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INDUSTRIAL POLICY AND COMPETITION

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ABSTRACT

Industrial Policy and Competition*

The economic slowdown in the 70s in Latin America and Japan in the late 90s, generated a growing skepticism about the role of industrial policy in the process of economic development. Yet, new considerations have emerged over the recent period, which invite us to revisit the issue. This paper argues that sectoral state aids tend to foster productivity, productivity growth, and product innovation to a larger extent when it targets more competitive sectors and when it is not concentrated on one or a small number of firms in the sector. Using a theoretical framework in which two firms may choose either to operate in the same "higher-growth" sector or in different, "lower-growth" sector. We use a panel of medium and large Chinese enterprises for the period 1998 through 2007 to test for complementarity between competition and industrial policy. A main implication from our analysis is that the debate on industrial policy should no longer be for or against having such a policy. As it turns out, sectoral policies are being implemented in one form or another by a large number of countries worldwide, starting with China. Rather, the issue should be on how to design and govern sectoral policies in order to make them more competition-friendly and therefore more growth-enhancing.

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Industrial Policy and Competition

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1 Introduction

In the aftermath of WWII, several developing countries opted for policies aimed at promoting new infant industries or at protecting local traditional activities from competition by products from more advanced countries. Thus several Latin American countries advocated import substitution policies, whereby local industries would more fully benefit from domestic demand. East Asian countries like Korea or Japan, rather than advocating import substitution policies, would favor export promotion, which in turn would be achieved partly through tariffs and non-tariff barriers and partly through maintaining undervalued exchange rates. For at least two or three decades after WWII, these policies, which belong to what is commonly referred to as “industrial policy,” remained fairly noncontroversial as both groups of countries were growing at fast rates.

However, the economic slowdown in the 70s in Latin America and Japan in the late 90s, generated a growing skepticism about the role of industrial policy in the process of economic development. On the empirical front, the debate was launched by Krueger and Tuncer (1982) who analyzed the effects of industrial policy in Turkey in the 60s, and “show” that firms or industries not protected by tariff measures were characterized by higher productivity in growth rates than protected industries.¹ On the theoretical front, the provision by domestic governments of subsidies or trade protection targeted to particular firms or industries, has come under disrepute among academics mainly on the ground that it prevents competition and allows governments to pick winners (and, more rarely, to name losers) in a discretionary fashion, thereby increasing the scope for capture of governments by vested interests. This argument appears to have won over traditional counteracting considerations, in particular those based upon the infant industry idea (e.g., see Greenwald and Stiglitz (2006)).² This disrepute has affected not only the selection and promotion of national champions – what

¹However, see Harrison (1994).

²For an overview of infant-industry models and empirical evidence, see Harrison and Rodriguez-Clare (2010). The infant-industry argument could be summarized as follows. Consider a local economy that includes both a traditional sector (especially agriculture) and an industry in its infancy. Production costs in industry are initially high, but “learning by doing” decrease these costs over time, even faster as the volume of activity in this area is high. In addition, increased productivity which is a consequence of this learning by doing phase has positive spillovers on the rest of the economy, ie it increases the potential rate of growth also

could be termed industrial policy in the narrow sense - but also any kind of public intervention going beyond horizontal supply-side policies with the aim to influence sectoral developments and the composition of aggregate output. a first argument against industrial policy and the infant industry argument, is that governments are not particularly good at picking winners, and providing them with an excuse to subsidize particular firms or sectors might end up favouring the emergence of industrial lobbies.

Yet, new considerations have emerged over the recent period, which invite us to revisit the issue. First, climate change and the increasing awareness of the fact that without government intervention aimed at encouraging clean production and clean innovation, global warming will intensify and generate negative externalities (droughts, deforestations, migrations, conflicts) worldwide. Beyond the pricing of this externality through cap-and-trade systems or carbon taxation, many governments have engaged in targeted intervention to encourage the development of alternative technologies in the production (e.g., from renewables) or the use (e.g. by efficient housing) of energy. Second, the recent financial crisis has prompted several governments, including the US, to provide support to particular industries (e.g., the automobile or green sectors). Also, an increasing number of scholars (in particular in the US) are denouncing the danger of laissez-faire policies that lead developed countries to specialize in upstream R&D and in services while outsourcing all manufacturing tasks to developing countries where unskilled labor costs are lower. They point to the fact that countries like Germany or Japan have better managed to maintain intermediate manufacturing segments through pursuing more active industrial policies, and that this in turn has allowed them to benefit more from outsourcing the other, less human capital-intensive segments.

In this paper we argue that the debate on industrial policy should no longer be “existential”, i.e., about whether sectoral policies should be precluded altogether or not, but rather on how such policies should be designed and governed so as to foster growth and welfare. Our focus is on the relationship between sectoral policy and product market competition. In the first part of the paper we develop a theoretical framework in which two firms may choose either to operate in the same “higher-growth” sector (we refer to this as the choice to *focus* on the same technology) or they may choose to operate in different sectors, including in “lower-growth” sectors in order to reduce the intensity of competition among them (we refer to this as the choice to *diversify*). When firms focus on the same high-growth sector they generate more innovation and growth for two reasons: first, because the size of innovations, and therefore the post-innovation rents, are higher in a higher-growth sector; second, because when the two firms choose to operate in the same sector they compete more intensely, which in turn

in the traditional sector. In this case, a total and instantaneous liberalization of international trade can be detrimental to the growth of the local economy, as it might inhibit the activity of the local industry whose production costs are initially high: what will happen in this case is that the local demand for industrial products will turn to foreign importers. It means that learning by doing in the local industry will be slowed itself, which will reduce the externalities of growth from this sector towards the traditional sector.

induces both firms to invest more in innovation in order to escape competition with the rival firm (see Aghion et al (2005)). The more intense competition within a sector, the more firms innovate if they operate in the same sector. At the same time, more intense competition within sectors may induce firms to choose diversity as an alternative way to avoid competition. This is where industrial policy comes into play: by inducing the two firms to operate in the same sector, the government induces firms to innovate “vertically” rather than differentiate “horizontally” in order to escape competition with the other firm. The more intense within-sector competition, the more growth-enhancing it is to induce both firms to operate in the same “high-growth” sector. In other words, there is a complementarity between product market competition and sectoral policy in fostering innovation and growth.

In the second part of the paper we test for the complementarity between competition and industrial policy. We use a panel of medium and large Chinese enterprises for the period 1998 through 2007. Our measures of industrial policy are: (1) subsidies, allocated at the firm level, and (2) trade tariffs, which are determined at the sector level. We measure competition in two ways: using industry-level Lerner indices, which capture the degree of markups over cost, and the extent to which industrial policies preserve or increase competition. We then look at the effect on productivity, productivity growth, and product innovation, of policies that preserve or increase competition through the sectoral dispersion of subsidies.

Our results suggest that if subsidies are allocated to competitive sectors (as measured by the Lerner index) and allocated in such a way as to preserve or increase competition, then the net impacts of subsidies on productivity, productivity growth, and product innovation measured by the share of new products in total sales, become positive and significant. In other words, targeting can have beneficial effects depending on both the degree of competition in the targeted sector as well as depending on how the targeting is done.

Most closely related to our analysis in this paper is Nunn and Trefler (2010). Using cross-country industry-level panel data, they analyze whether, as suggested by the argument of “infant industry”, the growth of productivity in a country is positively affected by the measure in which tariff protection is biased in favor of activities and sectors that are “skill-intensive”, that is to say, use more intensely skilled workers. They find a significant positive correlation between productivity growth and the “skill bias” due to tariff protection. As the authors point out though, such a correlation does not necessarily mean there is causality between skill-bias due to protection and productivity growth: the two variables may themselves be the result of a third factor, such as the quality of institutions in countries considered. However, Nunn and Trefler show that at least 25% of the correlation corresponds to a causal effect. Overall, their analysis suggests that adequately designed (here, skill-intensive) targeting may actually enhance growth, not only in the sector which is being subsidized, but in other sectors as well.³

³The issue remains whether industrial policy comes at the cost of a lowering of competition,

The paper is organized as follows. Section 2 presents our model of the complementarity between competition and sectoral policy. Section 3 presents the empirical analysis. Section 4 discusses endogeneity issues. Section 5 concludes.

2 Model

2.1 Basic setup

Demand. The model focuses on two technologies or goods, denoted by A and B . Denote the quantity consumed on each technology by x^A and x^B . The representative consumer has income $2E$ and utility $\log(x^A) + \log(x^B)$ when consuming x^A and x^B . This means that, if the price of good i is p^i , demand for good i will be $x^i = E/p^i$.

Supply. The production can be done by one of two ‘big’ firms 1, 2, or by ‘fringe firms’. Fringe firms act competitively and have a marginal cost of production of c_f while firms $j = 1, 2$ have an initial marginal cost of c . Marginal costs are firm-specific and are independent of the technology in which production is undertaken. Price competition is postulated.

We make the following assumption: $E > c_f \geq c$. The assumption $c_f \geq c$ reflects the cost advantage of firms 1, 2 with respect to the fringe and the assumption $E > c$ insures that equilibrium quantities can be greater than 1.

