firms with import license, their relative output increased with a growing relative debt sales ratio. When the capital and labor are substitutes in production and shadow price of capital is moving downwards in faster way, they were able to speed up in capital deepening and their relative capital labor ratio increased. Quantitatively speaking, this steel industry specific model matches the trend of movement in relative firm size, and relative capital labor ratio. The relative debt sales ratio and relative capital productivity is over estimated a little. During 2005 to 2013, China experienced various policy shocks within and outside steel industry, and my model only intends to capture the impact from compulsory delegation policy. From Figure 15, it's clear that impact from this policy is quantitatively large.

Figure 16 and Figure 17 shows the implications for steel industry at aggregate level. I set the situation without such policy as benchmark and evaluate the impact of policy quantitatively with a counterfactual exercise. Figure 16 shows that aggregate capital productivity of steel industry has decreased faster relative than the case without capital subsidy. Since all firms are financially constrained, their marginal return to capital is larger than lending rate. When the policy brings more credit to some targeted firms, industry level capital will also become lower. In the 10-year scope, compared with the situation of no policy intervention, the capital productivity has decreased by 8.14%. However, at the

same time, capital allocation efficiency has been deteriorated. The counterfactual indicates that industry productivity decreased by 8.77% in the 10-year scope, compared with the situation of no policy intervention. It accounts for a quarter of the welfare losses from deteriorating misallocation during the same period.

In the above figures, implications for steel industry is evaluated with the one-sector model. The model predicts that introducing the targeted subsidy with the magnitude observed in the data can account for nearly 19% and 45% of the increase in their sales and debt-sales ratio relative to that of the non-licensed firms and 37% of the widened gap of marginal product of capital between the licensed and non-licensed firms. During the time of policy enforcement, returns to capital in steel industry decreased 35.20%. Meanwhile, the industry TFP went down by 8.77%, which accounts for half of welfare loss from deteriorating misallocation.

In the general equilibrium model, subsidizing steel industry means subtracting resource from other industries and will cause sectoral misallocation. When all the industries are independent, the capital subsidy paid to steel industry will reallocate capital from others industries to it, which will cause misallocation. Meanwhile, the worsened misallocation within the industry also reduces the aggregate output.

Figure 19 shows the results of counterfactual test. From the China Input Output Table in 2007, I calculate the capital share α_i and preference parameter β_i for each industry. Under the assumption that sectoral capital misallocation comes from the collateral constraint and inadequate net wealth, the relationship of capital income among all industries should be same as it of the capital stock. As a result, the initial marginal product of capital of each industry can be calculated. I assume all other things are constant over time and only the marginal product of capital and industry-level productivity of steel industry are influenced by this subsidy. When the marginal product of capital in steel industry becoming lower and lower, more and more capital will be allocation into this industry, which might create sectoral misallocation. I find that the marginal product of capital of steel industry is already relatively lower than others, and subsidizing it will worsen the sectoral capital misallocation. The welfare loss from sectoral capital misallocation is 0.1% in five years. Besides the welfare loss from sectoral capital misallocation, deteriorating within industry misallocation also affect the aggregate output. The welfare loss from within industry misallocation caused by this subsidy is 0.05% in five years. As a result, this subsidy to steel industry has brought net welfare loss to the economy, which is about 0.15% in five years and 0.23% in ten years.

Moreover, the effects of this subsidy would be propagated through production network.

According to the theoretical framework, subsidizing some firms in one industry will bring implications for the aggregate output from two aspects. On the one hand, the targeted subsidy brings down industry level capital productivity through a relaxation on financial constraints. On the other hand, this policy has deteriorated industry-level productivity through within industry misallocation. In the multi-sector model, I include labor in the production function of the representative firm $Q_j = A_j(K_j^{\alpha_j} L_j^{1-\alpha_j})^{1-\sigma_j}\Pi_{i=1}^N m_{ij}^{\sigma_{ij}}$, and the output elasticity of capital in industry j becomes $\alpha_j(1 - \sigma_j)$. Market imperfections among industries are measured by industry level net production tax. Production tax is paid by firms when they use various inputs in production and sell the output they have produced. I assume that the tax is paid when the representative firm using various inputs, including capital and labor. For example, industry j pays tax $tax_j = \chi_j$ for purchasing 1 dollar of inputs and it is industry specific in terms of its inputs.

$$\{\chi_{ij}\}_{i=1}^M = \chi_j^K = \chi_j^L = \frac{\mathrm{Tax}_j}{p_j Q_j} \tag{40}$$

Figure 20 shows the effects of this subsidy from 2004. The figure is interpreted as following: what are the welfare implications by comparing the situation with i years' policy enforcement and without. In this figure, the underlying assumption is that in short run, production network is stable where output elasticity, industry level productivity and market imperfections do not change. At the same time, this industrial policy only reshaped steel industry that its welfare implications can be isolated to analyze alone. Here I do not deny that this policy may also hurt whole sales and retail business, since small traders were who may be potentially important given their trend in resale business before 2004.

