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Picking winners? Government subsidies and firm productivity in China

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ABSTRACT

Are Chinese government subsidies making the targeted Chinese firms more productive? Alternatively, are efforts to promote productivity undercut by efforts to maintain or expand employment in less productive enterprises? In this paper, we attempt to shed light on these questions through the analysis of previously underutilized microdata on direct government subsidies provided to China's publicly traded firms. We estimate total-factor productivity (TFP) for Chinese listed firms and investigate the relationship between these estimates of TFP and the allocation of government subsidies. We find little evidence that the Chinese government consistently "picks winners". Firms' ex-ante productivity is negatively correlated with subsidies received by firms, and subsidies appear to have a negative impact on firms' ex-post productivity growth throughout our data window, 2007 – 2018. Neither subsidies given out under the name of R&D and innovation promotion nor industrial and equipment upgrading positively affect firms' productivity growth. On the other hand, we find a positive impact of subsidy on current year employment. These findings suggest that China's rising wave of government subsidies may have generated limited effects in promoting productivity.

1. Introduction

Each year, governments worldwide spend an enormous amount of money subsidizing businesses. The principal economic rationale for these policies is the market failure explanation (Schwartz and Clements, 1999). The problem, however, is that giving firms taxpayers' money is often not a simple remedy for market failures. Mis-calibrated government subsidies can actually cause even more market distortions, as put by Krugman (1983, p. 132), "… in economics two wrongs do not make a right."

In this paper, we try to peek into the black box of government subsidies to businesses in the context of China. Many countries have criticized China for playing favorites with indigenous Chinese firms when giving out subsidies (Haley and Haley, 2013). They argue that Chinese governments' preference to indigenous firms gives them an unfair advantage over foreign companies in the race to dominate the technological frontier of the future. Within China itself, government subsidies to firms remain equally controversial. While supporters argue that corporate subsidies are necessary for China to upgrade its industries, critics say that the Chinese government's strong preference for large state-owned enterprises and national champions has put private companies and small and

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mid-sized enterprises in a disadvantaged position.

Despite the growing intensity of these domestic and international debates, many of the claims advanced by Chinese government subsidy proponents and critics have yet to be subjected to serious empirical scrutiny. While the English language literature seeking to evaluate these subsidies is growing rapidly, and some of that work will be reviewed in the next section, much work remains to be done to provide more insights into the nature, scale, and purpose of these subsidies. The limitations of this literature reflect, in part, the difficulty of accurately measuring the existence and incidence of Chinese subsidies at the firm level.

In this paper, we try to shed light on these controversies by exploiting a heretofore underutilized source of firm-level data. Since 2007, companies listed on any of China's stock exchanges have been required to disclose all direct government subsidies received, along with a brief description of the nature of these subsidies. Based on these disclosures, we find that the total amount of direct government subsidies to Chinese listed companies increased by more than 7-fold from 2007 to 2018, rising from $4 billion to $29 billion.[2] Lardy (2019) has used an earlier version of these data to show that direct subsidies have grown substantially over time, from an amount equivalent to only 5 percent of listed firms' profits prior to receiving subsidies in 2010 to almost 14 percent in 2015. Lardy's work also demonstrated that almost all listed companies are receiving some subsidies, with state-owned enterprises getting 70% of the total in 2015. However, Lardy's work provides few insights regarding the impact of these subsidies at the firm level.

We seek to fill this gap in the literature by analyzing firm-level subsidy data for companies listed on the Chinese stock exchanges. We then relate these subsidies to firm productivity and other firm-level characteristics. Specially, we explore the following questions. Which firms are likely to get higher subsidies—those with higher productivity or lower productivity? Does the receipt of subsidies, especially those related to R&D and innovation or industrial and equipment upgrading, raise firms' productivity in subsequent years? Alternatively, does the receipt of subsidies raise employment?

While the Chinese government has articulated a clear ambition to promote innovation-driven growth through the use of industrial policy and corporate subsidies over the past one and a half decades, our research suggests that there is little evidence that it is able to consistently pick or create "winners" (Naughton, 2021). Subsidies seem to be allocated to less productive firms, and the relative productivity of firms' receiving these subsidies appears to decline further after disbursement. On the other hand, we find there is a positive association between subsidies and employment.

These results are subject to a number of caveats and limitations. We acknowledge throughout the paper that our subsidy data are limited, reflecting only one of the many policy instruments the Chinese government is actively using to shape the nation's industrial evolution. In addition, our analysis is largely descriptive. Nevertheless, our results cast doubt on the view that the rising wave of government subsidies will deliver the rising productivity that the Chinese economy will need to counter the pending decline in its labor force, the aging of its population, and the diminishing returns to capital accumulation it will face in coming decades.

The rest of the paper is organized as follows: Section 2 provides background information and an overview of related literature; Section 3 introduces our data and empirical methods; Section 4 presents our main empirical results; Section 5 concludes and draws policy implications.

2. Background and related literature

2.1. Government subsidies in China

Government subsidies can take various forms and be implemented for many reasons. Schwartz and Clements (1999) classify government subsidies into seven categories:

(1) Direct government payments to producers or consumers (cash subsidies or cash grants)
(2) Reductions of specific tax liabilities (tax subsidies)
(3) Government equity participation (equity subsidies)
(4) Government credit guarantees, interest subsidies to enterprises, or soft loans (credit subsidies)
(5) Government provision of goods and services at below-market prices (in-kind subsidies)
(6) Government purchases of goods and services at above-market prices (procurement subsidies)
(7) Implicit payments through government regulatory actions that alter market prices or access (regulatory subsidies).

In China, all seven of these categories have been used by the government to support businesses (Lim et al., 2018; OECD, 2019). Using this broad definition of government subsidies, early work suggests that government subsidies have long been one of the four most important sources of external finance for Chinese firms, along with commercial bank loans, firms' self-fundraising, and foreign direct investment (Allen et al., 2005). However, non-monetary subsidies or indirect subsidies of the kind enumerated in categories 2–7 above are usually not specifically reported by Chinese firms in their financial statements, even after the legal requirement to disclose direct subsidies went into effect.