Innovation. For simplicity, we assume that only firms 1, 2 can innovate. Innovation can reduce the cost of production of these firms, but the cost reduction is different in the two technologies A and B. Without loss of generality, we assume technology A is the ‘better’ one, in that innovation leads the cost level to become $c/\gamma_A = c/(\gamma + \delta)$ while on technology B it becomes $c/\gamma_B = c/(\gamma - \delta)$; obviously, we assume $\gamma - \delta > 1$ or $\delta < \gamma - 1$.

In order to allow innovators to earn rents (and thus have an incentive to reduce costs), we make the simple assumption that, with equal probability, each firm can be chosen to be the potential innovator; it then chooses the probability q at cost $q^2/2$ with which cost reduction will be realized. This is like saying that each firm has an exogenous probability of getting a patentable idea, which then has to be turned into cost reduction thanks to effort exerted by the firm.

Within sector competition: Let φ be the probability that two firms in the same sector can collude when they have the same cost, and let us assume that when colluding each firm can achieve a price of c_f . In this case, the expected profit of a firm with cost $c < c_f$ is $\varphi \frac{1}{2} \frac{c_f - c}{c_f} E$ since when collusion fails firms compete Bertrand.

Laissez-faire/targeting. Finally, we assume that, while under laissez-faire, firms choose the technology on which they want to produce (A or B), a planner may impose (or induce via tax/subsidies) such technology choices. Laissez-faire

e.g., between high and low skill intensive sectors or within a high skill sector. As we show in this paper, industrial policy in the form of targeting may in fact take the form of enhancing competition in a sector and serves the dual role of increasing consumer surplus and growth (see Appendix A).

can lead to *diversification* (different technology choices by the two firms) or *focus* (same choice, be it A or B), while *targeting* is planner-enforced focus.

2.2 Informational assumptions

We restrict attention to the case where there is perfect information about γ_i . Under laissez-faire, firms will either choose diversity or focus. Under focus, both firms choose the better technology A . Under diversity, one firm (call it firm 1) chooses A and the other (call it firm 2) chooses B (this is a coordination game and which firm ends up with technology A is random). Diversity is stable if the firm ending up with technology B does not want switch to technology A ; if it does then we are back to a focus configuration.

We shall first compare between equilibrium innovation rates under diversity and under focus respectively. This will tell us about whether diversity or focus is growth-maximizing. Then, we shall derive conditions under which diversity arises under laissez-faire. We show for sufficiently high degree of competition within sectors, focus is always growth-maximizing whereas there exists $\delta^L > 0$ such that diversity is privately optimal if $\delta \leq \delta^L$. In the Appendix we compare the laissez-faire choice between diversity and focus with the social optimum.

At the end of this theory section, we shall also briefly discuss cases with imperfect information about γ_i . We shall consider two extreme cases, respectively when firms know which is the better technology but the planner does not, and when neither the firms nor the planner knows which technology is best.

2.3 Equilibrium profits and innovation intensities.

2.3.1 Diversity

Under diversity, firm 1 is on technology A and firm 2 is on technology B and both firms enjoy a cost advantage over their competitors. Let e denote the representative consumer's expense on technology A , p_1 the price charged by firm 1 and c_f the limit price imposed by the competitive fringe.

The representative consumer purchases x_1^A, x_f^A in order to maximize $\log(x_1^A + x_f^A)$ subject to $p_1 x_1^A + c_f x_f^A \leq e$. The solution leads to $x_1^A > 0$ only if $p_1 \leq c_f$. The consumer spends e and since firm 1's profit is $e - c_1 x_1^A$, firm 1 indeed chooses the highest price (hence the lowest quantity x_1^A) consistent with $p_1 \leq c_f$, that is $p_1 = c_f$. It follows that $x^A = x_1^A$ and therefore $x^A = e/c_f$.

The problem is symmetric on the other technology and since the representative consumer has total income $2E$ she will spend E on each technology, yielding $x^A = x^B = E/c_f$.

If the firm is not a potential innovator (which happens with probability $1/2$), its profit is therefore:

$$\pi^{D_0} = \frac{c_f - c}{c_f} E.$$

If the firm on technology i is chosen to be a potential innovator and chooses a probability q , it will get a profit margin of $c_f - \frac{c}{\gamma_i}$ if it innovates and a profit

margin of $c_f - c$ if it does not. Hence, the profit function conditional on being chosen to be a potential innovator is:

$$\pi = q \left(c_f - \frac{c}{\gamma_i} \right) x^i + (1 - q)(c_f - c)x^i - \frac{1}{2}q^2$$

or

$$\pi = q \frac{\gamma_i - 1}{\gamma_i} c x^i + (c_f - c)x^i - \frac{1}{2}q^2.$$

Using $x^A = E/c_f$, the optimal probability of innovation under diversity q_i^D and the corresponding ex ante equilibrium profit when chosen to be a potential innovator π_i^{D1} , are respectively given by:

$$q_i^D = \frac{\gamma_i - 1}{\gamma_i} \frac{c}{c_f} E$$

and

$$\pi_i^{D1} = \frac{1}{2} \left(\frac{\gamma_i - 1}{\gamma_i} \right)^2 \left(\frac{c}{c_f} \right)^2 E^2 + \frac{c_f - c}{c_f} E.$$

Therefore the expected profit of diversifying on technology i is $\frac{1}{2}(\pi^{D0} + \pi_i^{D1})$, or

$$\pi_i^D = \frac{1}{4} \left(\frac{\gamma_i - 1}{\gamma_i} \right)^2 \left(\frac{c}{c_f} \right)^2 E^2 + \frac{c_f - c}{c_f} E.$$

We shall denote by $\pi^D(\delta)$ the profit under diversity for the firm on technology A , that is, with cost reduction $\gamma_A = \gamma + \delta$, and by $\pi^D(-\delta)$ the profit under diversity for the firm on technology B , that is, with cost reduction $\gamma_B = \gamma - \delta$. Similarly, we denote by $q^D(\delta), q^D(-\delta)$ the innovation intensities under diversity for firms on the good technology A and the bad technology B respectively.

2.3.2 Focus

Consider first the case with full Bertrand competition within the same sector or technology (A or B). If the two large firms decide to locate on the same technology, it is optimal for them to choose the best technology, namely technology A . Now, the next best competitor for firm 1 is firm 2 rather than the fringe, so the price is always equal to c which is lower than c_f by assumption. Hence, in this case, $x^A = E/c$ while $x^B = E/c_f$ since the consumer buys from the fringe on technology B .

If firm 1 is chosen to be a potential innovator, its profit is:

$$\pi^{F1} = q \left(c - \frac{c}{\gamma + \delta} \right) \frac{E}{c} - \frac{1}{2}q^2.$$

Note that if the firm does not innovate its profit margin is zero since firms 1 and 2 have the same marginal cost. It follows that the optimal probability of innovation is

$$q^F = \frac{\gamma + \delta - 1}{\gamma + \delta} E.$$

If the firm is not chosen to be a potential innovator, its profit is zero since it has necessarily a (weakly) higher cost than its next best competitor. Hence the expected profit of each firm under focus is

$$\pi^F = \frac{1}{4} \left(\frac{\gamma + \delta - 1}{\gamma + \delta} \right)^2 E^2.$$

Now suppose that two firms with the same cost within the same sector, collude with probability φ and thereby sustain a price of c_f . In this case, the expected profit of firms with cost c is $\varphi \frac{1}{2} \frac{c_f - c}{c_f} E$ since when they do not succeed colluding they play a Bertrand game.

The expected profit of a firm called upon to innovate under focus, is equal to:

$$q \frac{\gamma + \delta - 1}{\gamma + \delta} E + (1 - q) \varphi \frac{1}{2} \frac{c_f - c}{c_f} E - \frac{1}{2} q^2$$

and therefore the profit maximizing degree of innovation is

$$q^F(\varphi) = \left(\frac{\gamma + \delta - 1}{\gamma + \delta} - \frac{\varphi}{2} \frac{c_f - c}{c_f} \right) E.$$

In particular, as φ decreases, that is as the competitiveness of the sector increases, innovation increases. This captures an "escape competition" effect: the more intense within-sector competition, the higher the firms' incentives to innovate to escape competition.

The corresponding ex ante equilibrium profit is given by:

$$\pi^F(\varphi) = \frac{1}{4} \left[\frac{\gamma + \delta - 1}{\gamma + \delta} - \frac{\varphi}{2} \frac{c_f - c}{c_f} \right]^2 E^2 + \frac{\varphi}{4} \frac{c_f - c}{c_f} E$$

2.4 Growth-maximizing choice between diversity and focus

Focus is the growth-maximizing strategy whenever

$$2q^F(\varphi) > q^D(\delta) + q^D(-\delta) = \left(\frac{\gamma + \delta - 1}{\gamma + \delta} + \frac{\gamma - \delta - 1}{\gamma - \delta} \right) \frac{c}{c_f} E.$$

This condition is more likely to be satisfied the lower φ , i.e., the more intense the degree of within-sector competition, and it always holds for φ sufficiently small.

2.5 Laissez-faire choice between diversity and focus

Despite the lower cost reduction from innovation for a firm that diversifies on technology B instead of competing with the other firm on technology A , the firm that diversifies on B may prefer to stick to this technology precisely because

diversity shields it from competition: even if it does not innovate, the diversified firm obtains a positive profit equal to $\pi^{D_0} > 0$.