Welfare implications are decomposed into two parts according to the equation. First, when the policy over allocates capital to large firms, it worsens productivity of steel industry and this force generates negative impact on the aggregate consumption. The negative impact becomes larger and larger because of the deteriorating misallocation. After the policy has been enforced for 10 years, productivity in steel industry decreases by 8.7% and the welfare losses at this time are 2.01%. The second force is indicated by line marked with upward triangle. The welfare gains are increasing as the policy keeps subsidizing steel industry between 2004 and 2013. After 10 years' enforcement, welfare gains from a 8.15% drop in relative capital price are a 0.05% increase in aggregate output. Finally, the line marked with square shows the net welfare implications. The policy would result in a 1.96% decrease in aggregate output in ten years. When these effects are measured at

yearly basis, removing this policy will bring 0.2% increase in aggregate output.

The different welfare implications from Liu (2017) comes the change of within industry misallocation caused by subsidy. Holding industry level productivity unchanged, the subsidy paid to steel industry will generate welfare gains. However, in this case, the subsidy happened to flow into those how were less financially constrained. Although this subsidy has lowered marginal capital productivity of steel industry, it created within industry misallocation at the same time. Moreover, the welfare loss from within industry misallocation was amplified by the production network and eventually overweight the gains from subsidy.

To summarize, compulsory import delegation regulation on iron ore was a de facto industrial policy which subsidized large steel producer with import privilege. The subsidy, one the one hand, relaxed their financial constraints and promoted a debt driven expansion. On the other hand, it has worsened misallocation in steel industry. Guided by the theoretical framework, I quantify the welfare implications with a structurally estimated model. I find that introducing the targeted subsidy can account for nearly 19% and 45% of the increase in their relative increase in sales and debt-sales ratio, and 37% of the widened gap of marginal product of capital between the licensed and non-licensed firms. During the time of policy enforcement, the industry TFP and returns to capital go down by 8.77% and 8.15%, respectively. Extending the experiment to the multi-sector model shows that the worsened misallocation within the industry and across industries reduces the aggregate output and this effect is amplified by production network. The counterfactual exercise shows that incorporating the production network would increase the aggregate output by 0.05% from allocating more capital to steel industry and decrease the aggregate output by 2.01% from productivity decline of steel industry. Overall, the policy reduces aggregate output by 1.96% in the model in 10 years.

4   Conclusion

This paper investigates the welfare implications of targeted subsidy in a financially constrained economy. A theoretical framework with heterogeneous agents and borrowing constraints is developed to illustrate welfare consequences and the underlying mechanism. When a firm is constrained in borrowing, the targeted subsidy will relax its financial constraints and bring welfare gains to it. Meanwhile, as capital flows in, the targeted industry will also be better off. Two hidden effects emerge beneath this welfare gains. First, the expansion of targeted firms and industry is debt driven, which is reflected as a

decrease in marginal capital return. Second, industry productivity depends on relative financial constraints of those targeted firms. These two effects will spill over to other industries. In a general equilibrium model with wage and interest rates endogenously determined, I investigated the welfare implications for the whole economy. Capital subsidy paid to one industry will result in a reallocation of capital from other industries, which causes misallocation. Meanwhile, an improved(worsened) industry productivity by the targeted subsidy will generate welfare gains(losses) to the whole economy. These two effects may be amplified by the production network. Based on the theoretical predictions of the model, I evaluate a *de facto* industrial policy enforced by Chinese government. Compulsory import delegation regulation on iron ore relaxed financial constraints of large steel producers with import privilege, and promoted a debt driven growth of the targeted firms as well as the steel industry. Meanwhile, it has worsened misallocation and brought down productivity of steel industry. These two effects spill over into the whole economy through production network. Although promoting the development of steel industry by providing credits generates welfare gains, its effects are dominated by the welfare losses from deteriorating misallocation. Eventually, the net welfare implications of compulsory import delegation policy for the whole economy are negative.

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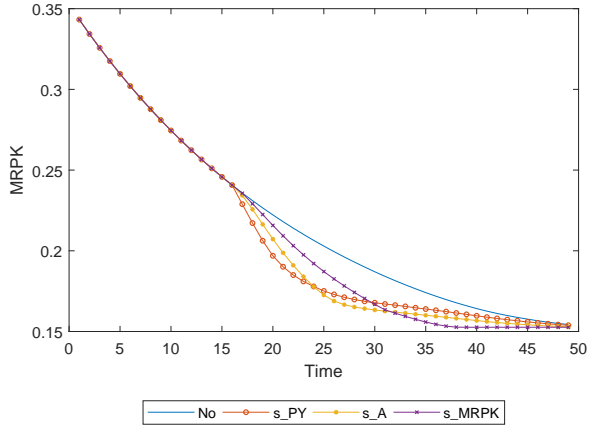# List of Figures

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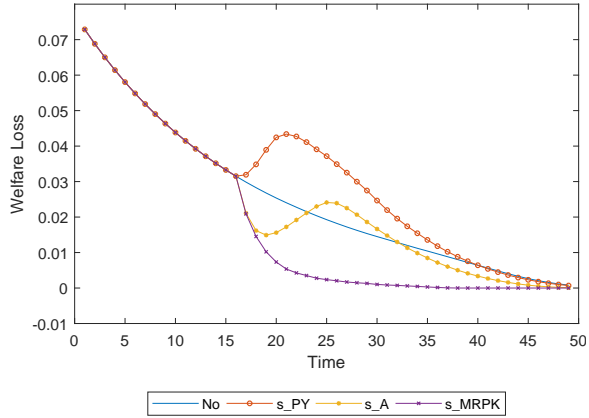