Direct cash payments from governments to producers—part of category #1 in the Schwartz and Clements taxonomy—is a different

[2] The exchange rate used in this paper is 1 USD = 7 RMB (Yuan). Unlisted companies account for the vast majority of firms in the Chinese economy, but they are not required to disclose how much government subsidies they receive. As a result, it is difficult to calculate the total corporate subsidies disbursed in China. That said, a recent estimate put the total value of direct corporate subsidies in 2017 at $61 billion (Financial Times, 2019), or 3.6 times the amount disclosed by listed companies in the same year.

story. Our research takes advantage of the information disclosure requirements regarding these direct subsidies for listed firms in China. Starting in 2007, Chinese law has required listed companies to disclose government subsidy information in the notes to their financial reports.[3] The information includes the amount of the subsidies the company received during the relevant financial period and the reasons for those subsidies.[4] Since these financial statements are reviewed by independent auditors before being released to the public, our subsidy data should be more reliable than other self-reported data sources.[5]

To the best of our knowledge, this is the first paper to submit these reported direct subsidy data to large-sample statistical analysis. These subsidies have grown in magnitude over time, reaching aggregate levels high enough to have a measurable impact on the behavior of at least some of our sample firms. On the other hand, we fully acknowledge that the direct subsidy amounts formally disclosed by our sample firms and used in our data analysis are likely to be only part of the total direct and indirect subsidies received by Chinese firms. Our analyses of the magnitude and impact of government subsidies in China will therefore be necessarily incomplete.[6]

Government subsidies can serve multiple functions, including the correction of market failures (such as underinvestment in R&D), the promotion of social policy objectives (Krugman, 1983; Schwartz and Clements, 1999), or the support of political and social goals of the government. The text describing the purpose of subsidies received by our sample firms appears to point to a wide range of objectives. For example, for the first purpose of offsetting market failures, we observe various subsidies specifically described as supporting R&D activities(重大科技创新项目). For the purpose of accomplishing social policy objectives, we find in our data "employment stabilization subsidies" (稳定就业补贴), subsidies for "national unity" (民族团结), and subsidies for "employment of disabled individuals" (残疾人就业), etc. We also see subsidies that are provided for reasons that are not easy to interpret: for example, "credit report subsidies" (信用报告补贴).Feeding this information into Google BERT and using manual validation, we have categorized subsidies into seven types, which we will explain in more detail in the next section.

However, money is likely to be fungible—firms receiving a subsidy designated for a specific purpose have substantial opportunity to reallocate the expenditure of the firm's own funds in order to pursue the firm's own objectives. These could differ from the government's objectives.[7] Recognizing this, in our empirical analysis, we will run regressions mainly using total subsidies, and see how these subsidies covary with key characteristics and outcomes of the firm, especially productivity.

2.2. *China's industrial policy goals since the 2000s*

While a full history of the evolution of China's industrial policy lies well beyond the scope of this article, it is important to note a major policy shift that began in the mid-2000s, just before our data window opens.[8] In early 2006, China's State Council released the "National Medium and Long-Term Plan for the development of Science and Technology (2006–2020) (国家中长期科学和技术发展规划纲要), which we will refer to as the "MLP." This document provided the first official high-level endorsement of the goal of promoting indigenous innovation, meaning the attainment of frontier technological capabilities by Chinese firms. The MLP laid out a vision for raising the productivity of the Chinese economy by transforming China into an innovation-driven economy that would rank as one of the world's leading scientific powers over the years 2006–2020. Later policy documents and Five-Year Plans strongly affirmed the goal of productivity growth through indigenous innovation, and provided detailed policy targets that spanned much of the manufacturing sector. These documents included the Fall 2020 "Decision of the State Council on Accelerating the Cultivation and Development of Strategic Emerging Industries" (国务院关于加快培育和发展战略性新兴产业的决定) and the Made in China 2025 program, first announced in 2015.

In order to successfully realize these goals, the Chinese government would first need to identify firms capable of making the leap from imitation/absorption of foreign technology to the successful creation of new-to-the-world inventions that would succeed in global markets. In the next necessary step, the Chinese government would provide financial support to these firms, making them even more innovative and productive than before. Successful translation of these policy goals into economic reality seems to imply that government financial support should be positively correlated with firms' productivity levels, since firms with greater innovative capacity should be more productive than their same-industry peers. Chinese policy success also seems to require that the firms who receive the financial support become even more productive than they were before receiving the subsidies. We derive from these conditions statistical hypotheses that we can take to our firm-level data.

[3] Accounting Standards for Enterprises No.16–Government Grants 《企业会计准则第16号-政府补助》

[4] While accounting law appears to require Chinese firms to provide a reason or rationale for all subsidies received, this provision is not followed by all firms in all years.

[5] This statement comes with the caveat that the quality of information disclosed by Chinese firms to the stock exchanges does not always meet the highest international standards (Chan et al., 2008).

[6] However, it seems likely that industries and firms targeted by government industrial will receive support through multiple channels. This logic implies that subsidies provided through tax breaks, soft loans, and favorable government procurement practices, which we do not measure directly, are likely to be highly correlated across firms and over time with the direct cash subsidies we do measure directly. To the extent that this is correct, our cash subsidy measures are likely to be an underestimate of the total subsidies received, and the estimated effects could be a lower bound of the total policy effects.

[7] The government's objectives may also not be clear—different levels of government could pursue different, conflicting objectives. Subsidies in China are provided by both the central government and local governments. In fact, our data suggests the subsidy providers involve all hierarchical levels of the Chinese governments, including central, provincial, prefecture, county, township and even village governments.

[8] For a more comprehensive review, see Naughton (2021) and Branstetter and Li (2023).

2.3. Related literature

An extensive literature has explored the impact of government subsidies on firm productivity, R&D spending, and innovation. Many studies find that properly targeted subsidies can raise the productivity of firms, especially small firms, at least to a limited degree (e.g., David et al., 2019; Girma et al., 2007; Lane, 2022; Liu, 2019; Rotemberg, 2019). This may be a reasonable outcome if factor markets are imperfect and firms face special challenges accessing capital, specialized labor, or other resources. However, other studies find no evidence of a positive effect on firm productivity (e.g., Koski and Pajarinen 2015), even when the programs in question seem to be well targeted.

