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Philippe Aghion
Mathias Dewatripont
Luosha Du
Ann Harrison
Patrick Legros

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ABSTRACT

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Philippe Aghion
Department of Economics
Harvard University
1805 Cambridge St
Cambridge, MA 02138
and NBER
paghion@fas.harvard.edu

Mathias Dewatripont
Universite Libre de Bruxelles
mathias.dewatripont@ulb.ac.be

Luosha Du
Department of Agricultural
and Resource Economics
UC Berkeley
Giannini Hall
Berkeley, California 94720
luosha@berkeley.edu

Ann Harrison
Management Department
The Wharton School
University of Pennsylvania
2016 Steinberg Hall-Dietrich Hall
3620 Locust Walk
Philadelphia, PA 19104-6370
and NBER
annh@wharton.upenn.edu

Patrick Legros
ECARES, Universite Libre de Bruxelles
CP114
50 avenue Franklin Roosevelt
1050 Brussels BELGIUM
plegros@ulb.ac.be

Industrial Policy and Competition

By Philippe Aghion, Jing Cai, Mathias Dewatripont, Luosha Du, Ann Harrison and Patrick Legros*

Using a comprehensive dataset of all medium and large enterprises in China between 1998 and 2007, we show that industrial policies allocated to competitive sectors or that foster competition in a sector increase productivity growth. We measure competition using the Lerner Index and include as industrial policies subsidies, tax holidays, loans, and tariffs. Measures to foster competition include policies that are more dispersed across firms in a sector or measures that encourage younger and more productive enterprises.

In the aftermath of World War II, several developing countries opted for "industrial policies" aimed at promoting new infant industries or at protecting local traditional activities from competition by products from more advanced countries. However, these policies came into disrepute in the 1980s mainly on the ground that industrial policy *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.

In this paper we argue that properly governed sectoral policies, in particular sectoral policies that are *competition-friendly*, may enhance productivity and

* Aghion: Harvard University, Department of Economics, Littauer Center 22, 1805 Cambridge Street, Cambridge MA 02138, and NBER; paghion@harvard.edu. Jing Cai: Department of Economics, University of Michigan, 611 Tappan Street, 365A Lorch Hall, Ann Arbor, MI 48109-1220; caijing@umich.edu. Dewatripont: Banque National de Belgique and Université libre de Bruxelles (ECARES), 50 avenue F.D. Roosevelt, C.P. 114-04, 1050 Bruxelles, Belgique; mdewat@ulb.ac.be. Du: China Development Bank, 18 fuxingmen neidajie, xichengqu, Beijing, China 100031; Duluosha@cdb.cn. Ann Harrison: The Wharton School, University of Pennsylvania, 2016 Steinberg Hall-Dietrich Hall, Philadelphia, Pennsylvania 19104-6370, and NBER; annh@wharton.upenn.edu. Legros: Université libre de Bruxelles (ECARES), 50 avenue F.D. Roosevelt, C.P. 114-04, 1050 Bruxelles, Belgium; plegros@ulb.ac.be. We thank the Editor, three anonymous referees, Jean Imbs, Amit Khandelwal, and conference participants at The World Bank, the Wharton International Lunch, Pennsylvania State University, Duke University, George Washington University, and the Asian Development Bank for very helpful comments.

productivity growth. Without industrial policy, innovative firms may choose to operate in different sectors in order to face lower competition on the product market, leading to high sectoral concentration and low incentives to innovate because of a "monopoly replacement effect". In such a case, industrial policies that encourage firms to be active in the same sector, such as through tax holidays or other tax-subsidy schemes, will decrease concentration in the targeted sector and enhance incentives for firms to innovate. Therefore there can be *complementarity* between competition and suitably designed industrial policies in inducing innovation and productivity growth.

To document the potential complementarity between competition and industrial policy, we use a comprehensive dataset of all medium and large enterprises in China between 1998 and 2007 and consider the effect of industrial policies on firm level productivity growth. Our main finding is that when sectoral policies are targeted towards competitive sectors or allocated in such a way as to preserve or increase competition, then these policies increase productivity growth. We measure competition using the Lerner Index and include as industrial policies subsidies, tax holidays, loans, and tariffs. Competition-friendly policies are defined as targeting that is more dispersed across firms in a sector or measures that encourage younger and more productive enterprises.

Our paper relates to a whole literature on the costs and benefits of industrial policy. First are the infant-industry models advocating government support to sectors with potential economy-wide knowledge externalities but with high initial production costs which decrease only progressively over time as a result of learning-by-doing: the idea is that these sectors need to be protected against foreign competition in the short-run until they become fully competitive (see for example Greenwald and Stiglitz (2006)).[1] The infant industry argument has been

[1]For 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, i.e., it increases the potential

challenged, both theoretically (the 'pick-winners" argument) and empirically. For example Krueger and Tuncer (1982) analyzed the effects of industrial policy in Turkey in the 60s, and "showed" that firms or industries not protected by tariff measures were characterized by higher productivity in growth rates than protected industries.[2] However none of these papers look at the design or at the governance of industrial policy.

Most closely related to our analysis is the paper by Nunn and Trefler (2010). Using cross-country industry-level panel data, they analyze whether, as suggested by "infant industry" arguments, the growth of productivity in a country is positively affected by tariff protection 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. The issue remains whether industrial policy comes at the cost of a lowering of competition, 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. We show this in our previous working paper version.

rate of growth also 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.

[2]However, see Harrison (1994) who shows that their results are not robust to rigorous statistical analysis.

The paper is organized as follows. Section 2 sketches a simple model to guide our empirical analysis.[3] Section 3 presents some brief historical background for industrial policy in China, as well as the data and measurement and some raw correlations between competition, industrial policies and firm level performance. Section 4 describes the estimation methodology and presents the main empirical results. Section 5 concludes.

I. The theoretical argument

In this section we sketch our theoretical argument for why properly designed sectoral policy may enhance rather than harm competition. The argument can be summarized as follows: consider an economy where two firms can either differentiate horizontally or innovate to improve their productivity. Under laissez-faire the two firms will typically choose to "diversify", i.e., to produce in different sectors in order to escape competition between them. Forcing (or encouraging) these firms to operate in the same sector and on an equal footing will induce them to resort to vertical innovation (i.e., to productivity-improving innovation) in order to escape competition with each other. This in turn will foster productivity growth.

Note that this argument is quite distinct from the infant industry argument and is also novel in the literature on the effects of industrial policy. In particular it does not rely on a learning-by-doing externalities or on knowledge externalities between an industrial (tradable good) sector and a traditional (non-tradable good) sector. Instead, it relies on standard growth externalities and on an escape-competition effect (see for instance Aghion et al 2005). Thus, while (foreign) competition is damaging for domestic growth in the infant-industry model, here competition is always growth-enhancing.

[3]The details of the model as well as the proofs are developed in Appendix B.

A. Basic setup

We consider a two-period model of an economy producing two goods, denoted by A and B. Denote the quantity consumed on each good by x^A and x^B. The representative consumer has income equal to $2E$ 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 $x^i = E/p^i$. To simplify the writing, we assume that $E = 1$ throughout this paper.[4]

Production can be done by one of two 'big' firms $1, 2$, or by 'fringe firms'. Fringe firms act competitively and have a constant marginal cost of production of c_f whereas firms $j = 1, 2$ have an initial marginal cost of c, where $1 > c_f \geq c$. The assumption $c_f \geq c$ reflects the cost advantage of firms $1, 2$ with respect to the fringe and the assumption $1 > c$ insures that equilibrium quantities can be greater than 1. Marginal costs are firm-specific and are independent of the sector in which production is undertaken.

Firms can improve productivity through quality-improving innovation. For simplicity, we assume that only firms $1, 2$ can innovate. Innovation reduces production costs, but the size of the cost reduction is different between the two sectors A and B. Without loss of generality, we assume that in sector A, innovations reduce production costs from c to $c/\gamma_A = c/(\gamma + \delta)$ whereas in sector B they reduce costs from c to $c/\gamma_B = c/(\gamma - \delta)$, where $\gamma - \delta > 1$ or $\delta < \gamma - 1$.[5]

We also make the simple assumption that, with equal probability, each firm can be chosen to be the potential innovator. To innovate with probability q this firm must incur effort cost $q^2/2$. 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.

[4] As will be soon apparent, the rate of innovation is linear in E, and except for this size effect, what matters for the analysis are the ratios E/c and E/c_f.

[5] Even if $\delta = 0$, that is if the two sectors are similar, industrial policy is beneficial. In previous versions of the paper we considered also imperfect information about the identity of the high growth sector, and our results were qualitatively similar. This suggests that a regulator does not need necessarily to identify the "high growth" sector in order to implement the type of industrial policy we are considering.

Finally, we assume Bertrand competition within each sector unless the two leading firms choose the same sector and collude within that sector. Let φ be the probability of the two leading firms colluding in the same sector when they have the same cost, and let us assume that when colluding the two firms behave as a joint monopoly taking the fringe cost c_f as given. In this case, the expected profit of each leading firm with cost $c < c_f$ is $\varphi \frac{1}{2} \frac{c_f - c}{c_f}$ since when collusion fails firms compete Bertrand.

B. *The effects of targeted tax/subsidies*

Firms can choose to be active in different sectors or in the same sector: we refer to the first situation as one of diversity, and the second as one of 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 to switch to technology A; otherwise the equilibrium is focus. Conditional on this choice firms then decide to invest in order to innovate.

We look at how firms' choice whether to produce in the same sector or in different sectors, and their resulting innovation intensities, depends upon industrial policy. For industrial policy we will focus on interventions based on taxes or subsidies that are proportional to profit levels, that is on tax levels t_A, t_B per profit level in sectors A, B respectively, where $t_k < 0$ is a subsidy and $t_k > 0$ is a tax.[6] We restrict attention to the case where there is perfect information about γ_i and where the profit is net of the cost of innovation.[7]

We first derive the equilibrium choices under arbitrary tax/subsidy schemes $t_A \leq t_B$ ("laissez-faire" corresponds to the case $t_A = t_B = 0$) and show the

[6] We assume without loss of generality an initial level of taxation equal to zero in each sector.

[7] If the tax/subsidy is on the profit gross of the cost of innovation, then it will also affect the rate at which firms innovate. A reduction in the tax rate on gross profits has a similar effect as a subsidy to the marginal cost of innovation.

interaction between our measure of competition φ and the growth rate that can be achieved via such a tax system. We then identify the growth-maximizing tax/subsidy scheme when the planner is subject to a budget constraint.