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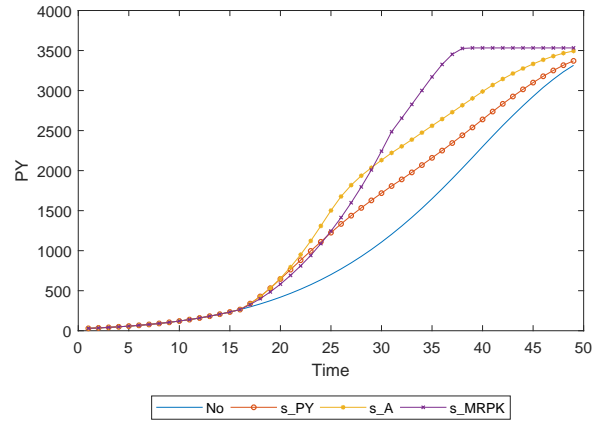
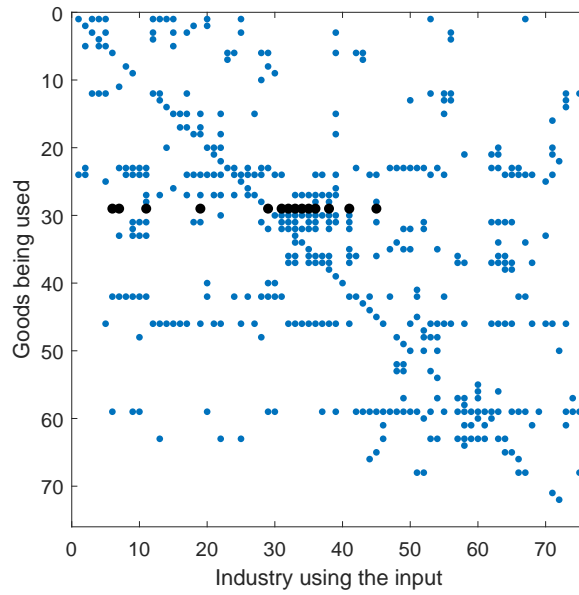Figure 3: Aggregate Output in Simulated Model

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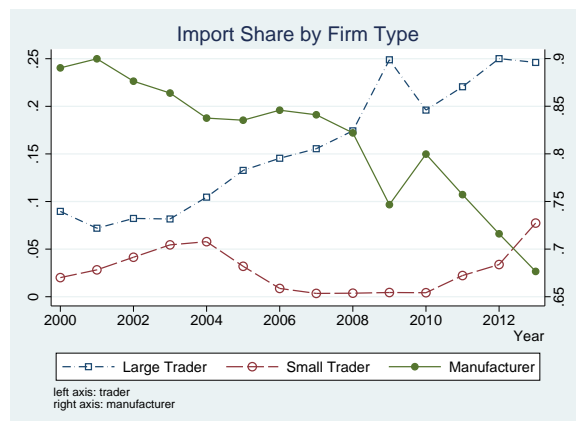

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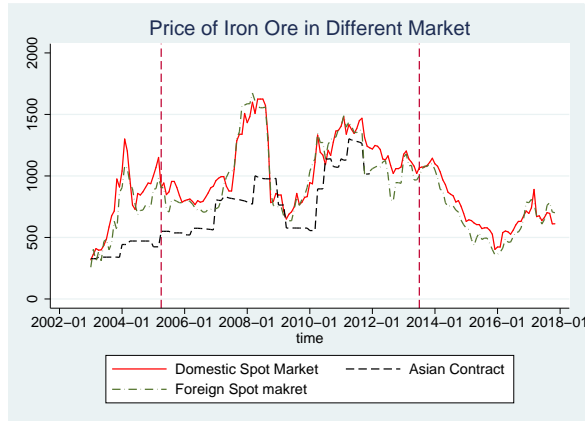
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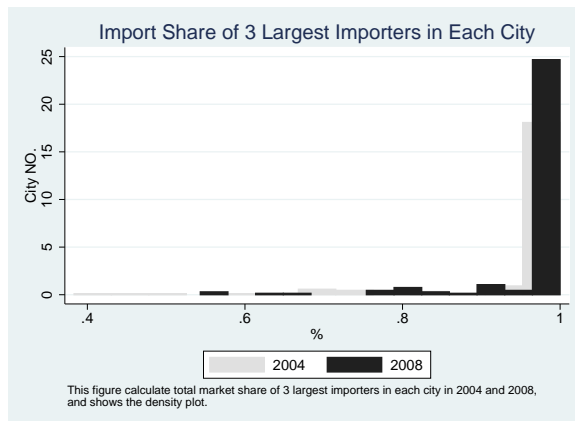Figure 8: Distribution of Import Share

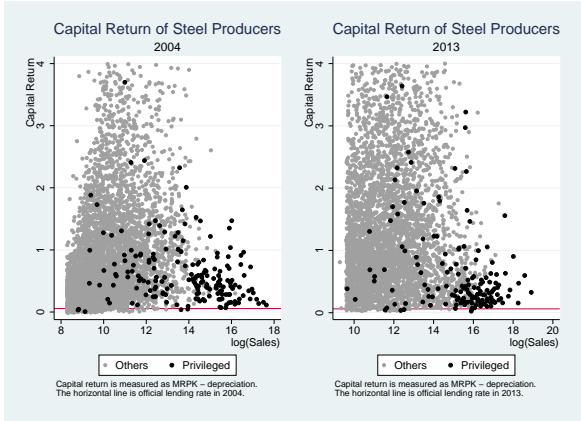Figure 9: Capital Return of Steel Producers