One market failure that subsidies can help to correct is the tendency for profit-maximizing firms to underinvest in R&D in the presence of spillovers (Arrow, 1962; Howell, 2017). A number of recent papers have examined the impact of R&D related government subsidies in China on firm innovation and performance (e.g., Fang et al., 2022, 2018; Guo et al., 2018; Guo et al., 2016; Hu, 2001; Wang et al., 2017). The findings in this literature have been mixed, with different studies based on different data sources and methods pointing to different conclusions. Some studies find a positive effect on patenting, new product sales, exports, and productivity (e.g., Guo et al., 2018; Guo et al., 2016), while others find no effect on firm survival, patenting, or venture funding (e.g., Wang et al., 2017). Many of these studies rely on proprietary or limited access data, making it difficult to resolve the differing conclusions reached by different groups of scholars.[9] Other recent studies have tended to cast Chinese government subsidies in a more negative light, suggesting that government subsidies and interventions generate significant market distortions (e.g., Bai et al., 2020; Barwick et al., 2021, 2019; Kalouptsidi, 2018; OECD, 2019) and may lead to the misallocation of R&D spending toward less innovative firms and projects (Cao et al., 2022; Chen et al., 2021).

Today's debate on Chinese industrial policy may remind some readers of the earlier debate concerning Japanese industrial policy. In the 1980s and 1990s, an extensive and contentious literature on Japanese industrial policy drew significant attention as U.S.-Japan trade frictions created political pressure for the U.S. (and other Western nations) to adopt protectionist policies (Destler, 2005). While some argued that Japan's recovery and growth after WWII could be explained by effective industrial policy (Johnson, 1982; Prestowitz, 1988; Vogel, 1979), skeptics suggested that government intervention tended to favor declining industries rather than growing ones (Calder, 1988; Gary Saxonhouse, 1983). Careful empirical analysis eventually undermined the idea that industrial policy drove Japan's economic miracle (Beason and Weinstein, 1996). As it turned out, the policy efforts to promote rising sectors championed by some elements of Japan's bureaucracy were undermined by countervailing efforts to buttress the employment levels and solvency of politically connected but economically weak firms and industries. Today, few scholars argue that Japanese industrial policy is a model worthy of emulation (Ito and Hoshi, 2020).

The urgency of studying the effectiveness of government subsidies in China is heightened by growing evidence of a recent decline in Chinese GDP growth and productivity growth (e.g., Brandt et al., 2020; Bai and Zhang 2017; Chen et al., 2019; Wu 2020; Hu and Yao 2019; Lardy, 2019). Many of these authors see increasing government intervention in China as one reason for this deceleration, although there are certainly other causes.[10] In this paper, we will use our new microdata to examine the correlation between industrial policy support, as evidenced by government subsidies, and firm productivity.[11]

3. Data and empirical methods

3.1. Data

We obtain firm-level subsidy and other financial data from the China Securities Markets and Accounting Research Database (CSMAR). Firm ownership information is drawn from the Wind financial database.[12] CSMAR and Wind are analogous to Compustat in the U.S. context. Both databases have been widely used by scholars to study Chinese listed firms. Our sample includes all firms listed on the Shanghai and Shenzhen stock exchanges from 2007 to 2018, but we exclude financial services firms from all of our analyses. Due to the nature of their business, these firms' financial statements are quite different from that of other industries, making it difficult to estimate reasonable production functions if we apply the same approach we use for other sectors.

Our study period begins in 2007 because it was the first year in which all Chinese listed firms were required to report government

[9] In light of this issue, one strength of our paper is that it relies solely on publicly available data, although some of it requires a subscription to commercial data providers.

[10] A recent paper that parallels some of our work finds that innovation subsidies tend to go disproportionately to politically connected firms, and these subsidies do not result in higher quality patents or higher productivity (Cheng et al., 2019)).

[11] This work is motivated in part by the recent work of Nicholas Lardy (2019). Lardy has long maintained, in the face of growing criticism, that China was continuing to move toward a more market-oriented economic model. In Lardy (2019), however, he marshals a wide range of evidence to support the view that this progress towards a more market-oriented model has not only stopped, but gone into reverse in recent years. However, Lardy's work does not extend to regression analysis of firm-level microdata.

[12] Wind determines the company's ownership type according to the nature of the controlling shareholder(s) disclosed by the company. Appendix A describes the definitions of the five firm ownership types, including central state-owned enterprises, local state-owned enterprises, private enterprises, foreign-funded enterprises, and ambiguous ownership companies. Under Chinese law, publicly traded companies are required to disclose the identity of controlling shareholders. However, there are a small number of companies whose equity ownership is so dispersed that no controlling shareholders are identified. These publicly traded companies can therefore not be conclusively assigned to any of the other ownership categories. We refer to these as "ambiguous ownership companies."

subsides according to the newly revised GAAP in China. Fig. 1 shows the direct subsidy distribution of our sample by firm ownership types. The surge in subsidies to state-owned enterprises in 2008 reflects part of the Chinese government's aggressive fiscal response to the beginning of the global financial crisis (Lardy, 2019). As one can see, government subsidies have generally been increasing over the past decade, the bulge in 2008 notwithstanding.

Fig. 2 shows the total subsidy received by firms in each industry category during this period, ranked from highest to lowest; Fig. 3 presents the industry distribution of firms in our analyses of direct subsidies.[13]

Table 1 shows the summary statistics of key variables used in our empirical analyses. The maximum value for subsidies, which was given to China Petroleum & Chemical Corporation (or Sinopec), the state-owned oil and gas company, in 2008, is quite large. The largest R&D expense was spent by ZTE. Wage is a calculated variable: we divide the lump sum of cash paid to and for employees from the Cash Flow Statement by the total number of employees in each year.[14]

Although we believe subsidy money is likely to be fungible, we also explored the heterogeneous effects of different types of subsidies on productivity. We used Google BERT, along with manual validation, to parse the detailed text associated with firms' disclosures of subsidies to categorize subsidies into seven major categories, including:

1 R&D and innovation subsidies
2 Industrial and equipment upgrading subsidies
3 Employment stabilization and promotion subsidies
4 Environment protection subsidies
5 General business subsidies
6 Other subsidies
7 Unknown

More detailed information about the subsidy categorization methods and procedures can be found in Appendix C. Despite our best efforts, the omissions and ambiguities in the disclosure data posed some significant challenges to our efforts to assign subsidies to these categories. Even though Chinese accounting rules require firms to provide details on the purpose and nature of the subsidies, many do not disclose these details and apparently pay no penalty for these omissions. In other cases, some details were disclosed, but not enough to enable unambiguous assignment of the recorded subsidy to one of the categories listed above.