Considering the laissez-faire situation with $t_A = t_B = 0$, firms will choose focus only if the equilibrium profit is greater than the lowest profit obtained under diversity. This will be the case only if the degree of competition is not too high; hence the stronger competition as measured by $(1-\varphi)$, the higher the range of δ's for which firms will choose diversity.

Proposition 1. *There exists a cutoff value $\delta^F(\varphi)$, a decreasing function of φ such that focus is the industry equilibrium if, and only if, $\delta \geq \delta^F(\varphi)$.*

Now, let us introduce a system of tax/subsidies, and let us use as a measure of targeting the ratio

$$\tau \equiv \frac{1-t_A}{1-t_B}. \tag{1}$$

The larger τ is, the higher are the "tax holidays" in sector A with respect to sector B. It should be clear that τ is sufficient to characterize the incentives of firms to choose between diversity or focus. Alternatively, τ is a measure of the asymmetry in tax holidays between the two sectors. The effect of the tax ratio on industry equilibrium is summarized in the following result.

Corollary 1. *Consider a system of tax/subsidies with a targeting ratio $\tau = \frac{1-t_A}{1-t_B}$. When $\tau > 1$, there exists a cutoff $\Delta(\varphi,\tau) < \delta^F(\varphi)$ such that the industry equilibrium is focus whenever $\delta > \Delta(\varphi,\tau)$. Moreover this cutoff is decreasing in τ and in φ.*

Hence, a larger target ratio τ increases the range of values of δ for which there will be focus. Alternatively, if $\delta < \delta^F(\varphi)$, there exists a targeting tax τ such that $\delta = \Delta(\varphi,\tau)$; because $\Delta(\varphi,\tau)$ is a decreasing function of τ, the lower the value of δ, the higher this value of τ should be.

Now solving for the optimal innovation investments respectively under focus and under diversity, we obtain the complementarity between the degree of competition in a sector and the effectiveness of a tax/subsidy scheme.

Proposition 2. *An effective τ-industrial policy has a bigger effect on per capita GDP and on innovation intensity in more competitive industries.*

C. Predictions

The following predictions from the above theoretical discussion will guide our empirical analysis in the next sections:

1) A tax policy that is more targeted towards sector A has a bigger impact on output and innovation: a higher value of τ (that is a lower t_A with respect to t_B) makes it more likely that focus will be the industry equilibrium. By Proposition 2, it follows that higher values of τ have a larger effect on innovation and on the level of per capita GDP, independently of φ.

2) Since a policy that gives a tax holiday to only one firm will not modify the industry equilibrium, tax holidays that are common to the two firms have a bigger impact on innovation and the level of per capita GDP than a policy that would apply to a unique firm.

3) There is complementarity between industrial policy through tax holidays and the degree of competition.

II. Background, Data and Measurement

A. Background

The Chinese government has long been actively involved in promoting industrialization in China. Industrial policy relies on a whole range of instruments, including tariff protection, low-interest loans, tax holidays, and subsidies for the purpose of promoting investment in key sectors. We begin by documenting the range of industrial policies and their changes over the sample period. Readers interested in more detailed descriptions of China's changing industrial policies over the sample period are referred to Du, Harrison, and Jefferson (forthcoming) or Harrison (forthcoming).

The first row of Table 1 reports the percentage of firms who received positive subsidies from the government. In 1998, 9.4 percent of all reporting firms received subsidies. That number climbed steadily during the sample period, reaching a high of 15.1 percentage of all manufacturing firms in 2004, before falling to 12.4 percent in 2007. The number was even higher for state owned enterprises (SOEs) and foreign firms (many of which formed joint ventures with SOEs), but lower for domestic firms with no public or foreign participation. For private domestic enterprises ("Domestic Private Only" in Table 1), the share of firms receiving subsidies was slightly lower, increasing from 8 percent of all firms in 1998 to a high of 13.8 percent in 2004, before falling to 11.6 percent in 2007.

The second row of Table 1 indicates the percentage of firms receiving tax holidays over the sample period. We define a firm as receiving a tax holiday if either the firm paid less than the statutory corporate income tax rate in that year or if the firm paid less than the statutory value added tax rate. A large share of manufacturing firms paid less than the full statutory rate during the sample period. The share of enterprises with tax holidays varies from 41.6 percent in 1998 to nearly 50 percent in 2007. Comparing the incidence of tax holidays across different types of enterprises, Table 1 shows that the incidence was lowest for SOEs and highest for firms with foreign equity participation. Up to 59 percent of foreign firms received some type of tax holiday in 2003, compared to only 36.5 percent for SOEs.

While low-interest loans have been an important form of industrial policy in China, we do not have data on directed credit provided through state banks or local governments. However, firms do report total interest and current liabilities, so we can calculate an effective interest rate on loan obligations. We report those averages in the third row of Table 1. The average ratio of interest paid to current liabilities across all firms with non-zero interest or liabilities was 5.57 percent in 1998. The interest ratio steadily declined during the sample period, to a low of 2.7 percent in 2004 and then increased to 3.3 percent in 2007. Across different ownership categories, there was significant variation, with domestic private enterprises facing an effective interest rate that was almost double that faced by SOEs.

In the last row of Table 1 we report the average tariff on imports by year for 1998 through 2007. Since tariffs are set nationally by sector, there is not significant variation in tariffs across enterprise types. During the sample period, average tariffs came down dramatically, from an average of 20 percentage points in 1998 to an average of 10 percentage points in 2007. By contrast, average tariffs in the United States over the last several decades have been less than 5 percent. The largest drop in tariffs occurred in 2001, the year China joined the WTO.

Table 2 reports average industrial policies across 2 digit manufacturing sectors between 1998 and 2007. There was significant variation in the intensity of industrial policy across different subsectors. For example, the ratio of interest payments to current liabilities, our proxy for the (subsidized) interest rate facing the enterprise, was very low for the computer and telecommunications sector, averaging 1.8 percent, but significantly higher for non-metallic minerals (4.6 %), beverages (4.4 %), and paper products (4.4 %). Tariffs also show significant dispersion, with the highest tariffs on goods such as tobacco products (over 52 %), transport equipment (17 %) and the lowest tariffs on wood products (7.6 %), and fuels (6 %). The percentage of firms receiving subsidies and tax holidays also varied across sectors, as reported in the last two columns of Table 2.

Table 1. Summary Statistics

	1998	2000	2001	2002	2003	2004	2005	2007
All Companies								
% of Firms with Subsidies	0.0937	0.110	0.115	0.129	0.138	0.151	0.137	0.124
% of Firms with Tax Holidays	0.416	0.453	0.441	0.443	0.456	0.419	0.454	0.497
Ratio of Interest Payments to Current Liabilities	0.0557	0.0413	0.0366	0.0340	0.0319	0.0268	0.0313	0.0330
Average Tariff on Imports	19.48	18.68	13.84	13.58	12.23	10.91	10.17	10.12
SOEs only								
% of Firms with Subsidies	0.139	0.162	0.171	0.181	0.197	0.197	0.224	0.253
% of Firms with Tax Holidays	0.306	0.355	0.334	0.343	0.365	0.337	0.367	0.455
Ratio of Interest Payments to Current Liabilities	0.0416	0.0288	0.0255	0.0238	0.0222	0.0184	0.0183	0.0200
Average Tariff on Imports	19.81	19.11	13.76	13.48	12.05	11.01	10.24	10.24
Foreign Firms Only								
% of Firms with Subsidies	0.0678	0.0839	0.103	0.133	0.154	0.181	0.146	0.142
% of Firms with Tax Holidays	0.540	0.591	0.572	0.585	0.593	0.577	0.598	0.608
Ratio of Interest Payments to Current Liabilities	0.0408	0.0282	0.0249	0.0219	0.0198	0.0164	0.0185	0.0198
Average Tariff on Imports	21.29	19.83	14.65	14.41	12.99	11.45	10.68	10.45
Domestic Private Firms Only								
% of Firms with Subsidies	0.0835	0.105	0.107	0.119	0.126	0.138	0.131	0.116
% of Firms with Tax Holidays	0.418	0.431	0.417	0.412	0.421	0.374	0.413	0.467
Ratio of Interest Payments to Current Liabilities	0.0668	0.0491	0.0424	0.0391	0.0365	0.0304	0.0356	0.0368
Average Tariff on Imports	18.65	18.14	13.58	13.33	12.00	10.74	10.00	10.02

Table 2. Industrial Policies by Sector

Sector	Interest Rate	Tariff	Subsidies	Tax Holidays
Foodstuff	0.0424	21.67	0.109	0.476
Manufacture of beverages	0.0441	27.48	0.106	0.451
Manufacture of Tobacco	0.0336	52.28	0.229	0.320
Manufacture of Textiles	0.0357	14.39	0.120	0.444
Manufacture of textile wearing apparel, footwear	0.0256	20.32	0.101	0.492
Manufacture of leather, fur, feather	0.0308	18.17	0.0959	0.486
Processing of timber, manufacture of wood, bamboo	0.0578	7.557	0.114	0.548
Manufacture of furniture	0.0397	8.776	0.0923	0.501
Manufacture of paper and paper products	0.0438	10.60	0.105	0.454
Manufacture of articles for culture, education and sport activity	0.0230	11.99	0.126	0.474
Processing of petroleum, coking, processing of nuclear fuel	0.0391	6.046	0.106	0.388
Manufacture of raw chemical materials and chemical products	0.0391	9.513	0.145	0.452
Manufacture of medicines	0.0391	6.148	0.166	0.468
Manufacture of chemical fibers	0.0381	8.743	0.166	0.426
Manufacture of Rubber	0.0376	15.66	0.116	0.455
Manufacture of Plastics	0.0323	11.45	0.107	0.451
Manufacture of non-metallic mineral products	0.0462	12.38	0.139	0.445
Smelting and pressing of non-ferrous metals	0.0367	6.193	0.109	0.413
Smelting and pressing of metals	0.0397	5.602	0.160	0.433
Manufacture of metal products	0.0293	12.15	0.107	0.432
Manufacture of special purpose machinery	0.0288	9.112	0.138	0.419
Manufacture of transport equipment	0.0289	17.57	0.150	0.413
Manufacture of electrical machinery and equipment	0.0266	11.67	0.144	0.423
Manufacture of communication equipment, computers and other electronic equipment	0.0182	7.081	0.155	0.538
Manufacture of measuring instruments and machinery for cultural activity and office work	0.0205	9.442	0.170	0.470
Manufacture of artwork and other manufacturing	0.0344	17.03	0.102	0.485

B. Data and measurement

We measure industrial policy using four types of policy instruments: subsidies, interest paid as a share of current liabilities, tax holidays, and tariffs. Subsidies, interest payments, and tax holidays are allocated at the firm level, while tariffs are set at the national level. Our data for tariffs are available at the 2 or 3 digit level. Tariffs are set nationally and are exogenous with respect to a particular region or a particular firm. However, since tariffs do not vary across firms, we cannot use measures of policy dispersion within a sector to test whether tariffs are set in a way that preserves competition. For tariffs, all we can do is test whether the imposition of tariffs in more competitive sectors is more likely to result in higher firm performance.