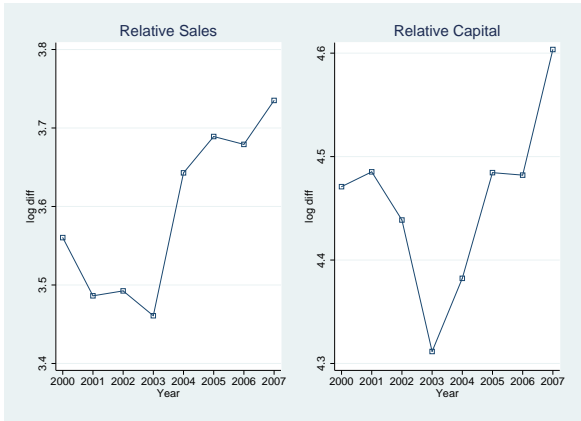Figure 10: Relative Firm Size Change

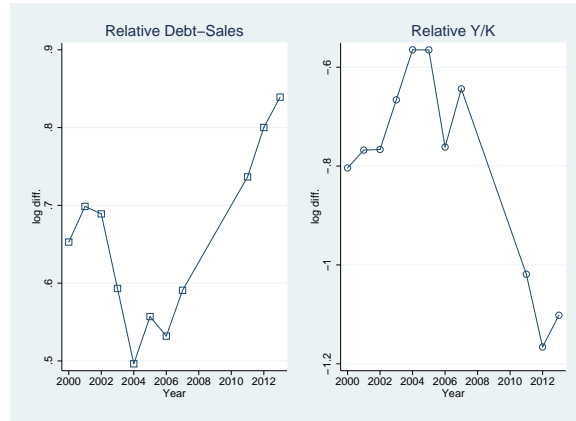Figure 11: Debt Driven Growth

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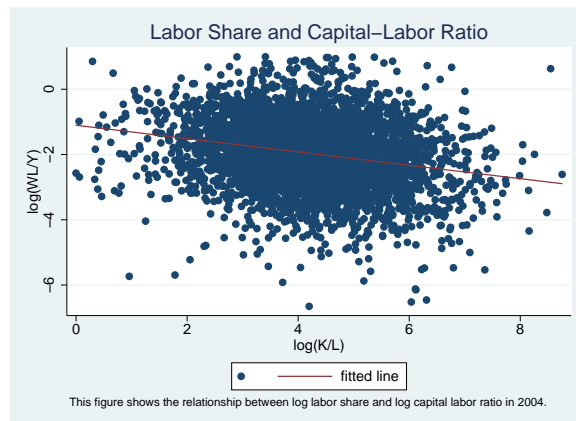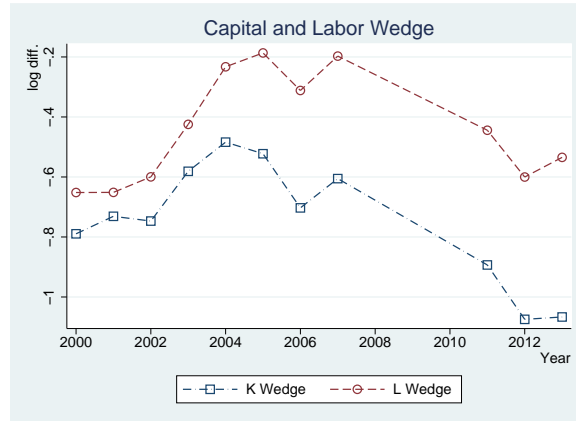
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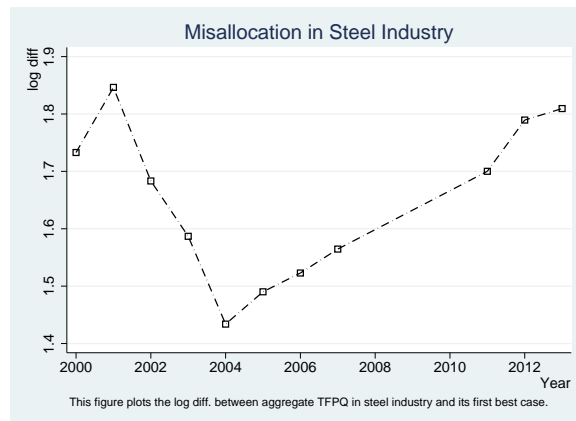Figure 14: Misallocation in Steel Industry
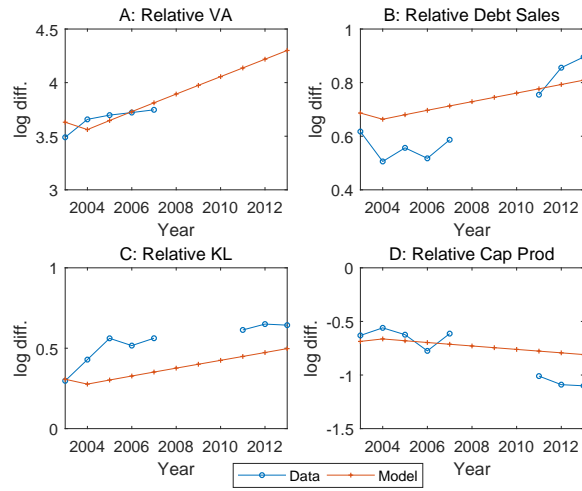
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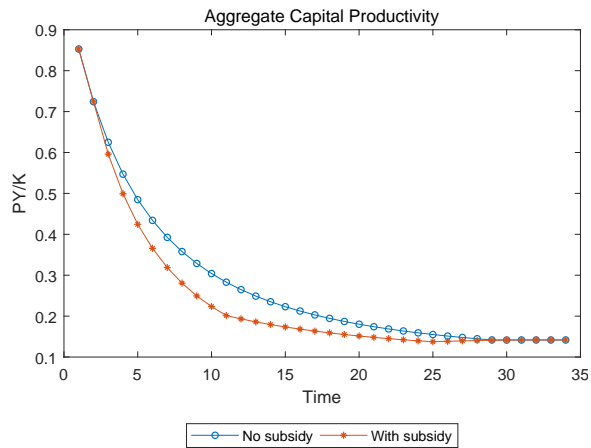Figure 16: Counterfactual of Capital Productivity