These disclosure issues may reflect the underlying complexities and ambiguities in Chinese government subsidy programs themselves. Confidential interviews conducted with consultants and firm managers based in three eastern Chinese cities reveal that Chinese firms increasingly rely on specialized government subsidy application agents and brokers to navigate the complicated web of subsidy programs. These agents and brokers are responsible for figuring out their clients' eligibility for various subsidies offered by multiple levels of government and preparing all the paperwork on clients' behalf. If a subsidy application succeeds, the clients usually pay a certain percentage of the subsidy amount as a commission to the broker; if the application fails, the clients either do not need to pay or just a small amount. Given these practices, company managers may themselves have a limited understanding of exactly which subsidy programs their firm is benefitting from or what the original policy goals of those programs were. Instead, firms are relying on consultants to milk the subsidy system, without necessarily altering their real business plans in the ways the local and national government architects of the subsidy programs may have intended.

3.2. *Estimation framework for government subsidies*

To understand how government subsidies might be related to firm productivity in China, we conduct a two-stage analysis: in the first stage, we estimate standard Cobb-Douglas production functions separately by industry, and compute total-factor productivity (TFP) as the residual calculated for each firm in each year. In the second stage, we seek to understand the relationship between government subsidies and firm productivity in China. In some specifications, we also use employment or R&D investments as a dependent variable.

In the first stage, we rely on work by Wooldridge (2009) to estimate the total-factor productivity (TFP) of firms from 2006 to 2018.[15] The correct estimation of total-factor productivity is crucial to this study, because it will be our main dependent variable in the second stage. One major econometric concern in estimating TFP is the potential existence of important demand or productivity shocks that are unobservable to the econometrician but are observed by the managers of the firms in our data set. In this case, firms will

[13] We aggregate the China Securities Regulatory Commission's (CSRC) industry codes into broader industry categories in order to get enough observations for industry-level productivity estimation. The concordance of the CSRC codes and our classifications can be found in Appendix B.

[14] While cash paid to and for employees is the lump sum payment for the whole year, the total number of employees is only reported at the year's end. As such, in some extreme cases, e,g., when filing for bankruptcy, the company may report a small amount in cash paid to and for employees or a small number of employees, resulting in small and large wage numbers that seem to be out of the range of a normal wage. These outliers lie within the 1st percentile or beyond the 99th percentile of observations. In the regressions using wages as a control variable, we run robustness checks by dropping these outliers, and our results remain.

[15] We begin our estimation one year before 2007 in order to have valid estimates for lagged productivity which are used in the second stage analysis. This second stage analysis proceeds from the year 2007, when mandatory disclosure of government subsidies is implemented for all listed firms.

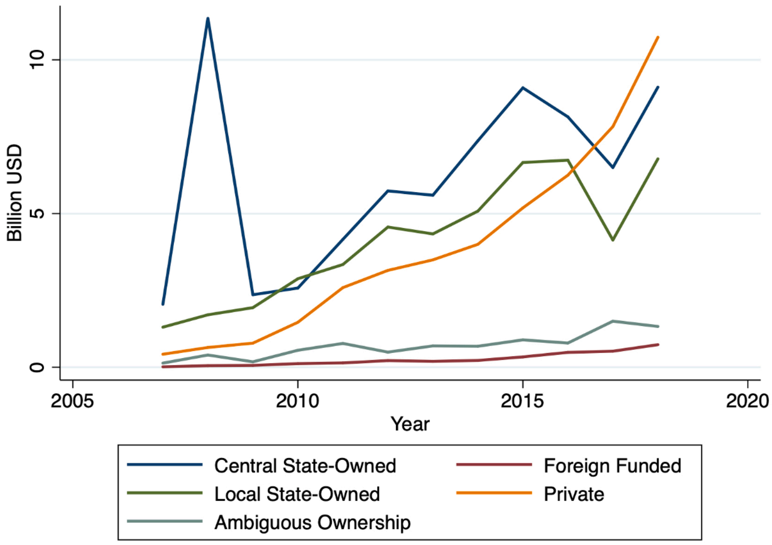

Fig. 1. Direct subsidy distribution by firm ownership over time.

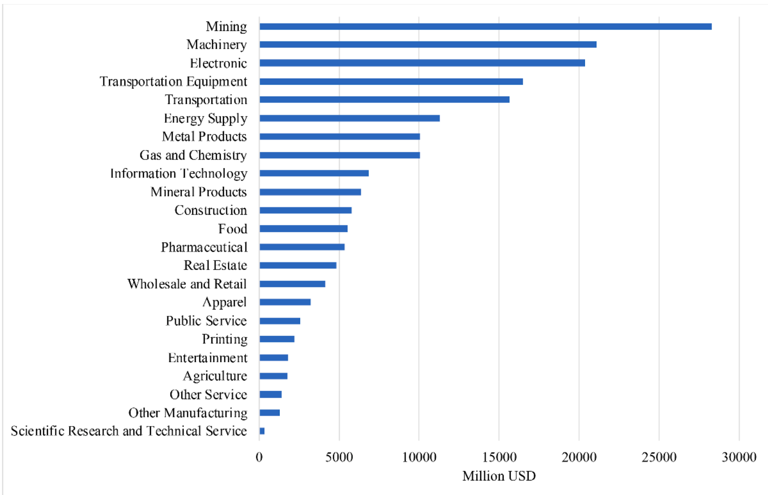

Fig. 2. Total (Direct) subsidies received by industries from 2007 to 2018.

respond to these positive or negative shocks by increasing or decreasing their input levels, and there will be a positive correlation between the input variables and the unobservable shocks, leading to biased ordinary least squares (OLS) estimates of the production function coefficients.