To measure competition, we will compute a Lerner index at both the county and sector level. The Lerner Index measures the importance of markups (the difference between prices and marginal costs) relative to the firm's total value added. To calculate it, we first aggregate operating profits, capital costs, and sales at the industry, county and year level. The Lerner index is defined as the ratio of operating profits less capital costs to sales. Under perfect competition, there should be no excess profits above capital costs, so the Lerner Index should equal zero. Since the Lerner Index is an inverse measure of competition, we redefine competition as 1 - Lerner, so under perfect competition it should equal 1. A value of 1 indicates perfect competition while values below 1 suggest some degree of market power. We address the potential endogeneity of competition using initial period Lerners in all the estimating equations below.

The standard approach to measuring firm-level performance is to identify total factor productivity (TFP) levels or growth. Since TFP is an overall efficiency parameter, it is best understood as measuring process innovation–the cost reductions associated with improving the efficiency in producing an existing product. Another measure of innovation is product innovation–associated with the introduction of new products or higher quality goods. Our primary focus is on process innovation, since product innovation is not reliably measured and was also less pervasive for firms in the sample during this period.

The dataset, collected by the Chinese National Bureau of Statistics, is described in greater detail in Du, Harrison, and Jefferson (2012). We retain only the manufacturing enterprises and eliminate establishments with missing values or negative or zero values for key variables such as output, employees, capital and inputs. The years covered include 1998 through 2007. This is a true panel, following the same firms over time. We dropped three sectors with incomplete information on prices from the sample[8]. The final sample size is $1,545,626$ observations.

The dataset contains information on real and nominal output, assets, number of workers, renumeration, inputs, public ownership, foreign investment, sales revenue, and exports. Because domestically owned, foreign, and publicly owned enterprises behave quite differently, in all the regression results presented below we will restrict the sample to firms that have zero foreign ownership and have only minority state ownership. In the dataset, $1,069,563$ observations meet the criterion[9].

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. During the sample period, average tariffs fell nearly by 9 percentage points, which is a significant change over a short time period. While the average level of tariffs across all years 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.

Before adopting a more formal approach to analyzing the relationship between

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

[9]Typically we distinguish domestic and foreign-invested firms based on whether the share of subscribed capital owned by foreign investors is equal to or less than 10%. The results are generally robust to the choice of definition for foreign versus domestic ownership.

industrial policy, competition, and firm-level outcomes in the next section, we first report some raw correlations in Table 3. The remainder of the paper will focus only on domestically owned firms, but for the correlation results we include all enterprises in order to highlight the significant differences across ownership types. All the reported correlations are statistically significant at the 5 percent level. In particular these correlations indicate: (i) that firms receiving subsidies exhibited higher total factor productivity levels; (ii) that subsidies were significantly associated with new product introductions; (iii) that while subsidies and tax holidays are significantly and positively correlated with firm-level innovation, final goods tariffs are not; (iv) that higher levels of TFP are positively correlated with firm-level subsidies and tax holidays; however, the two other industrial policy measures are negatively correlated with firm-level performance as defined by levels of TFP: final goods tariffs and low interest payments.

Table 3.

	Index_subsidy	Index_tax	Index_interest	Final Tariff	TFP_OP	public	foreign	New Product Share in Sales
Index_subsidy	1							
Index_tax	-0.0047	1						
Index_interest	-0.0248	-0.0087	1					
Final Goods Tariff	-0.0373	-0.0113	-0.016	1				
TFP_OP	0.0275	0.108	-0.0106	-0.118	1			
public	0.0418	-0.0679	0.0344	0.142	-0.19	1		
foreign	0.0116	0.146	0.0821	0.0529	0.152	-0.16	1	
New Product Share in Sales	0.109	-0.0021	-0.0523	-0.037	0.0489	0.0728	-0.0034	1

Notes: Index_subsidy, index_tax, and Index_interest are dummy variables which equal 1 if a firm receives subsidies, tax breaks, or a below-median borrowing interest rate, respectively. TFP is estimated with the Olley- Pakes method. For the OP estimation of TFP, we use a two-stage procedure. In the first stage, we use the OP regression method to obtain estimates for the input coefficients and then calculate TFP (the residual from the production function). In the second stage, we regress TFP on the remaining controls. Ownership variables public and foreign vary from zero to 100 percent publicly or foreign owned.

The raw correlations also confirm that SOEs and foreign firms behave quite differently from other enterprises. Industrial policies were also allocated differently for these enterprises, consistent with the evidence presented in Tables 1 and 2. Public sector enterprises were more likely to receive subsidies and tariff protection, but less likely to receive tax holidays. Public ownership was negatively associated with TFP, with a correlation coefficient of -0.19. These correlations are consistent with the perception of SOEs as less competitive and less efficient than other enterprises. Firms with foreign ownership (column (8)) were systematically more likely to receive all types of industrial support. In contrast to SOEs, foreign ownership is positive and signicantly correlated with TFP. The very different performance outcomes and industrial policy targeting for SOEs and foreign firms justifies our decision to focus on domestically owned enterprises with only minority public ownership in the remainder of this paper.

Overall, these correlations suggest that some forms of industrial policy, such as subsidies and tax holidays, were associated with significant firm level innovation, while others–such as tariffs, which typically discourage competition–were not. Our empirical analysis in the next section will confirm these conjectures.

III. Empirical analysis and results

In this section we analyze the complementarity between industrial policy and competition using two approaches. First, we test the hypothesis that introducing industrial policies in more competitive sectors is more likely to lead to improved outcomes. This is a somewhat different approach from "picking winners": instead, this approach suggests picking sectors where firms *already* compete intensively. The intuition would be that to make government support effective, it needs to be allocated where there is competition, and not collusion. Second, for given sectoral choice, we investigate what would be the best strategy for allocating support across firms within a sector. In a nutshell, the first approach explores differences *across* sectors, whereas the second approach explores how best to allocate industrial policy support *within* a sector.

A. Estimation methods

To implement our first approach, which tests Corollary 1, we measure the correlation of subsidies with competition and then to see whether a stronger correlation coefficient at the city-year level 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:

$$\Omega_{rt,subsidy} = Corr(SUBSIDY_{rjt}, COMPETITION_{rj0}) \tag{2}$$

Since all industrial policies vary over time, we thus obtain a time-varying change in the correlation between initial levels of competition in year zero and the patterns of interventions across different parts of China. We then explore whether higher correlations between current period subsidies and initial competition, as measured by $\Omega_{rt,subsidy}$, are associated with better performance. As an illustration, if in Shanghai the largest amount of subsidies are allocated to sectors with low markups and small or zero subsidies are given to sectors with high markups in the year 2003, then for Shanghai in 2003 this correlation coefficient will be close to unity.

Similarly, we introduce the variables $\Omega_{rt,interest}$ and $\Omega_{rt,taxholidays}$ where:

$$\Omega_{rt,interest} = Corr(INTEREST_{rjt}, COMPETITION_{rj0}) \tag{3}$$

$$\Omega_{rt,taxholidays} = Corr(TAXHOLIDAYS_{rjt}, COMPETITION_{rj0}) \tag{4}$$

The only type of industrial policy which does not vary across regions is tariffs, but the Ω variable for tariff policies will still vary by location and year because the composition of industrial sectors is different, and the degree of competition varies across regions. Consequently, we can compute a separate Ω variable by replacing subsidies with tariffs and replacing 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 last correlation measure is now defined as:

$$\Omega_{rt,tariffs} = Corr(TARIFF_{jt}, COMPETITION_{rj0}) \tag{5}$$

Consequently we have four different correlation coefficients, that vary only across locations and over time. These Ω variables measure a city's scope to target more competitive sectors, where competition is pre-determined using beginning of period Lerner indices.[10] To calculate our measure of competition, 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 competition measure should equal 1. A value of 1 indicates perfect competition while values below 1 suggest some degree of market power.

Our second goal is to identify which approaches to allocating industrial support within a given sector are most effective. Our main empirical challenge is to capture the notion of firm-specific industrial support being allocated in a way that preserves or increases competition. We first consider the sectoral dispersion of industrial support as a measure of the degree of "competitiveness". As an (inverse) measure of sectoral dispersion, we use the Herfindahl index constructed using the share of support each firm in a given sector receives relative to the total support awarded to the sector. We thus derive a measure of concentration, such

[10] Recall that the Lerner index is defined as the ratio of operating profits less capital costs to sales. It is an inverse measure of product market competition.

as $Herf\_subsidy$, which for subsidies is given by:

$$Herf\_subsidy_{ijt} = \sum_{h \in j, h \notin i} \left(\frac{Subsidy_{ijt}}{Sum\_subsidy_{jt}} \right)^2 \tag{6}$$

We then do the same thing for tax holidays, and obtain a measure of concentration, $Herf\_tax$, where:

$$Herf\_tax_{ijt} = \sum_{h \in j, h \notin i} \left(\frac{TaxHoliday_{ijt}}{Sum\_TaxHoliday_{jt}} \right)^2 \tag{7}$$

The amount of tax holiday granted to any firm i is simply the quantity of tax revenues that the firm saves by qualifying for the tax holiday. During the time period of our analysis, corporate tax rates varied from 15 to 33 percent. Consequently, the amount of the tax holiday is equal to profits times the tax rate less actual taxes paid plus any savings from exemptions to the value-added tax (which was set to 17 percent of value-added). If the statutory tax rate facing an enterprise was 20 percent, then we calculate the tax holidays as the difference between profits multiplied by 20 percent and actual taxes paid. The results are robust to choice of statutory tax rate (ie the top 33 percent rate versus a lower rate).