Comparing the ex ante equilibrium profits $\pi^D(-\delta)$ and $\pi^F(\varphi)$ under diversity and focus for a firm initially diversified on the low technology B , diversity is an equilibrium outcome under laissez-faire whenever:

$$\left(\frac{c_f - c}{c_f}\right)\left(1 - \frac{\varphi}{4}\right) \geq \frac{1}{4}E \left[\left(\frac{\gamma + \delta - 1}{\gamma + \delta} - \frac{\varphi c_f - c}{2 c_f}\right)^2 - \left(\frac{\gamma - \delta - 1}{\gamma - \delta}\right)^2 \left(\frac{c}{c_f}\right)^2 \right]$$

where the LHS is the competitive benefit of diversity and the RHS the innovation disadvantage of technology B . The RHS is increasing in δ , and therefore there exists a maximum cutoff δ^L above which diversity cannot be an equilibrium outcome, leading to the following Proposition:

Proposition 1 *There exists a unique cutoff value δ^L such that diversity is chosen under laissez-faire if, and only if, $\delta \leq \delta^L$. This cutoff is decreasing in E and in φ .*

In particular, the lower φ , i.e., the more intense within-sector competition, the higher the cutoff δ^L , i.e., the higher firms' incentives to diversify. On the other hand, we have seen before that for sufficiently small φ focus is always growth maximizing, and the more so the lower φ . This in turn yields one of our main empirical predictions, namely that government intervention to induce several (in our model, two) firms instead of one firm to focus on the same activity, is more growth-enhancing the higher the degree of (ex post) within-sector product market competition. Our analysis also suggests that government intervention aimed at focusing on a particular sector, is more likely to be growth-enhancing if it preserves or increases competition, which, in our model, amounts to subsidizing entry on an equal footing between the two firms rather than providing a wedge to one firm (for example by subsidizing entry in sector A for only one firm, not the other).

3 Empirical analysis

3.1 Basic estimating equation

The theory presented so far suggests that targeting is more likely to be growth-enhancing when competition is more intense within a sector or when competition is preserved by sectoral policy. To test this theory, we need measures of targeting, competition, and outcomes. We propose to measure outcomes using a variety of measures: total factor productivity (TFP) in both levels and growth rates, and the share of new products in total sales. To capture targeting, we will primarily focus on the effects of subsidies given to individual firms, but we will also explore how the effects of tariffs vary with competition. Subsidies are allocated at the firm level, while tariffs are set on a sectoral basis. To measure

competition, we will calculate a Lerner index at the sector level, which is a measure of markups of prices over marginal cost.

The basic estimating equation will be the following:

$$\ln TFP_{ijt} = \beta_1 Z_{ijt} + \beta_2 S_{jt} + \beta_3 SUBSIDY_{ijt} + \beta_4 COMP_{jt} + \beta_5 SUBSIDY_{ijt} * COMP_{jt} + \alpha_i + \alpha_t + \epsilon_{ijt} \quad (1)$$

The vector Z includes a range of firm-level controls including state and foreign equity ownership at the firm level. The vector S includes sector-level controls, such as output and input tariffs, as well as sector-level foreign shares both within the same sector j as well as upstream and downstream. The specification above includes firm fixed effects α_i as well as time effects α_t . The question of critical interest for our framework is whether benefits from targeting, captured by our variable $SUBSIDY$, are positive when there is greater competition. If this is the case, then we would expect the coefficient on the interaction of subsidies and competition, β_5 , to be positive and significant.

3.2 Data and alternative estimation strategies

The dataset employed in this paper was collected by the Chinese National Bureau of Statistics. The Statistical Bureau conducts an annual survey of industrial plants, which includes manufacturing firms as well as firms that produce and supply electricity, gas, and water. It is firm-level based, including all state-owned enterprises (SOEs), regardless of size, and non-state-owned firms (non-SOEs) with annual sales of more than 5 million yuan. We use a ten-year unbalanced panel dataset, from 1998 to 2007. The number of firms per year varies from a low of 162,033 in 1999 to a high of 336,768 in 2007. The sampling strategy is the same throughout the sample period (all firms that are state-owned or have sales of more than 5 million yuan are selected into the sample).

The original dataset includes 2,226,104 observations and contains identifiers that can be used to track firms over time. Since the study focuses on manufacturing firms, we eliminate non-manufacturing observations. The sample size is further reduced by deleting missing values, as well as observations with negative or zero values for output, number of employees, capital, and the inputs, leaving a sample size of 1,842,786. Due to incompleteness of information on official output price indices, three sectors are dropped from the sample⁴. This reduces the sample size to 1,545,626.

The dataset contains information on output, fixed assets, total workforce, total wages, intermediate input costs, public ownership, foreign investment, Hong Kong-Taiwan-Macau investment, sales revenue, and export sales. Because domestically owned, foreign, and publicly owned enterprises behave quite differently, for this paper we restrict the sample to firms that have zero foreign

⁴They are the following sectors: processing food from agricultural products; printing, reproduction of recording media; and general purpose machinery.

ownership and are not classified as state owned enterprises. In the dataset, 1,072,034 observations meet the criterion.⁵

To control for the effects of trade policies, we have created a time series of tariffs, obtained from the World Integrated Trading Solution (WITS), maintained by the World Bank. We aggregated tariffs to the same level of aggregation as the foreign investment data, using output for 2003 as weights. We also created forward and backward tariffs, to correspond with our vertical FDI measures. During the sample period, average tariffs fell nearly 9 percentage points, which is a significant change over a short time period. While the average level of tariffs during this period, which spans the years before and after WTO accession, was nearly 13 percent, this average masks significant heterogeneity across sectors, with a high of 41 percent in grain mill products and a low of 4 percent in railroad equipment.

The earlier literature on production function estimation shows that the use of OLS is inappropriate when estimating productivity, since this method treats labor, capital and other input variables as exogenous. As Griliches and Mairesse (1995) argue, inputs should be considered endogenous since they are chosen by a firm based on its productivity. Firm-level fixed effects will not solve the problem, because time-varying productivity shocks can affect a firm's input decisions.

Using OLS will therefore bias the estimations of coefficients on the input variables. To solve the simultaneity problem in estimating a production function, we employ the procedure suggested by Olley and Pakes (1996) (henceforth OP), which uses investment as a proxy for unobserved productivity shocks. OP address the endogeneity problem as follows. Let us consider the following Cobb-Douglas production function in logs:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \epsilon_{it} \quad (2)$$

y_{it} , k_{it} , l_{it} , m_{it} represent log of output, capital, labor, and materials, respectively. ω_{it} is the productivity and ϵ_{it} is the error term (or a shock to productivity). The key difference between ω_{it} and ϵ_{it} is that ω_{it} affects firms' input demand while the latter does not. OP also make timing assumptions regarding the input variables. Labor and materials are free variables but capital is assumed to be a fixed factor and subject to an investment process. Specifically, at the beginning of every period, the investment level a firm decides together with the current capital value determines the capital stock at the beginning of the next period, i.e.

$$k_{it+1} = (1 - \sigma)k_{it} + i_{it} \quad (3)$$

⁵Actually, the international criterion used to distinguish domestic and foreign-invested firms is 10%, that is, the share of subscribed capital owned by foreign investors is equal to or less than 10%. In the earlier version of the paper, we tested whether the results are sensitive to using zero, 10%, and 25% foreign ownership. Our results show that between the zero and 10% thresholds, the magnitude and the significance levels of the estimated coefficients remain close, which makes us comfortable using the more restrictive sample of domestic firms for which the foreign capital share is zero. The results based on the 25% criterion exhibit small differences, but the results are generally robust to the choice of definition for foreign versus domestic ownership.

The key innovation of OP estimation is to use firms’ observable characteristics to model a monotonic function of a firm’s productivity. Since the investment decision depends on both productivity and capital, OP formulate investment as follows,

$$i_{it} = i_{it}(\omega_{it}, k_{it}) \quad (4)$$

Given that this investment function is strictly monotonic in ω_{it} , it can be inverted to obtain

$$\omega_{it} = f_t^{-1}(i_{it}, k_{it}) \quad (5)$$

Substituting this into the production function, we get the following,

$$\begin{aligned} y_{it} &= \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + f_t^{-1}(i_{it}, k_{it}) + \epsilon_{it} \\ &= \beta_l l_{it} + \beta_m m_{it} + \phi_t(i_{it}, k_{it}) + \epsilon_{it} \end{aligned} \quad (6)$$

In the first stage of OP estimation, the consistent estimates of coefficients on labor and materials as well as the estimate of a non-parametrical term (ϕ_t) are obtained. The second step of OP identifies the coefficient on capital through two important assumptions. One is the first-order Markov assumption of productivity, ω_{it} and the timing assumption about k_{it} . The first-order Markov assumption decomposes ω_{it} into its conditional expectation at time $t - 1$, $E[\omega_{it}|\omega_{it-1}]$, and a deviation from that expectation, ζ_{it} , which is often referred to the “innovation” component of the productivity measure. These two assumptions allow it to construct an orthogonal relationship between capital and the innovation component in productivity, which is used to identify the coefficient on capital.

The biggest disadvantage of applying the OP procedure is that many firms report zero or negative investment. To address this problem, we also explore the robustness of our results to using the Levinsohn Petrin (2003) approach. Both approaches involve a two-stage estimation procedure when using TFP as the dependent variable. The first step is to use OP or LP to obtain unbiased coefficients on input variables and then calculate TFP (as the residual from the production function). The second step is to regress TFP on firm-level controls, sector-level controls, and our targeting measures.