Various methods have been proposed to tackle this simultaneity issue. Over the past 25 years, techniques proposed by Olley and Pakes (1996) (OP) and Levinsohn and Petrin (2003) (LP) to address this endogeneity problem have been extensively used in the empirical literature. Wooldridge (2009) proposed a further improvement, showing how the Levinsohn–Petrin (LP) estimator can be obtained in a generalized method of moments (GMM) econometric framework, and that joint estimation of the parameters leads to better inference and more efficient estimation. Two advantages of using this method include that (1) it overcomes the potential identification issue highlighted by Ackerberg et al. (2015) in the first stage, and (2) robust standard errors can be easily obtained,

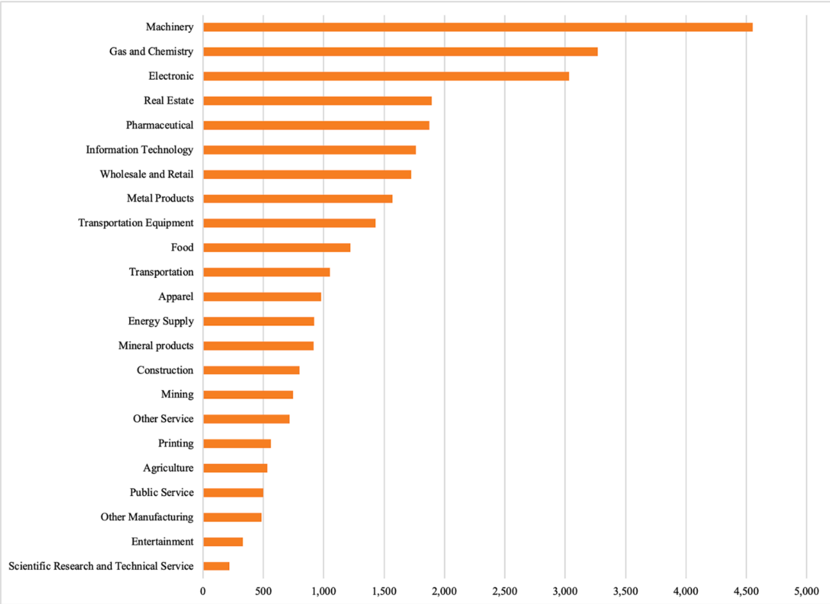

Fig. 3. Industry frequency distribution of sample firms (# of firms) in empirical analyses.

Table 1
Summary statistics for direct subsidy analyses.

Variable	Obs	Mean	Std.Dev.	Min	Max
Log Subsidy (Yuan)	29,649	14.69	4.391	0	24.54
Log Employment (Person)	30,988	7.496	1.387	0	13.22
Log Sales Revenue (Yuan)	31,028	21.08	1.577	8.928	28.67
Log Total Assets (Yuan)	31,080	21.69	1.360	10.72	28.31
Log Material Input (Yuan)	30,976	20.54	1.753	6.454	28.42
Log Net Profit (Yuan)	27,903	18.36	1.580	10.07	25.64
Age	30,581	16.15	5.762	0	63
IPO Indicator	31,085	0.0712	0.257	0	1
Log R&D Expense (Yuan)	31,085	10.50	8.705	0	25.03
Log Wage (Yuan/Person)	30,984	11.33	0.704	4.347	17.20
Log R&D & Innovation Subsidy (Yuan)	16,155	13.59	1.971	4.708	20.95
Log Industrial and Equipment Upgrading Subsidy (Yuan)	16,696	14.16	1.825	5.311	20.71
Log Employment Stabilization & Promotion Subsidy (Yuan)	7,897	12.00	1.893	3.720	19.21
Log General Business Subsidy (Yuan)	22,282	14.72	2.025	3.461	24.54

Note: For subsidies, 94.3% of observations have positive reported subsidies from 2007 to 2018, and we assume zero subsidy for the 5.7% of observations that did not report subsidy in the original financial reports, and, in order to take logs, we add 1 to all observations of subsidies, and then take the logarithm. We only use logged subsidies in models where subsidy is an independent variable. We treat R&D expense with the same method.

accounting for both serial correlation and heteroskedasticity. Therefore, we rely on this method and use the total-factor productivity levels estimated by this method in our second-stage analyses.

As is common in the literature, we compute a firm's total-factor productivity as the residual of the firm-level regression:

$$y_{it} = \alpha + \beta l_{it} + \gamma k_{it} + \delta m_{it} + \varepsilon_{it} \tag{1}$$

Where y_{it} is the logarithm of the sales of firm i during year t, l_{it} is the logarithm of the number of workers of firm i during year t, and k_{it} is the logarithm of the total assets of firm i during year t, and m_{it} is the logarithm of the expenses for material and other inputs of firm i during year t.[16] We separately estimate production functions by industry, so our estimate of TFP effectively captures a firm's deviation

[16] We use "cash payments for raw materials and services" in the cash flow statements of our sample firms to capture variation in materials and other variable inputs. We follow the lead of other empirical researchers who have estimated production functions with the Chinese micro data in using recorded measures of "total assets of the firm" as our proxy for our sample firms' capital stocks (Giannetti, Liao and Yu, 2015). Other measures of the firms' capital stocks available in the CSMAR data suffer from well-documented distortions, and the absence of an accurate investment series prevents us from building our own capital stock measures using the standard perpetual inventory method. To the extent that we measure variations in capital services with error, this could lead to a systematic downward bias in the capital coefficient.

from the average TFP level within its industry. We follow the GMM method proposed by Wooldridge (2009) using intermediate inputs m_{it} as our proxy variable for unobserved productivity to obtain consistent estimates for coefficients of all input variables. All variables other than labor input are deflated by their appropriate deflators in each year published by China's National Bureau of Statistics.[17]

In our second stage analysis, we attempt to answer the following three questions. First, *ex ante*, which firms are likely to get more subsidies, firms with high or low productivity? To answer this question, we regress total subsidies received by listed firms in each year on lagged total-factor productivity estimates and control for firm characteristics that might be important determinants of subsidy allocation. We use the Pseudo-Poisson Maximum Likelihood (PPML) model to contend with the large number of zero realizations in the dependent variable.[18] When we take the natural log of the values of our independent variables, we can interpret the coefficients generated by the PPML model as elasticities. The full regression specification is written below:

$$Subsidy_{it} = \alpha_i + \gamma_t + \beta_1 TFP_{i(t-1)} + \beta_2 Sales_{i(t-1)} + \beta_3 Assets_{i(t-1)} + \beta_4 Profit_{i(t-1)} + \beta_5 Employment_{i(t-1)} + \beta_6 IPO_{it} + \varepsilon_{it} \quad (2)$$

where $Subsidy_{it}$ is the total subsidy[19] received by firm i during year t,α_i is a firm fixed effect, γ_t is a year fixed effect, $TFP_{i(t-1)}$ is the total-factor productivity calculated by Wooldridge GMM method in Stage 1 for firm i during year $t-1$, and the other variables are sales revenue, total assets, net profit, number of workers hired in year $t-1$, and IPO status in year t. We take natural logs of all independent variables except for the IPO status indicator. IPO status is a dummy variable indicating whether the firm completed an initial public offering status in year t. Firms going through the IPO process might get an additional subsidy from the government in that year, so we can control for this extra "IPO bonus." All regressors are lagged one period to ameliorate simultaneity bias. To explore how the relationship between subsidy and TFP varies across firm types, we rerun these regressions separately for each of the major five firm ownership types.