As with standard Herfindahl indices, a smaller number indicates a higher degree of dispersion of subsidies or tax holidays, or a more equitable (and competition-preserving) allocation of those across firms in the sector. We then take the 1 - these Herfindahl indexes to capture the degree of sectoral dispersion of the tax holidays or subsidies. The $1-$ $Herf\_subsidy$ term we call $CompHerf\_subsidy$. The $1 - Herf\_tax$ term we call $CompHerf\_tax$. 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 in the productivity regression to be positive.

We also compute an analogous measure for loans. Since it is difficult to know what portion of loans are low-interest, we identify by sector and year the mean interest rate paid. We compute industrial support as the difference between mean interest rates paid in a sector and actual interest paid by firms for those enterprises paying lower rates. To the extent that firms in a particular sector and region are unable to access capital, we would expect a more concentrated distribution of subsidized interest payments.

If we were to regress firm-level measures of total factor productivity (TFP) on these sectoral dispersion measures, such an approach could raise potential endogeneity issues. For example, if governments favor large and more successful firms in the allocation process, then a firm that accounts for a large share of total tax holidays or subsidies within a sector might also exhibit higher TFP. These would lead our estimation procedure to reflect spurious relationships between state support and performance. A similar possibility exists if the government tends to support weaker enterprises, which could bias the coefficient in the opposite direction.

To address the potential endogeneity of our policy instruments, we calculate them separately for each firm and exclude the firm's own industrial support (subsidies, tax holidays, interest payments) in estimating our Herfindahl measures. This means that in calculating $1 - Herf\_subsidy$, we exclude firm i's subsidy in both the numerator and the denominator. For the inverse of the $Herf\_tax$ or the $Herf\_interest$, we do the same exclusion. Consequently, this sector-level measure is exogenous with respect to firm i's performance.

Combining our Ω's which measure the links between sectoral targeting and initial competition at the local level, and our Herfindahl indices which measure the dispersion of industrial policy, the basic estimating equation can then be written as follows, where m indicates an industrial policy type:

$$\ln TFP_{ijt} = \theta_1 Z_{ijt} + \theta_2 S_{jt} + \beta_m CompHerf_{imjt} + \alpha_m \mathbf{\Omega}_{mrt} + \ell_i + d_t + \epsilon_{ijt}, \quad (8)$$

where Z is a vector of firm-level controls including state ownership at the firm level. Although we are excluding 100 percent state-owned enterprises from the analysis, many so-called private firms retain some degree of state participation. The variable S includes sector-level controls, such as tariffs or the degree of (initial) competition in the sector or the degree of foreign penetration in the sector as well as upstream and downstream foreign investment. [11]

$CompHerf_{imjt}$ is a vector of industrial policies which measures the extent of sectoral dispersion in subsidies, tax holidays, and interest payments. The specification includes firm fixed effects ℓ_i as well as time fixed effects d_t. Our conjecture is that $\alpha_m > 0$, i.e that industrial policies targeted towards sectors with higher competition as measured by the Lerner index in the initial year of the sample are more TFP enhancing. We also conjecture that β_m is likely to be positive if the distribution of industrial policies targets innovators or promotes more competition. We explore different possible targeting schemes in our analysis below.

B. Baseline results

We begin with the baseline estimates from (8). The critical parameters are the coefficients on the vector of industrial policies $\alpha_m$and β_m.Table 4 reports the coefficient estimates. The dependent variable is the log of TFP, using both the Olley-Pakes (OP) method and OLS with firm-level fixed effects to compute input shares in the first stage as a comparison. Our OP approach follows Olley and Pakes (2003) in calculating sector-specific input coefficients in the first stage and is described in more detail in an online appendix. As indicated earlier, all specifications include both time and firm fixed effects. We also include as controls different sector-level measures of foreign presence, but do not report them in Table 4.

[11]For more discussion of the measures of foreign presence, which include measures for horizontal ("horizontal") and vertical ("backward" and "forward") foreign exposure, see Du, Harrison, and Jefferson (2012).

More dispersed intervention is more TFP-enhancing. — 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 $CompHerf$ to be positive. This is precisely what we obtain in the first row of Table 4, which shows positive and significant coefficients on $CompHerf$ for subsidies. The coefficient estimates in column (1) indicates that a perfectly dispersed set of subsidies, leading to a Herfindahl for subsidies of zero and consequently the complement of that at 1, would increase TFP by 3.9 percentage points.

Table 4. Competitiveness of Industrial Policies and Firm Productivity

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	TFP_OLSFE				TFP_OP			
comp_herfsubsidy	0.0388***			0.0305***	0.0407***			0.0319***
	(0.00976)			(0.00824)	(0.0110)			(0.00918)
cor_subsidy_lerner	0.00225			0.000959	0.00115			0.00009
	(0.00348)			(0.00397)	(0.00338)			(0.00394)
comp_herftax		0.0999***		0.0859***		0.103***		0.0861***
		(0.0207)		(0.0230)		(0.0229)		(0.0249)
cor_tax_lerner		-0.0143***		-0.0151***		-0.0152***		-0.0161***
		(0.00396)		(0.00421)		(0.00417)		(0.00458)
comp_herfinterest			0.0766***	0.0568***			0.0845***	0.0669***
			(0.0169)	(0.0164)			(0.0195)	(0.0190)
cor_interest_lerner			0.0133***	0.0124***			0.0126***	0.0122***
			(0.00399)	(0.00450)			(0.00389)	(0.00445)
cor_tariff_lerner	-0.0411***	-0.0208**	-0.0330***	-0.0305**	-0.0312**	-0.0163	-0.0281***	-0.0199
	(0.0143)	(0.00975)	(0.00995)	(0.0147)	(0.0145)	(0.0101)	(0.0104)	(0.0149)
lerner	10.63**	9.349***	9.404***	10.26**	12.98**	9.099**	9.396**	12.05*
	(4.712)	(3.449)	(3.417)	(4.535)	(6.320)	(3.677)	(3.677)	(6.102)
lernersquare	-6.141**	-5.362***	-5.413***	-5.953**	-6.963**	-4.927**	-5.108**	-6.464*
	(2.591)	(1.898)	(1.886)	(2.493)	(3.458)	(2.060)	(2.066)	(3.344)
exportshare_sector	0.328**	0.370***	0.346**	0.343**	0.632***	0.683***	0.651***	0.660***
	(0.141)	(0.139)	(0.139)	(0.141)	(0.178)	(0.175)	(0.175)	(0.178)
stateshare	0.00293	5.35e-05	-0.000432	0.00301	0.00310	-0.000412	-0.000588	0.00315
	(0.00470)	(0.00428)	(0.00399)	(0.00504)	(0.00481)	(0.00425)	(0.00397)	(0.00514)
index_subsidy	0.0116***	0.0110***	0.0116***	0.0105***	0.00805***	0.00759***	0.00833***	0.00674***
	(0.00181)	(0.00170)	(0.00168)	(0.00190)	(0.00193)	(0.00187)	(0.00185)	(0.00199)
index_tax	0.0220***	0.0201***	0.0218***	0.0205***	0.0214***	0.0197***	0.0213***	0.0200***
	(0.00104)	(0.000951)	(0.000906)	(0.00108)	(0.00103)	(0.000897)	(0.000873)	(0.00103)
index_interest	-0.0129***	-0.0142***	-0.0157***	-0.0120***	-0.0109***	-0.0124***	-0.0139***	-0.0101***
	(0.00163)	(0.00144)	(0.00148)	(0.00169)	(0.00187)	(0.00164)	(0.00167)	(0.00192)
lnTariff	0.0716	0.0619	0.0626	0.0690	0.0527	0.0416	0.0449	0.0476
	(0.0579)	(0.0556)	(0.0556)	(0.0576)	(0.0570)	(0.0551)	(0.0549)	(0.0565)
Constant	-2.876	-2.378	-2.398	-2.776	-4.500	-2.655	-2.794	-4.154
	(2.196)	(1.627)	(1.607)	(2.133)	(2.945)	(1.696)	(1.690)	(2.858)
Observations	810,740	903,455	962,076	746,304	810,740	903,455	962,076	746,304
R-squared	0.205	0.205	0.205	0.208	0.181	0.183	0.182	0.184

Notes: Robust clustered standard errors are presented in parentheses. the dependent variable is TFP (estimated by OLS with fixed-effects in columns (1), (2), (3), (4); estimated by Olley- Pakes method in columns (5), (6), (7), (8)). For the OP estimation of TFP, it's indeed a two-stage estimation. In the first stage, we use the OP regression method to obtain estimates for the input coefficients and then calculate TFP (the residual from the production function). In the second stage, we regress TFP on the remaining controls. Each regression includes firm fixed effect and year dummies. Comp_herf_XX are Herfindhal index of subsidy, tax, and interest rate policies, measured on the city-industry-year level. Cor_XX_lerner is constructed by the correlation between the industry-city level initial degree of competition (represented by lerner index) and current period of subsidies, tax breaks, and interest rate, all the correlations are on the city-year level. Each regression includes industry fixed effect and year dummies. Export share is calculated by export procurement divided by industrial sales. State share is defined as the proportion of the firm's state assets to its total equity. Those two shares are aggregated at the sector-year level. Index_subsidy, index_tax, and Index_interest are dummy variables which equal to one if a firm receives subsidies, tax breaks, or a below-median borrowing interest rate, respectively. Sector-level FDI and other (input) tariffs also included as controls but not reported. *significant at 10%, **significant at 5%, ***significant at 1%.

The coefficient on $\Omega_{rt,subsidies}$ indicates the extent to which targeting at the city level via subsidies is more efficient in more competitive industries, as measured by the initial degree of competition at the beginning of the sample period. The coefficient estimates are reported in the second row of Table 4. While the coefficient is positive across all specifications, it is not significantly different from zero.

Together, the first two rows of Table 4 indicate that while allocating subsidies to initially more competitive sectors did not significantly affect productivity, a greater dispersion of subsidies was associated with improved firm performance. Later we will explore how moving beyond equitable allocations of subsidies to targeting innovative firms could further increase the positive impact of firm subsidies on performance.

The next row of Table 4 looks at the correlation between firm level TFP and our measure for the dispersion of tax holidays $CompHerf\_tax$. The coefficient is statistically significant and positive, indicating that greater dispersion of tax holidays increases productivity. The coefficient estimate, which varies from .086 to .103, indicates driving the Herfindahl for the dispersion of tax holidays on income taxes and value-added taxes to zero would leads to an increase in TFP of 8.6 to 10.3 percentage points.