Moulton showed that in the case of regressions performed on micro units that also include aggregated market (in this case industry) variables, the standard errors from OLS will be underestimated. As Moulton demonstrated, failing to take account of this serious downward bias in the estimated errors results in spurious findings of the statistical significance for the aggregate variable of interest. To address this issue, the standard errors in the paper are clustered for all observations in the same industry.

3.3 Baseline results

We begin with the baseline estimates from (1). The critical parameter is the coefficient β_5 which indicates the impact of subsidies interacted with competition. Table 1 reports the coefficient estimates. The dependent variable is the log of TFP, using the OP method as outlined above. As indicated earlier, all

specifications include both time and firm fixed effects. We define subsidy as the ratio of subsidies received to industrial sales at the firm level. The subsidy variable is our measure of “targeting”, while our measure of industry-level competition is $1 - \text{the Lerner index}$. Summary statistics for all the variables, including sample means and standard deviations, are reported in Table 1 (Appendix B). The Lerner index is defined as the ratio of operating profits less capital costs to sales. We first aggregate operating profits, capital costs, and sales at the industry-level. Under perfect competition, there should be no excess profits above capital costs, so the Lerner Index should equal zero and the COMP measure should equal 1. A value of 1 indicates perfect competition while values below 1 suggest some degree of market power.

Columns (1) and (2) of Table 1 report the impact of subsidies on TFP, but do not take into account differences in competition across sectors. The association between subsidies and total factor productivity is negative and highly significant, indicating that subsidies are associated with a twenty percent poorer productivity performance. However, when we add an interaction between competition and subsidies, in columns (3) through (6), the interaction term is positive and significant. Evaluated at the sample means, the net impact of subsidies on TFP, taking into account both the negative impact of subsidies alone and the positive impact of subsidies interacted with competition, varies across specifications. In columns (5) and (7), the net impact of subsidies taking into account the beneficial effects of competition is still negative, but small. In columns (3) and (5), the net impact of subsidies when there is perfect competition is positive, but again the magnitudes are small.

If, however, subsidies are allocated to competitive sectors (as measured by the Lerner index) and allocated in such a way as to preserve or increase competition, then the net impact of subsidies becomes positive and significant. In other words, targeting can have beneficial effects depending on both the degree of competition in the sector as well as depending on how the targeting is done. We measure policies that preserve or increase competition through the sectoral dispersion of subsidies. To identify sectoral dispersion, we construct a Herfindahl index using the share of subsidies a firm receives relative to the total subsidies awarded to one industry. We define a measure of concentration, *Herf_subsidy*, where:

$$Herf_subsidy_{jt} = \sum_{i \in j} \left(\frac{Subsidy_{ijt}}{Sum_subsidy_{jt}} \right)^2 \quad (7)$$

As with standard Herfindahl indices, a smaller number indicates more dispersion of subsidies. In Table 2, we redo the specification from Table 1 but divide the sample into four groups based on the percentiles of the *Herf_subsidy*. Table 2 compares the results from the second quartile, where subsidies are more dispersed, with the fourth quartile, which represents sectors where subsidies are more concentrated on fewer enterprises. The results are quite different. The bottom panel of Table 2, which reports the results when subsidies are more concentrated, indicates that the impact of subsidies are negative even when there

is perfect competition in the sector. In column (6), for example, the sum of 6.238 and -6.338 is negative. The top panel of Table 2, however, indicates that the net impact of subsidies is positive when there is perfect competition. For example, the net impact of subsidies in columns (3) and (5) is positive, and the coefficients indicate that a one standard deviation increase in the level of subsidies would lead to an increase in productivity of .7 percentage points, using the coefficients in column (3).

Table 3 replaces the interaction of competition and subsidies with our measure of the dispersion of subsidies, which can be defined as the inverse of our *Herf_subsidy* term, or *InvSubsidyHerf*. To the extent that greater dispersion of subsidies within a sector induces greater focus by encouraging more firms to innovate within a specific sector, we would expect the coefficient on that variable to positively affect productivity. The results in Table 3 show that this is indeed the case. The coefficient on *InvSubsidyHerf* is positive and statistically significant. The coefficient estimates indicate that a one standard deviation increase in the variable leads to an increase in TFP of 1.4 percentage points.

While not reported here, the results presented in Tables 1 through 3 are qualitatively the same if we transform the equations into differences and estimate the impact of changes in competition and subsidies on TFP growth. It should not be surprising that the results are robust to taking first differences, as all the specifications in Tables 1 through 3 include firm and year fixed effects. Next, in Tables 4 and 5, we replace TFP as our performance measure with an alternative measure of innovation. We identify as our new measure the share of a firm's output value generated by new products. This new product ratio, which we define as "*Ratio_newproduct*", is an alternative proxy for innovation by the firm.

In Table 4, we report the results for all observations, with the dependent variable *Ratio_newproduct*. Competition as measured by the Lerner index is significantly and positively associated with the share of new products in total sales, and the subsidy is associated with a negative but insignificant impact on new products. The interaction term is insignificant across all specifications. Without taking into account targeting policies that preserve or enhance competition (which we measure using the dispersion of subsidies), the net impact of subsidies on the share of new products even in a competitive environment is not statistically significant.

In Table 5, we separate the sample according to the dispersion of subsidies. As we saw in Table 2, the positive effects of subsidies are only apparent when there is both significant competition and significant dispersion, as proxied by the inverse of the subsidy herf. The second quartile, which indicates greater dispersion of subsidies, shows that while subsidies alone are associated with either insignificant or negative effects on the share of new products in sales, when coupled with greater competition the impact is positive and significant. The net impact of subsidies when there is significant competition, as indicated by the coefficients in column (6), suggest that a one standard deviation increase in subsidies is associated with a small net increase in the share of new products in sales. However, in the fourth quartile, where subsidies are concentrated on

very few firms, there is no significant positive impact of subsidies on new product sales even when there is perfect competition.

The results in Tables 1 through 5 together indicate that innovation, as measured by either total factor productivity or the share of new products in total sales, is increasing with subsidies only when two conditions hold. First, there must be sufficiently high competition, as measured by $[1 - \text{Lerner index}]$. Second, how the promotion is done is equally important: promotion tools must be sufficiently widespread across many firms.

One issue which could be raised is the potential endogeneity of targeting. What if targeting is applied to firms already likely to succeed? Conversely, what if targeting is only for firms likely to fail, and is in fact a bailout or soft budget constraint masquerading as industrial policy? In the former case, we are likely to over-state the benefits of industrial policy, while in the latter case we are likely to under-estimate them. In the next section, we propose one approach to address potential endogeneity.

3.4 Addressing endogeneity: an alternative specification

In this part, we propose an alternative approach to understanding the importance of competition and focus in making industrial policy work. In particular, we test whether a pattern of subsidies focused on more competitive sectors, using the pattern of competition across different industrial sectors at the beginning of the sample period, explains differential success of industrial policies. We then introduce an alternative targeting measure, tariffs, which address some of the endogeneity concerns at the firm level because they are set nationally.

We begin by measuring the pattern of subsidies at the city-year level, employing one method developed in Nunn and Trefler (2010). To test whether subsidies are more effective when introduced in a competitive setting, we propose to measure the correlation of subsidies with competition and then see whether the strength of that correlation raises firm performance. To measure whether subsidies are biased towards more competitive sectors in city r in year t , we calculate the correlation between the industry-city level initial degree of competition and current period t subsidies in sector j and city r :

$$\Omega_{rt} = \text{Corr}(SUBSIDY_{rjt}, COMPETITION_{rj0}) \quad (8)$$

Since subsidies vary over time, we have a time-varying change in the correlation between initial levels of competition and the patterns of interventions. We then explore whether higher correlations between subsidies and competition, as measured by Ω_{rt} , were associated with better performance. Total factor productivity is computed using four methods: AW et al 2001 (AW), OLS, OLS with fixed effects, and Olley & Pakes 1996 (OP). The firm-level estimation equation is as follows:

$$\ln TFP_{ijrt} = \alpha_0 + \alpha_1 \Omega_{rt} + \alpha_2 SUBSIDY_{ij,t-1} + \alpha_3 X_{ijrt} + \alpha_i + \alpha_t + \epsilon_{ijt} \quad (9)$$

TFP_{ijrt} is the total factor productivity for firm i in industry j located in city r in year t . $SUBSIDY_{ij,t-1}$ is the level of subsidy for firm i in sector j and

region r in year $t - 1$. X_{ijrt} includes firm level controls such as the share of the firms' total equity owned by the state, etc. f_i is firm fixed effects and D_t represents year dummies.

To check the impact of targeting on industry level performance, which takes into account both within-firm changes in behavior as well as reallocation across firms, we also compute aggregate industry productivity measures for each city every year and estimate the following equation:

$$\ln TFP_{jrt} = \alpha_0 + \alpha_1 \Omega_{rt} + \alpha_2 SUBSIDY_{jt-1} + \alpha_3 X_{jrt} + \alpha_i + \alpha_t + \epsilon_{ijt} \quad (10)$$

In a given city and year the aggregate industry productivity measure $\ln TFP_{jrt}$ is a weighted average of the firm's individual un-weighted productivities $\ln TFP_{ijrt}$ with an individual firm's weight s_{it} corresponding to its output's share in total industry output in a particular year and city:

$$\ln TFP_{jrt} = \sum_i s_{it} \ln TFP_{ijrt} \quad (11)$$

In the industry-level equation, X_{jrt} includes industry-city level controls, η_j and h_r are industry fixed effects and region dummies, respectively, and D_t includes year dummies.