Next, does receipt of a subsidy help improve the receiving firm's productivity *ex post*? Alternatively, do subsidies increase firm R&D investments or employment? To answer these questions, we regress total-factor productivity, R&D expenditure and employment on subsidies received by the firm in the most recent three years, controlling for firm and year fixed effects. When the dependent variable is R&D expenditure, we use the Pseudo-Poisson Maximum Likelihood (PPML) model again to contend with the large number of zero realizations in measured R&D expenditure. When the dependent variable is employment, measured as logarithm of the number of workers, we use the Arellano–Bond approach to address potential endogeneity issues since a lagged dependent variable is included in the set of regressors, and we follow (Arellano and Bond, 1991) to control for other important variables affecting employment. When the dependent variable is productivity (firm-level TFP), we use OLS regressions and a specification similar to that used in the R&D expenditure model.

The model for productivity is as follows:

$$Y_{it} = \alpha_i + \gamma_t + \beta_1 S_{it} + \beta_2 S_{i(t-1)} + \beta_3 S_{i(t-2)} + \delta X_{i(t-1)} + \varepsilon_{ijt} \quad (3)$$

where Y_{it} are the total-factor productivity residuals calculated using the Wooldridge GMM method in Stage 1 for firm i during year t, α_i is a firm fixed effect, γ_t is a year fixed effect, S_{it} is the logarithm of the subsidy received by firm i during year t, and $S_{i(t-1)}$ and $S_{i(t-2)}$ are logged subsidies received in the previous two years. $X_{i(t-1)}$ is a vector of additional control variables for firm i during year $t-1$. We use a similar specification to examine the impact of subsidies on R&D expenditure and employment levels (logarithm of the number of workers). The alternative specification focused on employment was inspired by an extensive literature suggesting the emphasis placed by the government on securing social stability through the provision of jobs to Chinese citizens.[20]

4. Results

4.1. First stage results

In the first stage, we estimate the total-factor productivity (TFP) of firms in each year from 2007 to 2018 at industry level, so our estimate of TFP captures a firm's deviation from the TFP within its industry. Table 2 shows the industry-level production functions for all industries listed in Fig. 2. The TFP values obtained from these regressions are used in our second stage estimation.[21]

[17] Sales revenue (y_{ijt}) is deflated by the producer price index by industry, capital value (k_{ijt}) is deflated by the official capital price index, and intermediate material input (m_{ijt}) is deflated by the industrial producer input price index in each year. Note that we measure revenue, not physical output. To the degree that Chinese firms exercise market power, our measures of productivity will be contaminated by the ability of some firms to price above marginal cost; given our data constraints (in particular, the absence of firm-specific price deflators) there is no effective way to control for this in our econometric estimation.

[18] The paper by Bellégo and Pape (2019) introduced the method in detail, and we use the package ppmlhdfe in Stata to deal with high-dimensional fixed effects.

[19] Subsidy amounts are deflated by the Consumer Price Index.

[20] Here are two examples of policies to secure social stability through employment subsidy in China: Ministry of Education of the People's Republic of China, http://www.moe.gov.cn/jyb_xwfb/s5147/202006/t20200612_465322.html, accessed June 6, 2021; The State Council of the People's Republic of China, http://www.gov.cn/zhengce/content/2019-12/24/content_5463595.htm, accessed June 6, 2021.

[21] As robustness checks, we also present the pooled regression results for both OLS and Wooldridge GMM methods in Appendix D Table D.1. The coefficients of OLS and Wooldridge estimates are quite similar, with the fixed-effects model (column 3) generating slightly different results than other methods.

Table 2
Wooldridge GMM estimation of production functions at industry level.

Industry	Agriculture	Apparel	Construction	Electronic	Energy supply	Entertainment
lnl	0.107***	0.118***	0.152***	0.180***	0.0467***	0.217***
	(0.0152)	(0.0129)	(0.0125)	(0.00769)	(0.00858)	(0.0127)
lnk	0.163**	0.281***	0.672***	0.335***	0.333***	0.350***
	(0.0723)	(0.0372)	(0.0471)	(0.0209)	(0.0367)	(0.0470)
lnm	0.486***	0.559***	0.533***	0.482***	0.487***	0.457***
	(0.0404)	(0.0277)	(0.0302)	(0.0161)	(0.0274)	(0.0417)
Observations	459	833	671	2537	808	265
No. of Groups	64	132	124	466	110	64

Industry	Food	Gas and Chemistry	Information Technology	Machinery	Metal Products	Mineral Products
lnl	0.146***	0.0528***	0.288***	0.185***	0.113***	0.204***
	(0.0120)	(0.00839)	(0.00790)	(0.00578)	(0.00935)	(0.0143)
lnk	0.368***	0.320***	0.351***	0.356***	0.258***	0.399***
	(0.0470)	(0.0229)	(0.0255)	(0.0173)	(0.0280)	(0.0369)
lnm	0.742***	0.592***	0.387***	0.569***	0.585***	0.507***
	(0.0274)	(0.0157)	(0.0169)	(0.0125)	(0.0174)	(0.0238)
Observations	1062	2811	1417	3879	1363	792
No. of Groups	153	442	311	649	201	118

Industry	Mining	Other Manufacturing	Other Service	Pharmaceutical	Printing	Public Service
lnl	0.212***	0.172***	0.135***	0.291***	0.0316	0.236***
	(0.0104)	(0.0126)	(0.0101)	(0.0119)	(0.0219)	(0.0151)
lnk	0.381***	0.0909**	0.309***	0.496***	0.0837	0.255***
	(0.0471)	(0.0404)	(0.0474)	(0.0409)	(0.0592)	(0.0891)
lnm	0.454***	0.821***	0.444***	0.433***	0.637***	0.604***
	(0.0255)	(0.0343)	(0.0309)	(0.0214)	(0.0319)	(0.0480)
Observations	646	380	571	1605	485	400
No. of Groups	95	96	126	249	73	97