The coefficient estimate on the correlation between tax holidays and initial competition $\Omega_{rt,taxholidays}$ at the city level in column (1), equal to -0.0143, indicates that if the correlation between tax holidays and competition at the city level was perfect (100 percent), then productivity would be 1.43 percent higher. Based on the sample means, a one standard deviation increase in the city-industry correlation would increase TFP by .3 percentage points for firms in that city and industry.

The fifth row of Table 4 reports the impact of wider dispersion of interest payments for loans on productivity outcomes. The coefficient on the Herfindahl for interest payments is positive and significant across all specifications, indicating that a wider dispersion of subsidized interest payments is consistent with higher productivity at the firm level. The coefficient estimate varies from .057 to .085, indicating that a perfectly disperse set of interest payments would be associated with higher productivity by 5.7 to 8.5 percentage points. A one standard deviation increase in the variable would be associated with 1.2 to 1.6 percentage points increase in TFP.[12]

While the first 3 columns of Table 4 report the effects of different industrial policies separately, column (4) combines all of them in one specification. The coefficient estimates are unaffected. The results in column (4) indicate that a more equitable dispersion of subsidies, tax holidays, and interest payments across firms within a sector are unequivocally associated with higher productivity growth at the firm level. While a higher level of subsidies or tax holidays are associated with higher productivity in initially competitive sectors, the results are mixed or negative for loans and tariffs. We shall see below that the positive effects at the city level of subsidies and tax holidays, and the mixed role of tariffs and low interest loans, are consistent with their individual effects at the firm level.

Robustness. — The coefficient estimates when using Olley-Pakes to estimate TFP are reported in the last four columns of Table 4. Consistent with reviews of the productivity literature, the results are not very different when using OP estimates of TFP versus OLS with firm fixed effects. One difference is that the coefficient on the correlation of tariffs and initial competition becomes insignificant, but remains negative with an attenuated coefficient.

The remaining part of Table 4 reports the coefficients on the sector and firm level controls. At the sector level, competition measured using $1 - Lerner$ is positively

[12]While the first five rows of Table 4 suggest potentially significant positive effects of industrial policies, these are not uniform. In particular, the correlation between interest payments and competition is positive, suggesting improved TFP when effective interest rates are *higher* in more initially competitive sectors. Similarly, the correlation between tariffs and competition in the sector, is negative, indicating that tariff interventions in more competitive sectors have been associated with lower TFP. The coefficient estimate, which ranges from -0.0199 to -0.0411, suggests that if higher tariffs were perfectly correlated with higher initial competition, then TFP would be from 2 to 4 percentage points lower.

and significantly associated with increased TFP. We also include a squared term, and the coefficient is negative. This nonlinear relationship between competition and productivity, which is increasing at lower levels and falling at higher levels, is consistent with the inverted U-shape found in particular by Aghion et al (2005). If, instead, we measure competition using sectoral export shares, we also find a significant and positive association with TFP. This strong, positive, independent impact of competition–measured using either the sector-level Lerner index or export shares, is consistent with an important role for competition in enhancing firm performance.

One question which might arise is the potential endogeneity of the Lerner index and its square, which are included as controls. We address the potential endogeneity of the correlation and herfindahl measures by explicitly excluding the own firm in the calculations and using initial period Lerners to construct the correlations. For the Lerner control measures, endogeneity is also unlikely to be a problem as we use the initial period Lerner measure in that location and sector. Using Lerner measures as controls that were calculated at the beginning of the sample period mitigate possible reverse causality between firm behavior, sectoral productivity distributions, and market structure.

We also include controls for subsidies, tax holidays, tariffs, and low-interest loans at the individual enterprise level. We include a zero-one control variable, *index_subsidy*, which is equal to one if the enterprise received non-zero and positive subsidy amounts in that year. We also include a zero-one control indicating whether the firm received tax holidays, *index_tax*. The tax break is defined as a zero-one variable indicating whether the firm paid either taxes at a lower rate than the statutory corporate tax rate or value-added taxes at a lower rate than the statutory rate. The coefficients on the subsidy and tax holiday dummies are positive and significant. We also include a control for loans, which is equal to one if the firm's interest payments to current liabilities (an effective interest rate) are below the average for that sector and year. The coefficient on the index_interest term is negative and significant. Firms which receive lower interest rates do not perform better when performance is measured using TFP. These results for loans as an industrial policy measure are consistent with the coefficients on the industry-city correlations indicating better performance at the city level when interest payments are higher, not lower.[13]

SUMMARIZING. — Overall, the results in Table 4 suggest that preserving competition through a more equitable targeting policy is associated with superior performance, as measured by productivity. We addressed the potential endogeneity of targeting by excluding a firm's own subsidies or tax holidays when estimating the impact of sectoral dispersion of subsidies or tax holidays on that firm's TFP. Overall, the evidence suggests that instruments such as tax holidays and subsidies have systemically been associated with improved productivity performance when combined with high initial levels of competition, as measured by the Lerner index.

One interesting question to ask is how much actual tariff and subsidy levels at the city-industry level were in fact correlated with actual competition levels. The summary statistics in Appendix Table 1 suggest that in fact the Chinese government did not set tariff or subsidy levels higher in cities or industries where competition was more intense. The average correlation coefficient between tariffs and the Lerner measure is -0.02, suggesting almost zero correlation between tariffs and competition. The correlation with subsidies is positive but close to zero, at 0.03. The only instrument where there is significant targeting is taxes, where the correlation with competition is equal to -0.1. The coefficient of -0.1 is suggestive of a strong negative association between more initial competition and

[13]The impact of tariffs depends on where they are allocated. While final tariffs facing a sector are positively associated with TFP, the effect is not statistically significant. Higher tariffs in input or using sectors have negative effects on firm TFP. These insignificant or negative effects of tariff protection on firm level TFP are consistent with our results showing that even if tariffs are targeted at more competitive sectors they fail to yield improved performance. Tariffs discourage competition and are generally second-best incentive devices, so it is not surprising that using tariffs as a tool of industrial policy is not effective in the Chinese context.

lower taxes. While the evidence in Table 4 is consistent with higher performance as measured by TFP when policy instruments are introduced in conjunction with greater competition, the actual pattern of policies does not suggest that this is what the Chinese actually did. One interpretation is that there is enormous scope for improved performance outcomes associated with industrial policy if it is introduced in a way that preserves competition in the future.

C. Targeting innovative enterprises

Should some firms receive more support than others? This is the question we address in Table 5. If industrial policies are more effective when they induce greater competition between innovating firms as we are hypothesizing, then it should in principle be possible to improve on a purely equitable distribution by targeting firms most likely to engage in innovation. The new heterogeneous firm literature pioneered by Hopenhayn (1992) and Melitz (2003) predicts that the most productive firms are also likely to be the largest firms. These firms are also likely, in the heterogeneous firm literature, to be the lowest cost and most competitive producers. Consequently, one possibility is to redo the analysis with Herfindahls but give greater weight to larger enterprises. We report the unweighted results in columns (1) and (2), and the results weighting by firm size using number of employees in column (3).

Another way to induce greater competition is to promote new entry and encourage younger firms to enter. To capture the importance of entry, we redo the Herfindahls and weight the individual subsidy, interest, and tax holiday allocations by the inverse of a firm's age. Effectively, this means giving the greatest weight to the youngest firms. These results are reported in column (4) of Table 5.

The results in Table 5 suggest that in the Chinese case, targeting younger but not bigger firms significantly increases the positive impact of industrial policies on total factor productivity.[14] For subsidies, the coefficient on the Herfindahl increases by a factor of 3. The coefficient estimate, at 0.10, indicates that a one standard deviation increase in the Herfindahl would increase a firm's TFP by 3 percentage points. One reason why targeting younger firms may be more beneficial is that younger firms generally have higher TFP (measured either using the OP procedure or OLS with firm fixed effects).

One potential pitfall of measuring process innovation using total factor productivity is when output is calculated using sector deflators with firm level revenue. This revenue-based TFP is potentially misleading because it could reflect changes in firm-specific quality or mark-ups. One solution exists when firm-specific price deflators are available, which account for price heterogeneity (due to market power differences or quality differences) across firms. For the Chinese industrial census data, such firm-specific deflators are available for the years 1998 through 2003. Consequently, we redo the results presented in Table 5 with this shorter time series, using the firm-specific price deflators to calculate first output and then TFP. The results using firm-specific price deflators to calculate TFP are reported in Table 6.

[14]This is consistent with the analysis in Acemoglu et al (2013).

Table 5. The Impact of the Competitiveness of Industrial Policies on Firm TFP: Weighted Herfindhal

VARIABLES	(1) TFP_OLSFE	(2) TFP_OP	(3) TFP OP	(4) TFP_OP
comp_herfsubsidy	0.0305***	0.0319***		
	(0.00824)	(0.00918)		
comp_herftax	0.0859***	0.0861***		
	(0.0230)	(0.0249)		
comp_herfinterest	0.0568***	0.0669***		
	(0.0164)	(0.0190)		
comp_herfsubsidy_weightsize			0.0255***	
			(0.00909)	
comp_herftax_weightsize			0.0555***	
			(0.0124)	
comp_herfinterest_weightsize			0.0616***	
			(0.00983)	
comp_herfsubsidy_weightage				0.102***
				(0.0313)
comp_herftax_weightage				0.0781***
				(0.0255)
comp_herfinterest_weightage				0.0541**
				(0.0253)
lerner	10.26**	12.05*	12.72**	12.62**
	(4.535)	(6.102)	(6.253)	(6.262)
lernersquare	-5.953**	-6.464*	-6.813*	-6.760*
	(2.493)	(3.344)	(3.420)	(3.424)
index_subsidy	0.0105***	0.00674***	0.00781***	0.00786***
	(0.00190)	(0.00199)	(0.00198)	(0.00196)
index_tax	0.0205***	0.0200***	0.0201***	0.0200***
	(0.00108)	(0.00103)	(0.00104)	(0.00105)
index_interest	-0.0120***	-0.0101***	-0.0100***	-0.0100***
	(0.00169)	(0.00192)	(0.00191)	(0.00192)
exportshare_sector	0.343**	0.660***	0.672***	0.673***
	(0.141)	(0.178)	(0.179)	(0.179)
stateshare	0.00301	0.00315	0.00273	0.00289
	(0.00504)	(0.00514)	(0.00516)	(0.00511)
Constant	-2.776	-4.154	-4.474	-4.521
	(2.133)	(2.858)	(2.936)	(2.944)
Observations	746,304	746,304	747,158	746,740
R-squared	0.208	0.184	0.182	0.182

Notes: Robust clustered standard errors are presented in parentheses. For column (1), the dependent variable is TFP (estimated by OLS with fixed-effects); in columns (2), (3), and (4) TFP is estimated by OP as described in the text. Each regression includes firm fixed effect and year dummies. Comp_herf_XX are Herfindhal indices of subsidy, tax, and interest rate policies, measured on the city-industry-year level. Columns (1) and (2) use an unweighted Herfindhal index, column (3) computes a Herfindhal index weighted by firm size (number of employees), and column (4) weights the Herfindhal index using 1/age (year since establishment). Export share is calculated by export procurement divided by industrial sales. State share is defined as the proportion of the firm's state assets to its total equity. Those two shares are aggregated at the sector-year level. Index_subsidy, index_tax, and Index_interest are dummy variables which equal to one if a firm receives subsidies, tax breaks, or a below-median borrowing interest rate, respectively. Sector FDI measures included but not reported. *significant at 10%, **significant at 5%, ***significant at 1%.