The coefficient on the subsidy term captures the own firm or own industry effect of the policy on total factor productivity. The coefficient on the correlation coefficient between subsidies and competition indicates the beneficial effect of targeting, at the city level, when such targeting via subsidies is higher in competitive industries, as measured by the initial degree of competition at the beginning of the sample period.

Table 6 presents results for estimation equation (9). Columns (1) to (3) show firm-level estimation results using OLS, OLS with firm fixed effects, and OLS when TFP is calculated using the Olley-Pakes approach. All specifications include year and firm fixed effects. These results show that while the individual effects of subsidies at the firm level is associated with a negative impact on TFP, a positive correlation coefficient between the pattern of subsidization and competition is associated with a positive and significant impact on firm productivity. The coefficient estimate in column (3), .072, indicates that if the correlation between subsidies and competition at the city level was perfect (100 percent), then productivity would be 7.2 percent higher. Based on the sample means, a one standard deviation increase in the city-industry correlation would increase TFP by 0.6 percentage points for firms in that city and industry.

Table 7 separates the sample by the dispersion of subsidies, using the Herf-subsidy variable defined earlier. The impact of subsidies in the second quartile (when subsidies are more dispersed) are reported in in the top panel of Table 7 and the impact in the fourth quartile (when subsidies are more concentrated) is reported in the bottom panel. In the top panel, the coefficient on the correlation between subsidies and competition is positive, significant, and twice the size of the coefficient in Table 6. The coefficient estimate, at 0.145 in the third column, indicates that perfect correlation between subsidies given and competition levels

would increase productivity by 14.5 percentage points. The coefficient on subsidies alone, while still negative, is barely significant at conventional levels. The net impact of a one standard deviation increase in subsidies and the correlation variable would lead to a net increase in productivity of 1.2 percentage points. In contrast, the bottom panel of Table 7 shows no significant positive effects of the correlation measure. The results in Table 7 indicate that when subsidies are not sufficiently disbursed across firms, then subsidies do not positively affect productivity even when subsidies are higher in more competitive sectors. These results confirm the earlier results in Tables 1 and 2 suggesting that both competition and focus are necessary to promote industrial performance.

Tables 8 and 9 repeat the specifications reported in Tables 6 and 7 but estimate (10) instead, where the firm-level measure of the log of total factor productivity is replaced with the share-weighted industry-level measure as defined above. The results are comparable at the industry level to those at the firm-level, indicating that the benefits of industrial policy when there is competition and focus survive at the aggregate level.

Another approach to addressing the endogeneity of subsidies is to redo the analysis using an instrument of industrial policy which does not vary across firms. One such instrument is tariffs, which protect all firms in a particular sector. Consequently, we redid the estimation, but replaced subsidies with tariffs and replaced the correlation between initial competition and subsidies with the correlation between initial competition and current period tariffs. At the city level, the correlation between that city's degree of competition at the beginning of the sample period and current period tariffs should be strictly exogenous, as the level of competition is predetermined and tariffs are set at the national, not the city, level. Our new correlation measure is now defined as:

$$\Omega_{rt} = \text{Corr}(\text{TARIFF}_{jt}, \text{COMPETITION}_{rj0}) \quad (12)$$

The results are reported in Tables 10 and 11. In Table 10, the coefficient on the correlation measure defined in (12) is positive and statistically significant across all specifications. The coefficient, which ranges from .0722 to .0833, indicates that a perfect (100 percent) correlation between higher tariff levels in sector j and time t and the degree of competition in region r , sector j and the initial year would lead to an increase in productivity of 7 to 8 percentage points. However, the independent effect of tariffs on productivity is negative and significant, as indicated by the coefficient on $\ln\text{Tariff_lag}$. Evaluated using a one standard deviation increase in both variables from Appendix Table 1, the net impact of an increase in tariffs is likely to be negative. In Table 11, we repeat the analysis using industry-level variables, which takes into account not only within firm changes in productivity but productivity gains or losses from reallocating market shares across firms. The results are qualitatively similar, but the negative impact of tariffs on productivity are stronger and larger in magnitude. Unless the targeting of tariffs is significantly stronger, with a higher correlation between the degree of competition in a sector and sectoral tariff levels, the negative impact of tariffs (possibly due to their anti-competitive

effect) is likely to predominate. This is in contrast to subsidies, which the results indicate do have a net positive effect when we take into account the positive impact of targeting more competitive sectors.

Future extensions will further explore alternative ways to address the potential endogeneity of firms targeted for industrial policy. In particular, we have recently purchased a dataset on roads in China over time and across provinces to use as a potential instrument for our measures of competition.

4 Conclusion

In this paper we have argued that sectoral state aids tend to foster productivity, productivity growth, and product innovation to a larger extent when it targets more competitive sectors and when it is not concentrated on one or a small number of firms in the sector. A main implication from our analysis is that the debate on industrial policy should no longer be for or against having such a policy. As it turns out, sectoral policies are being implemented in one form or another by a large number of countries worldwide, starting with China. Rather, the issue should be on how to design and govern sectoral policies in order to make them more competition-friendly and therefore more growth-enhancing. While our analysis suggests that proper selection criteria together with good guidelines for governing sectoral support, can make a significant difference in terms of growth and innovation performance, yet the issue remains of how to minimize the scope for influence activities by sectoral interests when a sectoral state aid policy is to be implemented. One answer is that the less concentrated and more competition-compatible the allocation of state aid to a sector, the less firms in that sector will lobby for that aid as they will anticipate lower profits from it. In other words, political economy considerations should reinforce the interaction between competition and the efficiency of sectoral state aid. A comprehensive analysis of the optimal governance of sectoral policies still awaits further research.

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A Appendix: Theory

A.1 Social Optimum

In this first part of the Appendix we assume full Bertrand competition within sectors, and then compare the laissez-faire choice between diversity and focus with the choice that maximizes social welfare, not just innovation intensity and growth.

Suppose that a social planner could impose targeting on a single technology, i.e., force the two firms to focus on that same technology. The benefit of society from targeting on technology A is to provide a larger cost decrease from production and also a lower price for consumers. Hence targeting is necessarily

socially beneficial as far as technology A is concerned. However, as far as technology B is concerned, targeting on technology A is harmful: on the one hand, consumers have the same surplus with or without the presence of one of the big firms since anyway they consume $x^B = E/c_f$ at price c_f ; on the other hand, the good is provided at a higher marginal cost (net of the cost of innovation) than under diversity.

On technology B , consumers have the same total surplus of $\log(E/c_f) - E$ but the good is provided at cost $c_f E/c_f = E$ while the cost of provision under diversity, denoted by $C_B^D(\delta)$, is obviously the revenue of the firm, E , minus its profit, $\pi_B^D(\delta)$. Hence targeting leads a loss of $\pi_B^D(\delta)$ on technology B .

On technology A , consumers gain a surplus of $\log(E/c) - \log(E/c_f) = \log(c_f) - \log(c)$, which is a direct effect of increased product market competition. Moreover there is also a change in the total cost of production. Indeed, with diversity the cost of production, denoted by $C_A^D(\delta)$, is $E - \pi_A^D(\delta)$, while with focus the total cost is revenue E minus twice the expected profit of each firm, that is, $E - 2\pi^F(\delta)$. Hence targeting yields a gain of $\log(c_f) - \log(c) + 2\pi^F(\delta) - \pi_A^D(\delta)$.

Consequently, targeting is socially beneficial when:

$$\log(c_f) - \log(c) \geq \pi_A^D(\delta) + \pi_B^D(\delta) - 2\pi^F(\delta).$$

Let us denote $\Delta(\delta) \equiv \pi_A^D(\delta) + \pi_B^D(\delta) - 2\pi^F(\delta)$. From the previous section, we know that $\Delta(\delta^L) > 0$: firm 2 is indifferent between diversity and targeting but firm 1 strictly prefers diversity to targeting. Under diversity and focus, the price to consumers on island B is equal to c but with focus there is a higher probability that firms have lower costs and because total welfare is decreasing in price, it is the case that the above condition holds at δ^L .

We show now that $\Delta(\delta)$ is a decreasing function of δ implying the existence of a cutoff $\delta^S < \delta^L$ such that social welfare is greater under focus if and only if $\geq \delta^S$.

Indeed, letting $g_+ \equiv \frac{\gamma+\delta-1}{\gamma+\delta}$ and $g_- \equiv \frac{\gamma-\delta-1}{\gamma-\delta}$ Direct differentiation yields

$$\Delta'(\delta) \propto \frac{2}{(\gamma+\delta)^2} g_+ \left[\left(\frac{c}{c_f} \right)^2 - 2 \right] - \frac{2}{(\gamma-\delta)^2} g_- \left(\frac{c}{c_f} \right)^2$$

which is negative since $c < c_f$.