Industry	Real Estate	Scientific Research and Technical Service	Transportation	Transportation Equipment	Wholesale and Retail	
lnl	0.175***	0.289***	0.156***	0.145***	0.0400**	
	(0.0107)	(0.0185)	(0.00754)	(0.0124)	(0.0159)	
lnk	0.122**	0.155	0.271***	0.253***	0.123*	
	(0.0540)	(0.0953)	(0.0372)	(0.0369)	(0.0721)	
lnm	0.380***	0.473***	0.401***	0.663***	0.708***	
	(0.0225)	(0.0512)	(0.0202)	(0.0282)	(0.0514)	
Observations	1600	162	924	1213	1487	
No. of Groups	256	55	126	202	230	

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Inspection of the estimated coefficients reveals labor and capital coefficients that are lower than many readers might expect. However, other researchers estimating similar production functions using Chinese data (e.g., Yu, 2015) have obtained similar results. To understand these outcomes, recall that our output measure is sales, not value-added, and that we are directly measuring material inputs (and purchased services) other than capital and labor. For many firms, a substantial fraction of the value of sales consists of these purchased inputs. The direct measurement of purchased inputs other than capital and labor will naturally tend to drive the measured magnitudes of these coefficients down. These issues are not unique to China; inclusion of materials in production function analysis tends to lower the regression coefficients associated with labor and capital.

The political and social sensitivities surrounding layoffs and operating cost reduction considerations have led many listed Chinese firms in labor-intensive industries to rely quite heavily on so-called “labor dispatch” to provide labor. “Labor dispatch” is an arrangement under which an employee is hired by an employment agent (i.e., nominal employer) and then dispatched to work for another firm (i.e., actual employer). This arrangement allows the listed purchasing firm to reduce labor input, when necessary, by simply purchasing less from employment agents. Smaller, unlisted employment agents may be forced to lay off workers, but these entities are less visible to the authorities than the listed firms that are in the public eye. As such, much of the variation in labor actually deployed in a listed firm’s projects could wind up in the “purchased materials and services” variable rather that our measure of firm full-time employees (Xu, 2009). These practices are likely to be common to listed firms in certain industries, which means that our approach of estimating production functions separately by industry may enhance our ability to estimate firm productivity with reasonable accuracy.

4.2. Second stage results with direct subsidies

In Table 3, we regressed total subsidies received on a broad range of firm characteristics, including measures of firm productivity, size, and profitability. The chief guiding question behind this set of regressions is what sort of firm characteristics are associated with

Table 3
Determinants of firm-level total subsidies, including firm fixed effects.

Variables	(1) Total subsidy	(2) Total subsidy	(3) Total subsidy	(4) Total subsidy
Lagged TFP	−0.0215	−0.0408**	−0.0518***	−0.0457***
	(0.0261)	(0.0179)	(0.0160)	(0.0155)
Lagged Sales Revenue		−0.114	−0.193*	−0.225**
		(0.118)	(0.105)	(0.113)
Lagged Total Assets		0.732***	0.834***	0.788***
		(0.0689)	(0.182)	(0.164)
Lagged Net Profit			0.0948***	0.0933***
			(0.0273)	(0.0274)
Lagged Employment				0.108
				(0.0720)
IPO				0.160
				(0.102)
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Observations	26,869	26,869	24,218	24,218

Note: All Columns are Pseudo-Poisson Maximum Likelihood (PPML) regressions with firm and year fixed effect. Data include Chinese listed firms from 2007 to 2018. Standard errors are clustered at firm level. All independent variables are in logged values except for IPO indicator. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

the receipt of subsidies. We incorporate firm fixed effects to control for time-invariant, unmeasured characteristics not captured by our existing firm-level controls, and we include year fixed effects to control for macro fluctuations in subsidies associated with countercyclical fiscal policy efforts. In general, we find a negative correlation between subsidies and lagged TFP that is statistically significant at the 5% level in most specifications.[22] There appears to be a robust positive correlation between subsidies and firm size, as measured by the firm's total assets. The relationship between subsidies and net profit is also positive and significant at the 5% significance level. These results suggest that, overall, subsidies are given to larger and more profitable, but less productive firms.[23]

In the next round of regression analyses, we ask whether receiving a subsidy is correlated with subsequent growth in recorded TFP, R&D expenditure, or employment. Table 4 shows the regressions of TFP on total subsidies.[24] We find that total subsidies appear to have a *negative* and statistically significant impact on TFP, albeit a very modest one in terms of economic size.[25]

Using R&D expense as an alternative indicator of innovation input, in Table 5, we regress R&D expense on total subsidies. We find that 2-year lagged direct subsidies appear to have a very modest but positive and statistically significant impact on subsequent R&D spending; other lags appear to be uncorrelated with R&D spending.[26]

In Table 6, we regress employment on total subsidies. Current direct subsidies appear to have a positive impact on current employment levels while 1-year lagged subsidies seem to have a negative impact, potentially indicating that firms might be

[22] A referee suggested that we rerun this specification without firm fixed effects. When we do so, the estimated impact of TFP fades into statistical insignificance. These results are available upon request. Given the degree to which unmeasured heterogeneity across firms could influence the receipt of subsidies and their effects, we chose to include empirical results with firm fixed effects in the text of our paper.

[23] As shown in Appendix D Table D2.a, we regressed different types of subsidies on firm characteristics, using the specification of Column 4 in Table 3. Although we find heterogenous effects of lagged productivity on different types of subsidies received, there is no statistical evidence that subsidies have been given to more productive firms. We also experimented with running regressions separately by ownership type, the results of which are presented in Appendix D Table D3. We find there is a negative correlation between subsidy allocation and firm productivity for foreign-funded firms, but no statistically significant correlation for other types of firms. We also find profit and employment level to be positively correlated with the cash subsidy received by private firms, but not other types of firms, suggesting that private firms are being rewarded for improving profitability and hiring more workers. This conjecture is further confirmed by a positive relationship between employment stabilization and promotion subsidies and lagged employment for private firms, as seen in Appendix D Table D4.

[24] In Appendix D Table D5, we regress TFP on R&D and innovation subsidies, industrial and equipment upgrading subsidies, employment stabilization and promotion subsides, and general business subsides respectively using the full model of Column 4 in Table 4. Across all specifications, the coefficients of subsidy variables are not statistically significant at the 5% level. To the extent that we can draw conclusions from these results, it appears that even subsidies that appear to be closely related to productivity, i.e., R&D and innovation subsidies and industrial and equipment upgrading subsidies, do not contribute to productivity growth.