Table 6. Competitiveness of Industrial Policies and Firm Productivity: Robustness Check with TFP Calculated by Firm-level Price Deflator and TFP modified to include policies in first stage OP estimation

VARIABLES	(1)	(2)	(3)	(4)
	Using Firm-level Prices		Adding Policies in First Stage OP	
	TFP_OLSFE	TFP_OP	TFP_OLSFE	TFP_OP
comp_herfsubsidy	0.0325**	0.0560**	0.0306***	0.0427***
	(0.0150)	(0.0228)	(0.00857)	(0.0109)
comp_herftax	0.0497	0.126**	0.0857***	0.111***
	(0.0387)	(0.0568)	(0.0234)	(0.0285)
comp_herfinterest	0.0341	0.0920**	0.0573***	0.0876***
	(0.0299)	(0.0437)	(0.0172)	(0.0230)
lerner	17.42***	21.61**	10.19**	10.09**
	(5.885)	(8.681)	(4.554)	(4.179)
lernersquare	-9.200***	-11.22**	-5.902**	-5.474**
	(3.283)	(4.793)	(2.499)	(2.317)
exportshare_sector	0.506	0.354	0.350**	0.606***
	(0.423)	(0.610)	(0.146)	(0.205)
stateshare	0.0119	0.0147	0.00319	0.00107
	(0.00929)	(0.0108)	(0.00503)	(0.00411)
index_subsidy	0.0110***	0.0101**	0.0104***	0.0107***
	(0.00325)	(0.00383)	(0.00191)	(0.00184)
index_tax	0.0143***	0.0143***	0.0204***	0.0219***
	(0.00206)	(0.00218)	(0.00108)	(0.000902)
index_interest	-0.0109***	-0.0162***	-0.0120***	-0.0161***
	(0.00248)	(0.00322)	(0.00173)	(0.00185)
Observations	182,248	182,248	746,304	962,076
R-squared	0.082	0.129	0.207	0.191

Notes: Robust clustered standard errors are presented in parentheses. Regressions in the first two columns are based on a sub-sample of firms existed for all years between 1998 and 2003. We use this sub-sample in order to calculate the TFP using firm-level price-deflator, which is calculated by current value of output divided by constant value of output. The dependent variable is TFP (estimated by OLS with fixed-effects in columns (1) and (3); estimated by Olley- Pakes method in columns (2) and (4)). Each regression includes firm fixed effect and year dummies. Comp_herf_XX are Herfindhal index of subsidy, tax, and interest rate policies, measured on the city-industry-year level. Each regression includes firm fixed effects and year dummies. E xport share is calculated by export procurement divided by industrial sales. State share is defined as the proportion of the firm's state assets to its total equity. Those two shares are aggregated at the sector-year level. Index_subsidy, index_tax, and Index_interest are dummy variables which equal to one if a firm receives subsidies, tax breaks, or a below-median borrowing interest rate, respectively. Other controls include horizontal and vertical FDI shares and input and output tariffs, but the coefficients are not reported in this table. Columns (3) and (4) include policy variables above in the first stage of the OP estimation, which estimates factor share coefficients. *significant at 10%, **significant at 5%, ***significant at 1%.

The sample size using the earlier years is considerably smaller, at only a quarter of the full sample. However, the results are quite robust. The coefficient on the subsidy Herfindahl, calculated using the OP procedure, increases from 0.03 in Table 5 to .06, a doubling of magnitudes. The coefficients for the dispersion of tax holidays and low interest loans also increase significanty. The evidence suggests that using a much smaller sample and implementing firm-specific prices magnifies the effects significantly.

Another potential concern is the possible mis-measurement of TFP using Olley-Pakes when policies are omitted in the first stage. Recent developments in the productivity literature suggest that excluding policies in the first stage could lead to biased estimates in the first stage of OP, which estimates input share coefficients. To test for this possiblity, we redid the analysis adding all the key policies in the first stage, and report the results in the last two columns of Table 6. The coefficients on the herfindahl terms remain significant and even more important in magnitude than the original specification reported in Table 4. The evidence in Table 6 suggests that our results emphasizing the positive impact of dispersion on productivity are robust to many different specifications and subsamples.

D. Within-firm versus across-firm reallocation effects of industrial policy

In recent years, applied productivity researchers have shifted their focus away from the determinants of changes in behavior within the same firm to address market share reallocation across firms and the consequences for aggregate productivity. This shift in focus can be traced to the work of Olley and Pakes (1996), who propose a simple approach to disentangling within versus between components. The interest in *within* versus *between* firm reallocation also increased with the work of Hopenhayn (1992), Melitz (2003) and others, who assume that firms have a pre-determined exogenous productivity draw and that consequently much of industry productivity growth is not through learning within a firm but through reallocation of market shares across firms.[15]

Tables 4 through 6 explored the extent to which within-firm productivity gains were affected by how different types of industrial policies were allocated across firms. In Table 7, we explore reallocation towards more productive enterprises. This in turn requires a measure of TFP at the sector level, thus we recalculate our measure of TFP at the city-sector-year level, and execute the same specification as in Table 4 using these more aggregate reallocation terms. The results are reported in Table 7. Now, instead of focusing on whether industrial policies encourage the same firm over time to innovate more, we focus on whether industrial policies encourage reallocation of market shares towards the more productive enterprises. One can think of this as exploring the extensive margin of productivity growth, rather than the intensive margin, which focuses on improvements in firm performance within the same firm over time.

The first two columns of Table 7 report the relationship between the reallocation component of industry-city-level production and our policy measures. Column (1) reports the measures when TFP is calculated using OLS with firm fixed effects, and column (2) reports the OP estimates. The results indicate that while a broader distribution of low interest loans and tax holidays are significantly and positively associated with greater productivity improvements due to reallocation towards more productive firms, the unweighted results for subsidies are negative. Taken together with our earlier results, we can conclude that while low interest policies were not effective in contributing to within-firm improvements in innovation, they did encourage reallocation of market share towards more innovative firms. Low interest policies and a broader dispersion of tax holidays contributed to the extensive margin of productivity growth. The same is not true for subsidies –which appear to have operated more at the intensive margin, inducing

[15]The empirical work in this area has somewhat lagged behind the theoretical contributions. One of the first to apply the Olley and Pakes (1996) decomposition was Pavcnik (2003), who found that reallocation accounted for up to two thirds of productivity growth at the industry level and within firm learning accounted for one third. For India, the results are the opposite: Harrison, Martin, and Nataraj (2013) find that most of industry productivity growth is due to within firm effects and almost none is due to market share reallocations. This result for India is corroborated by work by Sivadasan (2010).

within firm productivity improvements.

Table 7. Competitiveness of Industrial Policies and Reallocation

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	TFP_OLSFE	TFP_OP	TFP_OLSFE	TFP_OP	TFP_OLSFE	TFP_OP
comp_herfsubsidy	-0.0116***	-0.0108***				
	(0.00207)	(0.00194)				
comp_herftax	0.0283***	0.0173***				
	(0.00576)	(0.00494)				
comp_herfinterest	0.0528***	0.0496***				
	(0.00431)	(0.00426)				
comp_herfsubsidy_weightsize			-0.00199	0.00223		
			(0.00598)	(0.00571)		
comp_herftax_weightsize			0.0175**	0.00853		
			(0.00806)	(0.00764)		
comp_herfinterest_weightsize			0.0667***	0.0617***		
			(0.00712)	(0.00659)		
comp_herfsubsidy_weightage					0.0668***	0.0536***
					(0.00776)	(0.00728)
comp_herftax_weightage					0.0892***	0.0743***
					(0.00590)	(0.00648)
comp_herfinterest_weightage					0.100***	0.0880***
					(0.00573)	(0.00665)
lerner	1.202***	1.082***	1.226***	1.095***	1.121***	1.008***
	(0.305)	(0.273)	(0.319)	(0.282)	(0.310)	(0.275)
lernersquare	-0.807***	-0.720***	-0.819***	-0.725***	-0.759***	-0.676***
	(0.187)	(0.167)	(0.195)	(0.171)	(0.189)	(0.167)
exportshare_sector	0.0156	0.00170	0.0127	0.00173	0.0195	0.00620
	(0.113)	(0.106)	(0.115)	(0.106)	(0.112)	(0.104)
stateshare	-0.0775	0.0168	-0.0596	0.0317	-0.0792	0.0157
	(0.0962)	(0.0956)	(0.0991)	(0.0977)	(0.0993)	(0.0980)
index_subsidy	0.000158	-0.00416	0.00754*	0.00432	0.0286***	0.0202***
	(0.00387)	(0.00353)	(0.00410)	(0.00378)	(0.00507)	(0.00469)
index_tax	-0.00263	-0.00148	-0.00264	-0.00201	-0.00355	-0.00279
	(0.00234)	(0.00203)	(0.00242)	(0.00215)	(0.00234)	(0.00207)
index_interest	0.00671**	0.00637**	0.0125***	0.0118***	0.0157***	0.0145***
	(0.00288)	(0.00279)	(0.00296)	(0.00284)	(0.00297)	(0.00288)
Constant	-2.539***	-2.417***	-2.622***	-2.494***	-2.696***	-2.553***
	(0.199)	(0.231)	(0.198)	(0.230)	(0.200)	(0.234)
Observations	64,455	64,455	64,455	64,455	64,455	64,455
R-squared	0.080	0.068	0.069	0.060	0.093	0.079

Notes: Robust clustered standard errors are presented in parentheses. The dependent variable is a measure of between-firm reallocation of TFP (estimated by OLS with fixed-effects in columns (1), (3), (5); estimated by Olley- Pakes method in columns (2), (4), (6)). Each regression includes province fixed effect and year dummies. Comp_herf_XX are Herfindhal index of subsidy, tax, and interest rate policies, measured on the city-industry-year level. Columns (1)-(2) use unweighted Herfindhal index, columns (3)-(4) are based on Herfindhal index weighted by firm size (number of employees), and columns (5)-(6) look at Herfindhal index weigthed by 1/age (year since establishment). Cor_XX_lerner is constructed by the correlation between the industry-city level initial degree of competition (represented by lerner index) and current period of subsidies, tax breaks, and interest rate, all the correlations are on the city-year level. Each regression includes industry fixed effect and year dummies. Export share is calculated by export procurement divided by industrial sales. State share is defined as the proportion of the firm's state assets to its total equity. Those two shares are aggregated at the sector-year level. Index_XX is defined as the share of firms within each city-industry-year receiving subsidies, tax breaks, or below-median interest rates, respectively. All specifications include sector-level FDI controls. *significant at 10%, **significant at 5%, ***significant at 1%.