Note that we can have $\delta^S > 0$ only if targeting is *not* socially beneficial at $\delta = 0$, that is when:

$$\begin{aligned} \log(c_f) - \log(c) &< 2 \frac{c_f - c}{c_f} E + \frac{1}{2} \left(\frac{\gamma - 1}{\gamma} \right)^2 \left(\left(\frac{c}{c_f} \right)^2 - 1 \right) E^2 \\ &= \frac{c_f - c}{c_f} E \left\{ 2 - \frac{1}{2} \frac{c_f + c}{c_f} \left(\frac{\gamma - 1}{\gamma} \right)^2 E \right\}. \end{aligned}$$

By the intermediate value theorem, there exists $\tilde{c} \in (c, c_f)$ such that $\log(c_f) - \log(c) = (c_f - c)/\tilde{c}$. Let $g \equiv (\gamma - 1)/\gamma$ be the cost improvement when $\delta = 0$.

The condition becomes:

$$\frac{1}{2} \frac{c_f + c}{c_f} g^2 E^2 - 2E + \frac{c_f}{\tilde{c}} < 0. \quad (13)$$

The discriminant of the quadratic is $1 - (c_f + c)g^2/(2\tilde{c}) < 0$. Therefore, if $g^2 > \tilde{c}/(c_f + c)$ there is no real root, and $\delta^S = 0$. However if $g^2 < \tilde{c}/(c_f + c)$, there exist two roots for the quadratic equation.⁶

For instance, if $\gamma = 1$, there is no cost improvement ($g = 0$) and the condition is that $E \in [0, 2c_f/(c_f + c)]$; if $g^2 = \tilde{c}/(c_f + c)$, the condition cannot be satisfied for any value of E . We summarize our findings in the following proposition.

Proposition 2 *1. There exists $\delta^S < \delta^L$ such that targeting is socially optimal if, and only if, δ is greater than δ^S .*

2. Letting $g = \frac{\gamma-1}{\gamma}$, $\delta^S = 0$ when $g^2 \geq \frac{1}{2} \frac{\tilde{c}}{c_f+c}$.

3. When $g^2 < \frac{\tilde{c}}{c_f+c}$, there exist E_0, E_1 with $E_0 < E_1$ such that $\delta^S > 0$ only if the market size $E \in [E_0, E_1]$; for $E < E_0$ or $E > E_1$, $\delta^S = 0$

These results are quite intuitive. First, ceteris paribus, for small values of δ , targeting has a low social benefit (in terms of higher competition and innovation) relative to the cost reduction on technology B achieved thanks to diversity. There may however be room for a targeting policy for higher δ 's: the desire to relax price competition by choosing diversity leads the big firms not to focus enough.

Second, with perfect information, (innovation-reducing) diversity is welfare-decreasing if γ , and thus the potential cost decrease from innovation, is high enough. In this case, laissez-faire conflicts with social optimal for all values of δ less than δ^L , and we can 'safely' go for targeting: it is either welfare-increasing (for $\delta < \delta^L$) or irrelevant (for $\delta \geq \delta^L$).

Third, for smaller values of γ , there exists an intermediate region for market size E , where diversity may be socially optimal for some values of δ . If market size (E) is large, targeting is desirable.

A.2 Imperfect Information

Our assumption of perfect information is obviously extreme. Below we consider two possibilities. One where the firms know the technology on which the cost reduction possibilities are greater but the planner does not. The other case is where neither the firms nor the planner know the identity of the technology with the greater cost reduction. It turns out that the first case is equivalent to the case of perfect information if the planner can use mechanisms. For the second case, the laissez-faire outcome looks very different from the one under perfect information since it is now for high values of δ that diversity emerges.

⁶The roots are $E_0 = 2c_f \frac{1 - \sqrt{1 - \frac{c_f+c}{2\tilde{c}}g^2}}{c_f+c}$, $E_1 = 2c_f \frac{1 + \sqrt{1 + \frac{c_f+c}{2\tilde{c}}g^2}}{c_f+c}$.

The possibility of conflict between the firms and the planner are still present and there is value for a targeting policy.

A.2.1 Only the planner has imperfect information

If the planner has imperfect information about the identity of the technology leading to higher cost reduction but the firms (or at least one of them) have perfect information, as long as δ is known by the planner, the perfect information outcome can be replicated.

For $\delta \geq \delta^S$, letting the firm diversify is socially optimal and the planner will not intervene. When $\delta < \delta^S$, the planner would like to impose targeting *on the better technology*, but it does not know which one it is. However, conditional on being obliged to focus, firms 1 and 2 prefer to do it on the better technology, so that a planner can simply impose targeting to firms 1, 2 and let them locate subject to this constraint.

If in addition the planner does not have information about the value of δ , since the parties have correlated information revelation mechanisms can be used to extract this information from the parties. The design of the optimal mechanism is beyond the scope of this paper however.

A.2.2 All parties have imperfect information

When neither the firms nor the planner have information about which technology leads to the higher cost reduction under innovation, there may be a coordination failure both under laissez-faire and under intervention.

We consider the case where firms locate without knowing whether the market they have chosen allows for a cost reduction of $\gamma + \delta$ or $\gamma - \delta$ but, upon being called to innovate, they learn which cost reduction can be generated. This interpretation facilitates comparison with the perfect-information case.

Assume first diversity. Then total industry profit is the same as before since firms make the same decisions when they are chosen to innovate.

Under focus, since at the time technology is chosen firms do not know which is the better one, focus yields with probability 1/2 the level of profit $\pi^F(\delta)$ and with probability 1/2 the same level of profit but with $\gamma + \delta$ replaced by $\gamma - \delta$, that is, $\frac{1}{2}(\pi^F(\delta) + \pi^F(-\delta))$.

By revealed preferences in the perfect information case, we have $\pi^D(\delta) > \pi^F(\delta)$ since a firm under diversity could have chosen to set the same price and use the same innovation intensity as under focus. A similar argument shows that $\pi^D(-\delta) > \pi^F(-\delta)$, therefore:

$$(\pi^D(\delta) + \pi^D(-\delta))/2 > (\pi^F(\delta) + \pi^F(-\delta))/2$$

and firms prefer to diversify rather than to focus for any value of δ .

Proposition A1 *Under imperfect information, the laissez-faire outcome is for firms to diversify for any value of δ and γ .*

Let us now turn to intervention. Diversity brings the same social value as under perfect information. With targeting on the good technology, the social benefit is the same as under perfect information; but the social benefit is much lower than under perfect information with targeting on the bad technology. When there is focus, the total cost is in fact $\frac{1}{2}(2E - \pi^F(\delta) - \pi^F(-\delta))$ and therefore targeting is socially optimal when:

$$\log(c_f) - \log(c) \geq \pi^D(\delta) + \pi^D(-\delta) - (\pi^F(\delta) + \pi^F(-\delta)).$$

The RHS is the difference in industry profit between diversity and focus, which is positive by Proposition A1. Using the expressions for the profit functions, we have:

$$\begin{aligned} & \pi^D(\delta) + \pi^D(-\delta) - (\pi^F(\delta) + \pi^F(-\delta)) \\ &= \frac{1}{4} \left[\left(\frac{\gamma + \delta - 1}{\gamma + \delta} \right)^2 + \left(\frac{\gamma - \delta - 1}{\gamma - \delta} \right)^2 \right] \left(\left(\frac{c}{c_f} \right)^2 - 1 \right) E^2 + 2 \frac{c_f - c}{c_f} E. \end{aligned}$$

We know from the derivations in section 2.4 that the term in brackets is decreasing in δ ; since $c < c_f$, the coefficient of E^2 is negative and therefore the expression is *increasing* in δ . This is in sharp contrast with the perfect information case since the difference in industry profit between diversity and focus was *decreasing* in δ . In the perfect information case, focusing on the “good” technology led to a decreasing opportunity cost since as δ increases the value of being located on the “bad” technology sector decreases. With imperfect information though, focusing makes it as likely to be on competition in the “good” or in the “bad” sector; since conditional on being on one sector firms prefer not to face competition as δ increases, firms value more diversity.

A necessary condition for targeting to be socially optimal is that $\log(c_f) - \log(c)$ be greater than the minimum difference in profits, which arises at $\delta = 0$, which is the case where both technologies yield the same cost reduction in the case of innovation. Using the same reasoning as in the perfect information case for deriving condition (13), if \tilde{c} solves $\log(c_f) - \log(c) = (c_f - c)/\tilde{c}$ the necessary condition can be written when $\delta = 0$ as (recall that $g \equiv (\gamma - 1)/\gamma$):

$$\frac{c_f + c}{c_f} g^2 E^2 - 2E + \frac{c_f}{\tilde{c}} > 0$$

which is (obviously) the same condition as under perfect information. Therefore when g^2 is larger than $\tilde{c}/(c_f + c)$, targeting is optimal when $\delta = 0$ and when g^2 is smaller than this value, targeting is optimal when E is smaller than the root E_0 or is larger than the root E_1 .

If focus is optimal at $\delta = 0$, by continuity there exists $\delta^* > 0$ such that focus is socially optimal for all δ less than δ^* .

Proposition A2 1. If $g^2 > \frac{\tilde{c}}{c_f + c}$, there exists $\delta^* > 0$ such that targeting is socially optimal for all $\delta < \delta^*$.