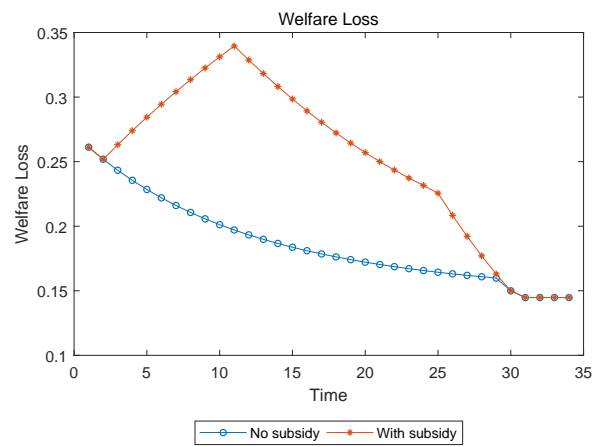Figure 17: Counterfactual of Aggregate Productivity
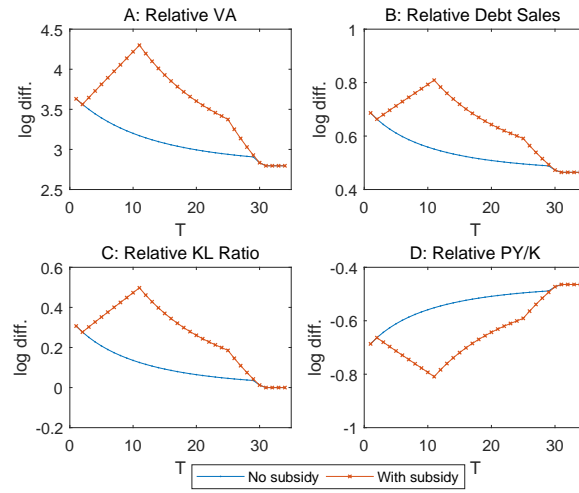
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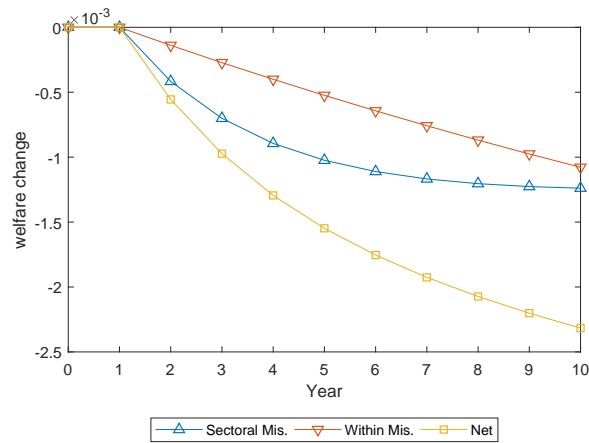
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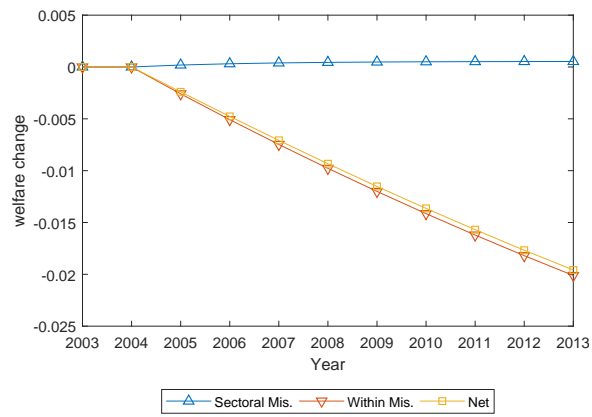
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Table 1: Parameters Used in Model Simulation