The next four columns of Table 7 report the outcomes when we weight industrial policy by firm size or the inverse of age. The results indicate that the impact of subsidies switch from negative to positive, suggesting that they can play a positive role in encouraging the reallocation component of TFP growth if they are directed at younger or larger enterprises.[16] As with the earlier results, the largest impact on TFP occurs when industrial policies are oriented towards younger enterprises. The last two columns of Table 7 show significant TFP gains from reallocation of market share when subsidies, tax holidays, and low interest loans are focused on younger enterprises.

IV. Conclusion

In this paper we have argued that sectoral state aid can foster productivity growth to a larger extent when it targets more competitive sectors and especially when it is not concentrated on one or a small number of firms within the sector.

Thus, using a comprehensive dataset of all medium and large enterprises in China between 1998 and 2007, we show that industrial policies (subsidies or tax holidays) that are allocated to competitive sectors (as measured by the Lerner index) or allocated in such a way as to preserve or increase competition (e.g. by inducing entry or encouraging younger enterprises), have a more positive and significant impact on productivity or productivity growth.

If we focus on the intensive margin of within firm behavior, spreading these instruments across more firms is associated with positive productivity increases at the firm level. Even greater benefits, leading to a doubling or tripling of the effects, is associated with allocating more benefits to more competitive (i.e., typically younger) firms.

[16]One question which arises is to what extent TFP growth in China reflects primarily increases in average firm productivity versus reallocation of market shares In the Chinese case, only five percent of industry level TFP reflects the reallocation component, as reported in Appendix Table A.2 The small role of market share reallocation underscores the importance of focusing on individual firm-level productivity changes, which has been the focus of most of our analysis. While market share reallocation has increased during the sample period, it is significantly smaller than in countries like the United States. The predominance of firm level productivity as acccounting for industry level performance for China was also highlighted by Loren Brandt and his co-authors.

We also find evidence of improved firm performance when industrial policies are targeted towards sectors with initially more competition. This is true for subsidies and tax breaks as instruments of industrial policy, but not for loans or tariffs. [17]

This in turn suggests that 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. 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: 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-friendly 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.

One question which might arise is how this approach can work when there are significant economies of scale. We tested the framework in the context of the Chinese domestic market, which is large enough to allow producers to exploit scale economies in most industrial sectors. In a smaller economy, the question of how to encourage more focus and rivalry while allowing firms to reap the cost gains from exploiting scale economies would have more relevance. In that context, competition could be preserved by exposing firms to international rivalry. It is not surprising that smaller economies like South Korea were able to exploit the benefits of competition by forcing firms that received targeted support to compete

[17] In China, low interest loans and tariffs were associated on net with lower productivity performance of targeted manufacturing firms. Not surprisingly, thus allocating higher tariffs or more low interest loans towards more competitive sectors as a result was not associated with improved productivity performance. A main implication from our analysis is that the debate on industrial policy should no longer be for or against the wisdom of such a policy.

on global markets. Further research exploring the implementation of industrial policy under increasing returns remains an avenue for future research.

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Tables

Appendix Table A1: Means and Standard Deviations for Variables

Variable	Mean	Standard Deviation	Min	Max
Comp Herf Subsidy	0.570	0.337	0	1
Comp Herf Tax	0.871	0.196	0	1
Comp Herf Interest	0.846	0.204	0	1
Corr Subsidy Lerner	0.0292	0.172	-1	1
Corr Tax Lerner	-0.100	0.216	-1	1
Corr Interest Lerner	0.0477	0.198	-1	1
Corr Tariff Lerner	-0.0164	0.165	-1	1
Lerner	0.988	0.0257	0.0275	1
Lerner Squared	0.976	0.0476	0.000756	1
Index Subsidy	0.114	0.318	0	1
Index Tax	0.423	0.494	0	1
Index Interest	0.690	0.462	0	1
Export Share	0.175	0.152	0.00634	0.685
State Share	0.0215	0.127	0	1
Horizontal FDI	0.240	0.128	0.000722	0.939
Backward FDI	0.0741	0.0401	0.00984	0.498
Forward FDI	0.0987	0.148	0	1.264
lnTariff	2.389	0.472	0.861	4.174
lnIndirect Tariff	1.971	0.413	0.902	3.230
lnInput Tariff	2.074	0.638	-1.376	3.099
log of TFP (OLS with Firm Fixed Effects)	2.016	0.448	-0.229	11.49
log of TFP (Olley Pakes)	1.853	0.464	-0.512	11.17

Appendix Table A2
Percentage of TFP Increase Due to Reallocation of Market Share Versus Average Firm Productivity Increases

1999

Variable	Obs	Mean	Std. Dev.
Reallocation Share (OLS with Fixed Effects)	7714	0.0359349	0.0509876
Average Firm Productivity (OLS with Fixed Effects)	7714	0.9640651	0.0509876
Reallocation Share (OP)	7714	0.0351037	0.0535686
Average Firm Productivity (OP)	7714	0.9648963	0.0535686

2000

Variable	Obs	Mean	Std. Dev.
Reallocation Share (OLS with Fixed Effects)	7649	0.0389031	0.0538936
Average Firm Productivity (OLS with Fixed Effects)	7649	0.9610969	0.0538936
Reallocation Share (OP)	7649	0.0377865	0.0579714
Average Firm Productivity (OP)	7649	0.9622135	0.0579714

2001

Variable	Obs	Mean	Std. Dev.
Reallocation Share (OLS with Fixed Effects)	7872	0.0403249	0.0520197
Average Firm Productivity (OLS with Fixed Effects)	7872	0.9596751	0.0520197
Reallocation Share (OP)	7872	0.0389779	0.0533513
Average Firm Productivity (OP)	7872	0.9610221	0.0533513

2004

Variable	Obs	Mean	Std. Dev.
Reallocation Share (OLS with Fixed Effects)	8382	0.0485715	0.0558423
Average Firm Productivity (OLS with Fixed Effects)	8382	0.9514285	0.0558423
Reallocation Share (OP)	8382	0.0456245	0.0563391
Average Firm Productivity (OP)	8382	0.9543755	0.0563391

2007

Variable	Obs	Mean	Std. Dev.
Reallocation Share (OLS with Fixed Effects)	8697	0.0552214	0.0572704
Average Firm Productivity (OLS with Fixed Effects)	8697	0.9447786	0.0572704
Reallocation Share (OP)	8697	0.0523665	0.0581827
Average Firm Productivity (OP)	8697	0.9476335	0.0581827

Mathematical Appendix

B1. Basic setup

Preferences and production. — We consider a two-period model of an economy producing two goods, denoted by A and B. Denote the quantity consumed on each good by x^A and x^B. The representative consumer has income equal to $2E$ 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 $x^i = E/p^i$. To simplify the writing, we assume that $E = 1$ throughout this paper.[18]

The production can be done by one of two 'big' firms $1, 2$, or by 'fringe firms'. Fringe firms act competitively and have a constant marginal cost of production of c_f whereas firms $j = 1, 2$ have an initial marginal cost of c, where $1 > c_f \geq c$. The assumption $c_f \geq c$ reflects the cost advantage of firms $1, 2$ with respect to the fringe and the assumption $1 > c$ insures that equilibrium quantities can be greater than 1. Marginal costs are firm-specific and are independent of the sector in which production is undertaken.

Innovation. — For simplicity, we assume that only firms $1, 2$ can innovate. Innovation reduces production costs, but the size of the cost reduction is different between the two sectors A and B. Without loss of generality, we assume that in sector A, innovations reduce production costs from c to $c/\gamma_A = c/(\gamma + \delta)$ whereas in sector B they reduce costs from c to $c/\gamma_B = c/(\gamma - \delta)$, where $\gamma - \delta > 1$ or $\delta < \gamma - 1$.

We also make the simple assumption that, with equal probability, each firm can be chosen to be the potential innovator. To innovate with probability q this firm must incur effort cost $q^2/2$. This is like saying that each firm has an exogenous

[18] As will be soon apparent, the rate of innovation is linear in E, and except for this size effect, what matters for the analysis are the ratios E/c and E/c_f.

probability of getting a patentable idea, which then has to be turned into cost reduction thanks to effort exerted by the firm.

COMPETITION. — We assume Bertrand competition within each sector unless the two leading firms choose the same sector and collude within that sector. Let φ be the probability of the two leading firms colluding in the same sector when they have the same cost, and let us assume that when colluding the two firms behave as a joint monopoly taking the fringe cost c_f as given. In this case, the expected profit of each leading firm with cost $c < c_f$ is $\varphi \frac{1}{2} \frac{c_f - c}{c_f}$ since when collusion fails firms compete Bertrand.

INDUSTRIAL POLICY VIA TAX/SUBSIDIES. — Laissez-faire can lead to *diversification* (different sector choices by the two firms) or *focus* (same choice, be it A or B). For industrial policy we will focus on interventions based on taxes or subsidies that are proportional to profit levels, that is on tax levels t_A, t_B per profit level in sectors A, B respectively, where $t_k < 0$ is a subvention and $t_k > 0$ is a tax.[19] We restrict attention to the case where there is perfect information about γ_i and where the profit is net of the cost of innovation.[20]

Firms can choose to be active in different sectors or in the same sector: we refer to the first situation as one of diversity, and the second as one of 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; otherwise the equilibrium is focus. Conditional on this choice firms then decide to invest in order to innovate.

[19] We assume without loss of generality an initial level of taxation equal to zero in each sector.