2. If $g^2 < \frac{\tilde{c}}{c_f + c}$, and $E < E_0$ or $E > E_1$, there exists $\delta^{**} > 0$ such that targeting is socially optimal for all $\delta < \delta^{**}$.

3. If $g^2 < \frac{\bar{c}}{c_f + c}$, and $E \in [E_0, E_1]$ targeting is not an optimal policy for all values of δ .

Because targeting under imperfect information yields a smaller surplus than under perfect information while diversity brings the same benefit, it must be the case that focus is less often socially optimal, and therefore δ^* is strictly smaller than the cutoff δ^S in Proposition 2.

Finally, one can show that $\delta^* > \delta^{**}$, so that, as in the perfect information case, the range of δ 's for which targeting is socially optimal, is bigger when the growth rate g is high than when it is low. To prove that claim, it suffices to note that if:

$$\Delta\Pi = \pi^D(\delta) + \pi^D(-\delta) - (\pi^F(\delta) + \pi^F(-\delta)),$$

we have:

$$\frac{\partial\Delta\Pi}{\partial\delta} > 0; \frac{\partial\Delta\Pi}{\partial\gamma} < 0.$$

To see this, note that:

$$\begin{aligned} \Delta\Pi &\approx - \left[\left(\frac{\gamma + \delta - 1}{\gamma + \delta} \right)^2 + \left(\frac{\gamma - \delta - 1}{\gamma - \delta} \right)^2 \right] \\ &\equiv -F(\delta, \gamma), \end{aligned}$$

where:

$$\frac{\partial F}{\partial\delta} = \frac{1}{(\gamma + \delta)^2} - \frac{1}{(\gamma + \delta)^3} - \frac{1}{(\gamma - \delta)^2} + \frac{1}{(\gamma + \delta)^3} < 0$$

and:

$$\frac{\partial F}{\partial\gamma} = \left(1 - \frac{1}{\gamma + \delta}\right) \frac{1}{(\gamma + \delta)^2} + \left(1 - \frac{1}{\gamma - \delta}\right) \frac{1}{(\gamma - \delta)^2} > 0.$$

A.3 Growth and dynamic welfare under focus versus diversity

Consider a dynamic extension of the model where the social planner seeks to maximize intertemporal utility

$$U = \sum_{t=1}^{\infty} (1+r)^{-t} [\log x_t^A + \log x_t^B],$$

although private consumers and entrepreneurs live for one period only. Moreover, assume that, due to knowledge spillovers, after one period all firms multiply their initial productivity by the same $\tilde{\gamma} \in \{\gamma + \delta, \gamma - \delta\}$ as the innovative firm. Then a social planner who wants to maximize intertemporal utility, will take into account not only the static welfare analyzed above, but also the average growth rates respectively under diversity and under focus.

The growth rates of utility under diversity and focus, are respectively given by:

$$G^D = \left[\frac{1}{2} \left(1 - \frac{1}{\gamma + \delta} \right) \log(\gamma + \delta) + \frac{1}{2} \left(1 - \frac{1}{\gamma - \delta} \right) \log(\gamma - \delta) \right] \frac{c}{c_f} E$$

and

$$G^F = \left(1 - \frac{1}{\gamma + \delta} \right) \log(\gamma + \delta) E.$$

We clearly have

$$G^F > G^D,$$

as a results of two effects that play in the same direction: (i) focus increases the expected size of innovation (always equal to $\log(\gamma + \delta)$ under focus, but sometimes equal to $\log(\gamma - \delta)$ under diversity); (ii) focus increases the expected frequency of innovation both because innovation under focus induces bigger cost reduction under focus (under diversity cost is sometimes reduced by factor $(\gamma - \delta)$) and because under focus there is more incentive to innovate in order to escape competition (term $\frac{c}{c_f}$ in the expression for G^D). This immediately establishes:

Proposition A3 *There exists a cut-off value $\delta^S(r) < \delta^S$, increasing in r , such that focus maximizes dynamic welfare whenever $\delta > \delta^S(r)$.*

B Appendix: Tables

Table 1

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent: lnTFP (based on Olley-Pakes regression)					
Stateshare	-0.00150 (0.00337)	-0.00144 (0.00331)	-0.00159 (0.00337)	-0.00152 (0.00331)	-0.00185 (0.00329)	-0.00179 (0.00326)
Horizontal	0.322*** (0.0756)	0.335*** (0.0793)	0.323*** (0.0755)	0.335*** (0.0793)	0.178* (0.0947)	0.198* (0.101)
Ratio_subsidy	-0.185*** (0.0279)	-0.188*** (0.0276)	-8.201*** (1.769)	-6.752*** (1.404)	-8.067*** (1.748)	-6.798*** (1.392)
Competition_lerner		0.512 (0.533)		0.482 (0.535)		0.427 (0.535)
Interaction_lerner			8.212*** (1.818)	6.724*** (1.441)	8.074*** (1.796)	6.773*** (1.429)
Backward					0.779*** (0.278)	0.762*** (0.273)
Forward					0.112 (0.0991)	0.0995 (0.0990)
LnTariff	-0.0382** (0.0162)	-0.0348** (0.0166)	-0.0380** (0.0162)	-0.0348** (0.0166)	-0.0335 (0.0214)	-0.0321 (0.0213)
LnbwTariff	-0.00764 (0.0174)	-0.00672 (0.0172)	-0.00770 (0.0174)	-0.00682 (0.0172)	-0.0223 (0.0194)	-0.0213 (0.0189)
LnfwTariff	-0.00373 (0.00260)	-0.00422 (0.00278)	-0.00379 (0.00260)	-0.00424 (0.00278)	-0.00418 (0.00544)	-0.00406 (0.00537)
Constant	1.726*** (0.0315)	1.213** (0.534)	1.725*** (0.0314)	1.242** (0.535)	1.699*** (0.0412)	1.274** (0.533)
Observations	1,072,034	1,072,034	1,072,034	1,072,034	1,072,034	1,072,034
R-squared	0.172	0.172	0.172	0.173	0.173	0.173

Notes: Robust clustered standard errors are shown in the parenthesis. Firm fixed effect and time effect are included in each specification.

Table 3

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent: lnTFP (based on Olley-Pakes regression)					
Stateshare	-0.00150 (0.00337)	-0.00106 (0.00322)	-0.00144 (0.00331)	-0.00106 (0.00322)	-0.00171 (0.00326)	-0.00133 (0.00317)
Horizontal	0.322*** (0.0756)	0.343*** (0.0785)	0.335*** (0.0793)	0.343*** (0.0785)	0.198* (0.101)	0.212** (0.0975)
Ratio_subsidy	-0.185*** (0.0279)	-0.200*** (0.0320)	-0.188*** (0.0276)	-0.200*** (0.0320)	-0.187*** (0.0277)	-0.199*** (0.0318)
Competition_lerner		0.448 (0.542)	0.512 (0.533)	0.448 (0.542)	0.457 (0.534)	0.399 (0.543)
Competition_HerfSubsidy		0.000177*** (6.24e-05)		0.000177*** (6.24e-05)		0.000170** (6.49e-05)
Backward					0.762*** (0.273)	0.738*** (0.274)
Forward					0.0992 (0.0990)	0.0931 (0.101)
lnTariff	-0.0382** (0.0162)	-0.0360** (0.0155)	-0.0348** (0.0166)	-0.0360** (0.0155)	-0.0322 (0.0213)	-0.0338* (0.0202)
lnbwTariff	-0.00764 (0.0174)	-0.00578 (0.0166)	-0.00672 (0.0172)	-0.00578 (0.0166)	-0.0212 (0.0189)	-0.0199 (0.0186)
lnfwTariff	-0.00373 (0.00260)	-0.00556** (0.00276)	-0.00422 (0.00278)	-0.00556** (0.00276)	-0.00402 (0.00537)	-0.00517 (0.00541)
Constant	1.726*** (0.0315)	1.311** (0.539)	1.213** (0.534)	1.311** (0.539)	1.245** (0.532)	1.337** (0.537)
Observations	1,072,034	1,072,034	1,072,034	1,072,034	1,072,034	1,072,034
R-squared	0.172	0.173	0.172	0.173	0.173	0.174

Table 6 Effect of Correlation (subsidy and lerner index) on Firm-level productivity

	Dependent: Firm-level TFP		
	TFP_ols	TFP_olsFE	TFP_OP
Cor_subsidy_lerner	0.0325 (0.0204)	0.0791*** (0.0193)	0.0720*** (0.0193)
Stateshare	-0.00265 (0.00386)	-0.00178 (0.00365)	-0.00347 (0.00366)
Horizontal	0.201** (0.0939)	0.187* (0.0978)	0.189* (0.0969)
Backward	0.744*** (0.269)	0.735*** (0.272)	0.733*** (0.270)
Forward	0.0900 (0.101)	0.104 (0.0986)	0.103 (0.0984)
Subsidy_lag (at firm level)	-0.0374 (0.0252)	-0.0666** (0.0257)	-0.0656** (0.0263)
Lerner_lag	0.00756 (0.105)	-0.139 (0.109)	-0.129 (0.108)
lnTariff	-0.0390* (0.0224)	-0.0369* (0.0215)	-0.0366* (0.0219)
lnbwTariff	-0.0205 (0.0197)	-0.0153 (0.0189)	-0.0164 (0.0190)
lnfwTariff	-0.00273 (0.00531)	-0.00278 (0.00511)	-0.00287 (0.00511)
Constant	0.973*** (0.111)	1.932*** (0.113)	1.729*** (0.113)
Firm FEs	yes	yes	yes
Year dummies	yes	yes	yes
Observations	727,460	727,460	727,460
R-squared	0.136	0.179	0.167