Parameter	α	η	β	$\mathbb{R}$	δ	W	θ	ϕ
Value	0.5	1.1	0.95	1.0526	0.1	1	5	0.2

Table 2: Import Share of Iron Ore by Type

| | Trader | | | | Manufacturer | | | |
| | Non-SOE | | SOE | | Non-SOE | | SOE | |
Year	Quantity	NO.	Quantity	NO.	Quantity	NO.	Quantity	NO.
2000	0.34	15	7.40	59	1.00	7	61.84	61
2001	1.35	31	8.90	70	4.74	11	87.22	61
2002	3.94	38	10.12	87	5.60	14	93.95	67
2003	9.46	83	11.07	93	8.34	19	121.93	73
2004	14.71	212	19.35	166	17.20	38	158.35	107
2005	19.10	176	26.35	117	30.77	36	199.82	118
2006	22.77	50	27.71	53	43.17	30	233.68	98
2007	27.94	42	33.25	47	55.47	31	266.17	89
2008	33.77	76	45.69	58	72.28	34	291.70	95
2009	65.27	67	94.99	44	109.02	32	358.34	93
2010	50.13	71	74.13	49	102.67	33	391.52	85
2011	59.29	92	107.28	63	117.81	42	401.63	96
2012	85.31	94	125.82	58	135.95	40	396.53	89
2013	146.41	356	118.42	101	150.27	53	403.72	107

Notes: The firm number is total number of subsidiaries. After 2005, there were 118 firm (group level) left. Among the non-SOE traders, 1/3 import was conducted by FOE. Although some firm conduct small value cross border trade is allowed, their import quantity is too small to affect the big picture. The quantity is measured at million ton.

Table 3: Share of Transaction by Type

Year	Contract Price Manufacturer	Contract Price Trader	Spot Market Price Manufacturer	Spot Market Price Trader
2000	84.29%	9.51%	5.14%	1.06%
2001	86.96%	7.78%	3.89%	1.36%
2002	80.95%	8.79%	8.36%	1.89%
2003	77.44%	8.84%	10.69%	3.03%
2004	75.41%	11.49%	9.40%	3.70%
2005	74.76%	12.76%	9.00%	3.48%
2006	74.95%	11.55%	9.79%	3.71%
2007	69.77%	10.59%	14.36%	5.29%
2008	72.32%	13.71%	9.93%	4.04%
2009	55.07%	18.40%	19.63%	6.90%
2010	69.07%	14.62%	10.93%	5.37%

Notes: The contract price after 2011 does not exist anymore. The large decrease of import share at contract in 2009 was caused by the negative price gap between sport market and contract price.

Table 4: Market Share in Resale Business

Year	Iron Ore Total	Iron Ore License Firm	Steel Products Total	Steel Products License Firm	Market Share Ore	Market Share Steel	Market Share Resale
2000	17583.98	11757.77	13146.00	9085.00	66.87%	69.11%	0.00%
2001	20479.82	15591.98	16067.61	11405.13	76.13%	70.98%	5.15%
2002	22236.66	16560.05	19251.59	14027.28	74.47%	72.86%	1.61%
2003	27351.28	20176.35	24108.01	16662.66	73.77%	69.12%	4.65%
2004	35535.20	24855.46	31975.72	20138.13	69.95%	62.98%	6.97%
2005	43162.00	30675.56	37771.14	24536.90	71.07%	64.96%	6.11%
2006	51840.47	36032.24	46893.36	29994.36	69.51%	63.96%	5.54%
2007	59151.44	41518.28	56560.87	35040.73	70.19%	61.95%	8.24%
2008	66383.81	48291.34	60460.29	36649.84	72.75%	60.62%	12.13%
2009	86645.45	58275.50	69405.40	41997.75	67.26%	60.51%	6.75%
2010	85607.72	61575.94	80276.58	49077.00	71.93%	61.13%	10.79%
2011	94634.79	64469.80	88619.57	53657.18	68.12%	60.55%	7.58%
2012	98582.55	67179.21	95577.83	55398.09	68.15%	57.96%	10.18%
2013	107758.68	69805.05	108200.54	57139.00	64.78%	52.81%	11.97%

This table calculate the share of iron ore control and output share of firms with license. The share before 2005 is calculated with firms license later. The difference is iron ore share and output share is the window for reselling iron ore by firms with license. The quantity is measured at million ton.

Table 5: Value of License

Year	Resale Quantity	Price Gap	Profit: Resale	OP: Total
2000	0.00			8463
2001	10.55			12103
2002	3.58			22073
2003	12.72	219.11	2787.19	50719
2004	24.76	483.45	11968.18	83188
2005	26.37	423.09	11155.50	70172
2006	28.74	264.01	7586.53	70958
2007	48.73	282.93	13786.36	125870
2008	80.51	419.23	33751.10	90640
2009	58.46	149.16	8719.30	-3703
2010	92.40	264.84	24470.65	62418
2011	71.71	191.30	13717.02	46460
2012	100.40	140.49	14104.38	-24257
2013	128.99	35.97	4640.27	-4119

Notes: The resale quantity is measured at million ton, price gap is measured at yuan and profit is measured at million yuan. In 2012 and 2013, all prices are spot market price. OP is total operational profit calculated from their financial statements in China Iron and Steel Yearbook.