[20] If the tax/subsidy is on the profit gross of the cost of innovation, then it will also affect the rate at which firms innovate. A reduction in the tax rate on gross profits has a similar effect to a subsidy to the marginal cost of innovation.

Tax/subsidies affect the sectorial choice of activity of firms, for instance, they may choose focus rather than diversity. Because the tax applies to total profits, net of the cost of investing in order to innovate, the investment level is unaffected by the tax rate put in place. Growth, the expected probability of innovation is therefore influenced by the *variance* of taxes across sectors.

We first derive the equilibrium choices under arbitrary tax/subsidy schemes $t_A \leq t_B$ ("laissez-faire" being the case $t_A = t_B = 0$) and show the interaction between our measure of competition φ and the growth rate that can be achieved via such a tax system. We then identify the growth-maximizing tax/subsidy scheme when the planner is subject to a budget constraint.

B2. Equilibrium profits and innovation intensities

DIVERSITY. — Under diversity, firm 1 is in sector A and firm 2 is in sector B and both firms enjoy a cost advantage over their competitors. Let e denote the representative consumer's expense on sector 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 in the other sector and since the representative consumer has total income 2 she will spend 1 on each sector, yielding $x^A = x^B = 1/c_f$.

Suppose first that there is no tax/subsidy in this sector. If the firm is not a potential innovator (which happens with probability 1/2), its profit is equal to:

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

If the firm in sector i is chosen to be a potential innovator, 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 ex ante expected payoff of the firm conditional on being chosen to be a potential innovator and upon choosing innovation intensity q, is equal to:

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

or

$$\pi_i^{DI} \equiv \max_q q \frac{\gamma_i - 1}{\gamma_i} c x^i + (c_f - c)x^i - \frac{1}{2}q^2.$$

Using $x^i = 1/c_f$, the optimal probability of innovation under diversity q_i^D and the corresponding ex ante equilibrium profit $\pi_i^{D_1}$ when chosen to be a potential innovator, are respectively given by:

$$q_i^D \equiv \frac{\gamma_i - 1}{\gamma_i} \frac{c}{c_f} \tag{B1}$$

and

$$\pi_i^{DI} = \frac{\left(q_i^D\right)^2}{2} + \frac{c_f - c}{c_f}.$$

For further use, we shall denote

$$q_A^D = q^D(\delta) \equiv \frac{\gamma + \delta - 1}{\gamma + \delta} \frac{c}{c_f},$$
$$q_B^D = q^D(-\delta) \equiv \frac{\gamma - \delta - 1}{\gamma - \delta} \frac{c}{c_f}.$$

Overall, the ex ante expected payoff from diversifying on sector i is

$$\pi_i^D = \frac{1}{2}(\pi^{DI} + \pi_i^{DN}),$$

that is:

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

With a tax rate t on profits in sector i, the investment in cost-reduction is still equal to q_i^D but the expected profit of the leading firm in sector i is

$$\pi_i^D(t) \equiv (1-t)\pi_i^D.$$

FOCUS. — Consider first the case with full Bertrand competition within each sector (A or B). If both leading firms decide to locate in the same sector, it is optimal for them to choose the sector with higher growth potential, i.e., sector A. Under focus, the next best competitor for firm 1 is firm 2 rather than the fringe, so the equilibrium price is always equal to c which is lower than c_f by assumption. Hence, in this case, $x^A = 1/c$ while $x^B = 1/c_f$ since the consumer buys from the fringe in sector B.

Suppose first that there is no tax/subsidy in sector A. If firm 1 is chosen to be a potential innovator, it will get a profit margin of $c - \frac{c}{\gamma+\delta}$ when it innovates since it will then compete in Bertrand with the other firm and gets the full market share $1/c$. If it does not innovate, it will collude with probability φ in order to set a price c_f and split the demand $1/c_f$ with a profit margin $c_f - c$; if collusion fails, the firms make zero profit. Hence, the firm that is called to innovate solves

$$\pi^{FI} \equiv \max_q q\frac{\gamma+\delta-1}{\gamma+\delta} + (1-q)\varphi\frac{1}{2}\frac{c_f-c}{c_f} - \frac{q^2}{2}$$

The optimal choice of q is then

$$q^F \equiv \frac{\gamma+\delta-1}{\gamma+\delta} - \frac{\varphi}{2}\frac{c_f-c}{c_f} \tag{B2}$$

and therefore

$$\pi^{FI} = \frac{(q^F)^2}{2} + \frac{\varphi}{2}\frac{c_f-c}{c_f}.$$

If the firm is not chosen to be the innovator, it will get positive profits only if the other firm fails and if collusion succeeds, that is the expected profit is

$$\pi^{FN} = (1 - q^F)\frac{\varphi}{2}\frac{c_f - c}{c_f}$$

Hence the expected profit of each firm under focus in sector A is

$$\begin{aligned}\pi^F &= \frac{1}{2}\pi^{FI} + \frac{1}{2}\pi^{FN} \\ &= \frac{1}{4}\left(q^F\right)^2 + (2 - q^F)\frac{\varphi}{4}\frac{c_f - c}{c_f}.\end{aligned}$$

Note that since the objective functions defining π^{FI} and π^{FN} are increasing in φ, the value functions are increasing in φ. Now, q^F is an increasing function of δ but is a decreasing function of φ, and has zero cross-partial variation with respect to δ, φ. It follows that

$$\begin{aligned}\frac{\partial^2 \pi^F}{\partial\delta\partial\varphi} &= \frac{1}{2}\frac{\partial q^F}{\partial\delta}\frac{\partial q^F}{\partial\varphi} - \frac{\partial q^F}{\partial\delta}\frac{1}{4}\frac{c_f - c}{c_f} \\ &< 0, \end{aligned} \tag{B3}$$

implying that the cross partial between δ and $1 - \varphi$ is positive.

If we introduce a tax rate of t in sector A, the probability of innovation of a firm is still q^F while its expected profit is

$$\pi^F(t) \equiv (1 - t)\pi^F. \tag{B4}$$

Industry equilibrium and the role of taxation. — Consider the laissez-faire situation with $t_A = t_B = 0$. Focus will be the industry equilibrium if no firm prefers to be active in sector B, the lowest profit sector, that is when $\pi^F \geq \pi_B^D$. This establishes Proposition 1 which shows that there exists a cutoff value $\delta^F(\varphi)$, a decreasing function of φ such that focus is the industry equilibrium if, and only if, $\delta \geq \delta^F(\varphi)$.

Hence, the stronger competition as measured by $(1-\varphi)$, the higher the range of δ's for which firms will choose diversity.

Putting in place a system of tax/subsidies will modify the industry equilibrium since diversity arises in equilibrium only if $(1-t_B)\pi_B^D > (1-t_A)\pi^F$, which is more difficult to achieve the larger t_B with respect to t_A. We will use as a measure of targeting the ratio

$$\tau \equiv \frac{1-t_A}{1-t_B}, \tag{B5}$$

the larger τ is, the higher the "tax holidays" in sector A with respect to sector B. It should be clear that τ is sufficient to characterize the incentives of firms to choose between diversity or focus. Alternatively, τ is a measure of the asymmetry in tax holidays between the two sectors. Note that tax systems with $\tau = 1$ are neutral in the sense that they do not modify the industry equilibrium since $\Delta(\varphi, 1) = \delta^F(\varphi)$.

Tax policies that are targeted towards sector A, that is have a higher value of τ will increase the likelihood of focus to be an industry equilibrium. Indeed, the industry equilibrium is focus whenever $\tau\pi^F > \pi_B^D$; the value $\Delta(\varphi, \tau)$ for which there is an equality is decreasing in τ since π^F is increasing in δ. It follows that targeting makes focus more likely, and establishes Corollary 1.

Hence, a larger target ratio τ increases the range of values of δ for which there will be focus. Alternatively, if $\delta < \delta^F(\varphi)$, there exists a targeting tax τ such that $\delta = \Delta(\varphi, \tau)$; because $\Delta(\varphi, \tau)$ is a decreasing function of τ, the lower the value of δ, the higher this value of τ should be.

Industrial policy, innovation and the level of per capita GDP. — Consider first the innovation rate under diversity versus focus, and the implication of this comparison for the effect of industrial policy. Focus maximizes the innovation rate if and only if it implies a higher innovation rate, namely whenever

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

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.

Whenever this condition is satisfied, but $\delta < \delta^F(\varphi)$, one can increase long run growth through a tax/subsidy policy such that $\delta > \Delta(\varphi, t)$.

Now consider the effects of industrial policy on the level of output (i.e the level of per capita GDP). If there is diversity, independently of the degree of innovation in this sector, the price is c_f since in each sector the leading firm competes with the fringe only: innovation decreases the cost of production but does not affect directly the price. Therefore, output under diversity is equal to:

$$Y^D = \frac{2}{c_f}. \tag{B6}$$

By contrast, under focus, innovation affects output directly. If there is no innovation, there is a probability φ that the firms collude and set a price c_f, but if they fail, the price will be equal to c since the two leaders compete in this case. If one firm innovates, the price will be equal to c. Hence, the level of output under focus is

$$\begin{aligned} Y^F &= \frac{q^F}{c} + (1-q^F)\left(\frac{\varphi}{c_f} + \frac{1-\varphi}{c}\right) \\ &= \frac{1}{c} - \varphi(1-q^F)\left(\frac{1}{c} - \frac{1}{c_f}\right). \end{aligned}$$

Therefore moving from diversity to focus increases output (i.e., the level of per capita GDP) by

$$\begin{aligned}\Delta Y &= Y^F - Y^D \\ &\approx \frac{c_f}{c} - \frac{\varphi}{2}(1-q^F)\left(\frac{c_f}{c}-1\right) - 1\end{aligned}$$

which is larger the smaller the product $\varphi(1-q^F)$. Note that this difference is positive when $\varphi = 0$.

Overall, by Corollary 1, an industrial policy taking the form of a taxation on profits targeted towards sector A, that is $\tau > 1$, will have an effect on innovation and the level of per capita GDP, if and only if there would be diversity without targeting and τ is large enough to induce the firms to choose focus. In this case we call the τ-industrial policy *effective*.

From (B2), q^F is decreasing in φ, and therefore $\varphi(1-q^F)$ is increasing in φ. It follows that industrial policy has a bigger impact on growth and output, the lower φ: competition and industrial policy , are complements. This discussion proves Proposition 2 in the text; an effective τ-industrial policy has a bigger effect on per capita GDP and on innovation in more competitive industries.