Table 7 Effect of Correlation (subsidy and lerner index) on Firm-level productivity
Second Quartile and Fourth Quartile

VARIABLES	(1) TFP_ols	(2) TFP_olsFE	(3) TFP_OP
Second Quartile			
Correlation (subsidy & lerner)	0.114*** (0.0407)	0.150*** (0.0413)	0.145*** (0.0411)
Subsidy_lag	-0.0910* (0.0519)	-0.118* (0.0624)	-0.127* (0.0633)
Competition_lerner_lag	-0.0333 (0.0818)	-0.179* (0.0913)	-0.169* (0.0910)
Fourth Quartile			
Correlation (subsidy & lerner)	0.0104 (0.0468)	0.0713 (0.0450)	0.0636 (0.0456)
Subsidy_lag	0.0721 (0.0692)	0.0435 (0.0740)	0.0465 (0.0743)
Competition_lerner_lag	-0.0357 (0.143)	-0.124 (0.149)	-0.124 (0.148)
horizontal	Yes	Yes	Yes
Backward	Yes	Yes	Yes
Forward	Yes	Yes	Yes
lnTariff	Yes	Yes	Yes
lnbwTariff	Yes	Yes	Yes
lnfwTariff	Yes	Yes	Yes

Table 8 Effect of Correlation (subsidy and lerner index) on Aggregate Firm Productivity

	Dependent: City-Industry Aggregate TFP		
	OLS	OLS with FEs	OP
cor_subsidy_lerner	0.0348* (0.0178)	0.0796*** (0.0192)	0.0689*** (0.0186)
stateshare_aggre	0.00506** (0.00243)	0.0288*** (0.00530)	0.0201*** (0.00422)
horizontal	-0.0546 (0.266)	-0.0717 (0.259)	-0.0696 (0.258)
backward	3.953*** (0.984)	3.546*** (0.923)	3.654*** (0.923)
forward	0.360 (0.487)	0.459 (0.419)	0.434 (0.432)
subsidy_lag	-0.0620 (0.0894)	-0.0640 (0.123)	-0.125 (0.113)
lerner_lag	-0.233*** (0.0798)	-0.355*** (0.0869)	-0.347*** (0.0871)
lnTariff	-0.190*** (0.0412)	-0.164*** (0.0394)	-0.169*** (0.0392)
lnbwTariff	-0.155** (0.0763)	-0.135* (0.0716)	-0.137* (0.0718)
lnfwTariff	0.0450*** (0.0154)	0.0409*** (0.0150)	0.0412*** (0.0147)
Constant	1.353** (0.510)	2.195*** (0.457)	2.001*** (0.468)
Industry FEs	Yes	Yes	Yes
City FEs	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes
Observations	76,923	76,923	76,923
R-squared	0.476	0.458	0.467

Table 9 Effect of Correlation (subsidy and lerner index) on Aggregate Firm Productivity
Second Quartile and Fourth Quartile

Dependent: City-Industry Aggregate TFP			
	(1)	(2)	(3)
	OLS	OLS with FEs	OP
Second Quartile			
Correlation (subsidy & lerner)	0.0399 (0.0278)	0.0892** (0.0422)	0.0812** (0.0384)
Subsidy_lag	-0.146 (0.0941)	-0.0816 (0.101)	-0.167* (0.0966)
Competition_lerner_lag	-0.197* (0.110)	-0.317** (0.154)	-0.303* (0.148)
Fourth Quartile			
Correlation (subsidy & lerner)	-0.00425 (0.0375)	0.0425 (0.0409)	0.0299 (0.0393)
Subsidy_lag	-0.0182 (0.141)	-0.113 (0.181)	-0.149 (0.172)
Competition_lerner_lag	-0.303*** (0.0802)	-0.348*** (0.0900)	-0.353*** (0.0891)
Horizontal	Yes	Yes	Yes
Backward	Yes	Yes	Yes
Forward	Yes	Yes	Yes
lnTariff	Yes	Yes	Yes
lnbwTariff	Yes	Yes	Yes
lnfwTariff	Yes	Yes	Yes

Table 10 Effect of Correlation (tariff and lerner index) on Firm Productivity

	Dependent: Firm-level TFP		
	OLS	OLS with FEs	OP
Correlation (tariff&lerner)	0.0833*** (0.0219)	0.0722*** (0.0203)	0.0745*** (0.0202)
Stateshare	-0.00257 (0.00385)	-0.00199 (0.00364)	-0.00365 (0.00367)
Horizontal	0.168* (0.0893)	0.159* (0.0935)	0.161* (0.0926)
Backward	0.688*** (0.255)	0.698*** (0.259)	0.692*** (0.256)
Forward	0.123 (0.0784)	0.134* (0.0774)	0.131* (0.0772)
Competition_lerner_lag	0.00278 (0.110)	-0.156 (0.113)	-0.144 (0.113)
lnTariff_lag	-0.0342** (0.0144)	-0.0340** (0.0139)	-0.0337** (0.0141)
lnbwTariff_lag	-0.0196 (0.0180)	-0.0167 (0.0172)	-0.0170 (0.0173)
lnfwTariff_lag	-0.00857*** (0.00214)	-0.00806*** (0.00209)	-0.00806*** (0.00211)
Constant	1.130*** (0.109)	2.131*** (0.112)	1.918*** (0.112)
Firm FEs	yes	yes	yes
Year Dummies	yes	yes	yes
Observations	728,274	728,274	728,274
R-squared	0.137	0.179	0.167

Table 11 Effect of Correlation (tariff and lerner index) on Aggregate Firm Productivity

	Dependent: City-Industry Aggregate TFP		
	OLS	OLS with FEs	OP
Correlation (tariff & lerner)	0.0783*** (0.0184)	0.0856*** (0.0223)	0.0873*** (0.0217)
Stateshare_aggre	0.00475* (0.00243)	0.0285*** (0.00522)	0.0198*** (0.00415)
Horizontal	0.0670 (0.260)	0.0303 (0.252)	0.0355 (0.251)
Backward	3.894*** (1.029)	3.464*** (0.968)	3.581*** (0.967)
Forward	0.179 (0.521)	0.304 (0.446)	0.275 (0.460)
Competition_lerner_lag	-0.210** (0.0851)	-0.339*** (0.0889)	-0.329*** (0.0894)
lnTariff_lag	-0.114*** (0.0271)	-0.101*** (0.0264)	-0.104*** (0.0260)
lnbwTariff_lag	-0.0256 (0.0256)	-0.0424* (0.0228)	-0.0367 (0.0231)
lnfwTariff_lag	-0.00177 (0.00627)	-0.00190 (0.00569)	-0.00242 (0.00577)
Constant	1.511*** (0.115)	2.503*** (0.119)	2.270*** (0.118)
Industry FEs	yes	yes	yes
City FEs	yes	yse	yse
Year dummies	yes	yse	yse
Observations	76,935	76,935	76,935
R-squared	0.472	0.456	0.465

Appendix Table 1 Summary Statistics

	Levels			Growth Rates		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
TFP	1,522,730	1.764	0.359	1,072,148	0.055	0.306
Stateshare	1,522,730	0.087	0.269	1,072,148	-0.007	0.144
Horizontal	1,522,730	0.256	0.142	1,072,148	0.004	0.045
Backward	1,522,730	0.078	0.046	1,072,148	0.002	0.015
Forward	1,522,730	0.104	0.174	1,072,148	0.004	0.066
Ratio_subsidy	1,522,730	0.003	0.019	1,072,148	0.000	0.020
Competition_lerner	1,522,730	0.975	0.019	1,072,148	-0.005	0.009
Interaction	1,522,730	0.003	0.019	1,072,148	0.000	0.019
lnTariff	1,522,730	2.418	0.505	1,072,148	-0.063	0.180
lnfwTariff	1,520,636	1.025	1.435	1,070,512	-0.017	0.525
lnbwTariff	1,522,730	1.262	0.505	1,072,148	-0.029	0.206
Competition_Herf_Subsidy	1,522,730	69.001	80.512	1,072,148	3.726	38.721
Subsidy_lag	1,072,148	0.003	0.019	742,902	0.000	0.019
Competition_lerner_lag	1,072,148	0.978	0.018	742,902	-0.004	0.008
Interaction_lag	1,072,148	0.003	0.019	742,902	0.000	0.019
lnTariff_lag	1,072,148	2.446	0.507	742,902	-0.079	0.188
lnbwTariff_lag	1,072,148	1.262	0.507	742,902	-0.075	0.175
lnfwTariff_lag	1,070,533	1.008	1.471	741,689	-0.342	1.635
Cor tariff lerner	1,522,730	0.022	0.141	1,072,148	0.016	0.039
Cor subsidy lerner	1,522,730	0.141	0.083	1,072,148	-0.013	0.057
Ratio_newproduct	1,323,089	0.034	0.150	891,800	0.001	0.128

Notes: Interaction = Ratio_subsidy*Competition_lerner and Interaction_lag = Subsidy_lag * competition_lerner_lag.