Table 6: Estimation Results

Predetermined Parameters	Parameter		
Elasticity of Substitution between K and L	σ	1.5367	
Capital Share	α	0.6929	
Markup	η	1.1893	
Capital Adjustment Cost	ϕ	0.455	
Discount Factor	β	0.9606	
Lending Rate	R	1.0410	
Depreciation Rate	δ	0.10	
Moments		Data	Model
Capital Productivity		1.4506	1.4484
Debt Capital Ratio		0.6201	0.6188
Rel. Labor Productivity		-0.3959	-0.3526
Rel. Sales		3.4931	3.6315
Rel. Debt Sales Ratio		0.6278	0.6872
Rel. Capital Labor Ratio		0.3171	0.3345
Rel. Capital Productivity		-0.6322	-0.6872
Estimated Parameters	Parameter	Estimates	s.e.
Initial Capital	K_0	0.0157	0.0001
Financial Friction	ϕ	0.6197	0.0003
Existing Wedge Diff.	$1 - \tau^Y$	1.5909	0.0037
Productivity Diff.	$1 + \tau^A$	1.0671	0.0023

Appendices

A Institutional Background of Policy

A.1 Regime of Iron Ore Trade

Regime of iron ore trade can be divided into two periods. Between 1981 and 2011, iron ore was mainly traded under long-term contract with a yearly fixed price and spot market served as a supplementary. After 2011, iron ore was only traded under spot market price, which usually follows Platts index.

The first regime begins at April 1st 1981. It was initiated between Japanese steel producers and Australian mining companies. At that time, if a steel producer wants to purchase iron ore from mining company, these two sides need to first sign a long-term contract, which usually covers 10 to 20 years. In this contract, both parties get agreement on the quantity of iron ore traded in each fiscal year, and leave the price to be determined later. Price will be settled down in a price talk before the next fiscal year begins. This talk is held between giant steel producers and largest mining companies, focusing on change in FOB price of benchmark iron ore products. Buyers bargain with sellers individually and once an agreement is achieved between any two of them, all others will follow. If agreement is not achieved before 1st April, price in last fiscal year will keep running for another three months. If buyers and sellers cannot even make any progress during this period, the long term contracts will be terminated automatically. To sum up, main feature of this regime is that trade volume is predetermined and a yearly price is determined afterwards in price talk. When a price is achieved between any pair of buyer and seller, it will apply to all others in the market.

For example, Wuhan Steel Group signed a contract with RIO in August 2003, that RIO will sell 3 million ton iron ore to Wuhan Steel Group at contract price in the next following 20 years. Again, on September 2004, it signed 25-year contact with BHP, which confirmed a annual purchase of 3.5 million ton iron ore. [6] In August 2004, JFE signed a contract with BHP confirming a purchase of 15 million ton iron ore in following 11 years. In September 2004, JFE signed a 10-year contract with VALE that confirmed a 10 million ton annual purchase. In these contracts, only the length of supplying and quantity purchased are specified, but price is not. When buyer and seller need to decide iron ore price in fiscal year of 2006, which begins from April 1st 2006 and ends at March 30th 2007,

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[6]This news is from SASAC. http://www.sasac.gov.cn/n2588025/n2588124/c4007150/content.html

they will sit together in November 2005, and bargain on the magnitude of price change. The buyer side in Asian market are NSSM and JFE from Japan, POSCO from Koran and Baosteel from China. The seller side are BHP and RIO from Australia (FMG joins later) and VALE from Brazil. These firms sit together and decide price change on some benchmark products. Steel manufacturers bargain with mining companies individually, and once an agreement is achieved between any two of them, the price change will be applied to all products in all transactions between all the buyers and sellers. In the price talk of 2006 fiscal year, Baosteel (CISA) first achieved agreement with BHP that price will increase 19% for ore fines in next fiscal year. Once they announced this agreement, all other firms will accept this price change. To sum up, once price change is agreed between any two of the buyers and sellers, all others will follow. In China, Baosteel Group represented all Chinese buyers to participate in this bargaining since 2003.

Under this regime, long-term contract price mainly works for large buyers and sellers, covering the majority of transactions. Besides, there is still a spot market functioning during this period and captures the residuals. Under the regime with co-existence of contract price and spot market price, large steel producers usually planned their demand first, and fulfill their needs with long-term contract. If they need to use more iron ore, they turn to the spot market, but trade volume at spot price is much smaller. For the steel manufacturers who are too small to sign long term contract with those mining giants, they turn to the spot market.

This trade regime operated quite well from 1981 to 2008. In 2008, the rule was broken by RIO and Baosteel (CISA). Although the price change was agreed between NSSM and VALE on February, RIO managed to get a higher price increase with Baosteel for their transactions. The buyer and seller did not follow the first outcome determined in the price talk. In 2009, the rule was broken again. CISA announced that it was not satisfied with the price change agreed by RIO and NSSM, and chose not to accept the result. Since both sides were at odds with this regime, from March 2010, the price became quarterly determined, and then monthly determined in 2011. Meanwhile, transaction price was no longer FOB price but became CFR price in destination markets. Naturally, the second price regime began to operate. From 2011, long term contract on trade quantity is still valid, but the price is not discussed year by year. Instead, the mining companies adjust this price according to Platts index. The agency Platts mainly focuses the highest price a buyer willing to pay and lowest price a seller willing to offer, and formulate this price index day by day to reflect equilibrium price in spot market. Under this regime, all buyers face the same benchmark price. Whether steel producers can get discount on their purchase

will be determined between them and mining companies individually.

A.2 Compulsory Import Delegation

Variation in contract price was very small before 2003, which was just 5% on average across years and was no higher than 10% after 1990. However, the price changes agreed between steel producer and mining companies for 2004 and 2005 were 19.5% and 76%, which were much larger than usual. What's more, even Baosteel had participate in this price talk, it did not make any achievement in settling down price. Faced with situation, CISA decided to take some actions to deal with the skyrocketing price. It accused small traders in China that they weakened the bargaining power of Baosteel Group in price talk. Based on this argument, CISA introduced this compulsory import delegation regulation.

Endorsed by Bureau of Commerce, China Chamber of Commerce of Metals, Minerals & Chemicals Importers & Exporters (CCCMMC henceforth) and China Iron and Steel Association (CISA henceforth), jointly announced that from April 2005, only firms with import license can directly purchase iron ore from foreign countries and name list of privileged importers was finalized on 31st March. The red-tape, entitled with Qualifications of Iron Ore Trade Companies and Applying Process of Import License, set some criteria for firms who can directly import from foreign countries. Basically, the firms can be divided into two groups, large steel producers and large trading agencies. For steel producers, they need to produce at least 1 million ton of crude steel in 2004 in order to apply for this license. For trading companies, they should at least import 0.3 million ton of iron ore in 2004. Finally, 118 firms got the license to import and 70 of them are steel producers, who conducted 84% of iron ore import in China. The license was issued at group level. If one steel group got the license, it can import iron ore under the name of group, set up a special trading subsidiary to conduct the business or just let all its affiliations to do the import. Although this action seemed to be taken within a short period, its prelude was played in the first half of 2004. CISA published a news in July 2004 said that it arranged its small members to purchase iron ore through large firms. In this news, CISA claimed it was a great success that small firms got a favorable price and large firms changed a reasonable commission fee in resale business. Both sides benefited from it. With such a success in hand, CISA developed this baby version license system into a regulation putting on the whole steel industry.

Besides the restrictions on importers, CISA set a special department to handle the price bargaining, which was led by Baosteel Group and cooperated with other large steel

producers, such as Ansteel Group and Wuhan Steel Group. In the mind of government, if CISA becomes the largest importer in Asia, foreign mining companies will yield to its huge purchasing power and offer a better price. However, there too many small importers in the market and their behavior was had to control. Those small traders had to be cleared out of market in order to achieve such a big bargaining power.

This policy was ended in July 2013. Due to changes in trade regime in 2011 that mining companies were no longer sell iron ore at a yearly price but follow the spot market one, this policy lost its foundation and was eventually ceased.

A.3 Outcomes of Price Bargaining

Did Chinese government achieved its target? It's hard to say so.

On the one hand, Asian contract price was achieved only twice by Chinese firms with mining companies. Table 7 shows the result of price talk from 2000 to 2009, including the price change and firms achieving the agreement. On the surface, this policy made Chinese firms' opinion get respected immediately that in 2006 and 2007, price was achieved between CISA and mining companies. However, the price was still higher than the expectation of mining companies. In 2006, RIO and BHP only expect a 10% to 15% increase, while the outcome was a 19.5% increase. In 2008, the price talk between CISA and RIO was totally a failure. On February, an agreement was already achieved by NSSM/POSCO and VALE. But BHP and RIO from Australia were not satisfied with this outcome and insisted on setting a higher price for Chinese firms. Under this condition, CISA did not exhibit any of the bargaining power it has claimed and accepted an additional price increase proposed by RIO.

On the other hand, such price regime also works in European market, and I find that European contract price is same as the Asian one. Table 7 compares the price from 2000 to 2009. Except in 2000 and 2009, the change in European price is no different from Asian price. Moreover, the price change achieved in these two years has nothing to do with Chinese firms. If I consider the price outcome between mining companies and European buyers as the counterfactual, CISA's performance in 2006 and 2007 cannot be considered as a success. What's more, in 2008, the performance of CISA was a failure. To conclude, there is no evidence to show government has achieved its goal.

Table 7: Price Change in Asia and Europe

Year	Price Change: Asia	Buyer	Seller	Price Change: Europe	Buyer	Seller
2000	4.35%	NSSM	RIO	5.42%	USINOR	SINM
2001	4.30%	NSSM	RIO	4.30%	RIVA	VALE
2002	-2.40%	NSSM	BHP/RIO	-2.40%	TKS	VALE
2003	8.90%	NSSM	BHP/RIO	8.90%	ARCELOR	VALE
2004	18.60%	NSSM	RIO	18.60%	ARCELOR	VALE
2005	71.50%	NSSM	RIO	71.50%	ARCELOR	VALE
2006	19.00%	CISA	BHP	19.00%	TKS	VALE
2007	9.50%	CISA	VALE	9.50%	RIVA	VALE
2008	65.00%	POSCO/NSSM	VALE	65.00%	TKS	VALE
	79.88%	CISA	RIO			
2009	-33.00%	NSSM	RIO	-28.20%	ARCELOR	VALE

1. Price change in Asia and Europe were usually the same, regardless of whether CISA (Baosteel) has jointed or not.
2. In 2008, even the price has been achieved between NSSM and VALE, RIO achieved an even higher price between it and CISA.