[25] Again, in response to a referee's comments, we reran this specification without firm fixed effects. The negative effect of subsidies on TFP remains, as does its statistical significance. These results are available upon request.

[26] In Appendix D Table D6, we regress R&D expense on different types of subsides using the full model of Column 4 in Table 5. Results presented in Column 1 suggest that R&D and innovation subsidies do not seem to have an effect on firms' R&D expense, which is quite surprising. Column 2 and 4 show that current industrial and equipment upgrading subsidies and current general business subsides appear to have a positive effect on firms' R&D expense, an effect that is significant at the 1% and 5% levels, respectively. Column 3 shows that 1-year lagged employment stabilization and promotion subsides seem to have a negative impact on firms' R&D expense, which is significant at the 5% level.

Table 4
Impact of total subsidies on firm-level TFP.

Variables	(1) TFP	(2) TFP	(3) TFP	(4) TFP
Current Total Subsidy	−0.0135***			−0.0112**
	(0.00508)			(0.00494)
1-Year Lagged Total Subsidy		−0.0141***		−0.0118***
		(0.00493)		(0.00439)
2-Year Lagged Total Subsidy			−0.0109**	−0.00776*
			(0.00503)	(0.00454)
Lagged Total Assets	0.389***	0.363***	0.355***	0.377***
	(0.0661)	(0.0658)	(0.0676)	(0.0681)
Lagged Employment	−0.271***	−0.230***	−0.220***	−0.209***
	(0.0558)	(0.0569)	(0.0586)	(0.0578)
Lagged R&D Expense				−0.00463
				(0.00308)
Lagged R&D Persons				−0.000717
				(0.00968)
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Observations	26,894	25,492	22,130	22,130
R-squared	0.849	0.861	0.875	0.876

Note: All columns are Multi–Way Fixed Effect Models (reghdfe) regressions including firm and year fixed effect. Data include Chinese listed firms from 2007 to 2018. Standard errors are clustered at firm level. All variables are in logged values. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5
Impact of subsidies on firm-level R&D expenditure.

Variables	(1) R&D expense	(2) R&D expense	(3) R&D expense	(4) R&D expense
Current Total Subsidy	−0.0152*			−0.00677
	(0.00902)			(0.00500)
1-Year Lagged Total Subsidy		−0.0198*		−0.0296**
		(0.0108)		(0.0151)
2-Year Lagged Total Subsidy			0.0524***	0.0563***
			(0.0143)	(0.0170)
Lagged Total Assets	0.485***	0.496***	0.408***	0.433***
	(0.0899)	(0.101)	(0.0812)	(0.0820)
Lagged Employment	0.0892	0.111**	0.0960*	0.110**
	(0.0590)	(0.0508)	(0.0512)	(0.0499)
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Observations	23,427	22,292	19,214	19,214

Note: All columns are Pseudo-Poisson Maximum Likelihood (PPML) regressions, including firm and year fixed effect. Data include Chinese listed firms from 2007 to 2018. Standard errors are clustered at firm level. All independent variables are in logged values. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

strategically manipulating employment numbers to get subsidies—temporarily increasing hiring during the period of receiving subsidies and then cutting it back during the next period.[27]

Taken together, the empirical results do not seem to support the view that direct subsidies, as measured at an aggregated level or across different types, are raising the productivity levels of Chinese firms. They provide some support for the view that subsidies may be boosting temporary employment, but this may come at the expense of productivity, inducing firms to hold on to more than the efficient level of employees and inhibiting, rather than enhancing, the flow of human and financial resources to the most efficient enterprises.

While our evidence is mostly descriptive and correlational, we believe it casts doubt on the idea that Chinese industrial policy has succeeded in reaching the goals articulated in high-level policy documents going back to the mid-2000s. If Chinese government subsidies are successfully making China's publicly traded firms more innovative, then these subsidies should be positively correlated with firm productivity. In other words, the Chinese government should be directing its subsidies to firms that already possess the capacity to innovate and become more productive, and therefore already have higher TFP. In addition, after these firms receive government subsidies, they should become even more productive than they were before. Now, even if we found a strong and robust positive correlation between Chinese government subsidies and productivity existed, the mere existence of that positive correlation

[27] In Appendix Table D7, we repeat the analyses in Table 6 but use employment stabilization and promotion subsidies as a depend variable. While 1-year lagged employment stabilization and promotion related subsidies are no longer significant this time, current employment stabilization and promotion related subsidies' positive effect remains and significant at 5% level. That said, these employment effects are also fairly modest in size.

Table 6
Impact of subsidies on firm-level employment (Arellano–Bond Estimator).

Variables	(1) Employment	(2) Employment	(3) Employment	(4) Employment
Current Total Subsidy	0.00595***			0.00483***
	(0.00126)			(0.00126)
1-Year Lagged Total Subsidy		−0.00419***		−0.00343***
		(0.00127)		(0.00127)
2-Year Lagged Total Subsidy			0.000313	−0.000826
			(0.00111)	(0.00101)
Current Wage	−0.780***	−0.779***	−0.789***	−0.789***
	(0.0205)	(0.0206)	(0.0206)	(0.0205)
Lagged Wage	0.450***	0.460***	0.465***	0.460***
	(0.0320)	(0.0325)	(0.0328)	(0.0330)
Current Total Assets	0.517***	0.524***	0.545***	0.539***
	(0.0259)	(0.0260)	(0.0253)	(0.0251)
Lagged Total Assets	−0.249***	−0.250***	−0.275***	−0.265***
	(0.0355)	(0.0358)	(0.0332)	(0.0329)
1-Year Lagged Employment	0.720***	0.734***	0.738***	0.728***
	(0.0392)	(0.0404)	(0.0375)	(0.0376)
2-Year Lagged Employment	−0.0421***	−0.0436***	−0.0496***	−0.0471***
	(0.00844)	(0.00860)	(0.00841)	(0.00831)
Lagged Industry Sales	0.00315*	0.00315*	0.00193	0.00197
	(0.00176)	(0.00177)	(0.00178)	(0.00178)
Year Fixed Effect	Yes	Yes	Yes	Yes
Observations	20,710	20,710	19,328	19,328
Number of Firms	2,821	2,821	2,818	2,818

Note: All columns use Arellano–Bond GMM estimators and include year fixed effect. Data include Chinese listed firms from 2007 to 2018. Standard errors are Arellano–Bond robust SE. All variables are in logged values. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

would not *prove* that subsidies caused higher productivity growth. However, if the correlation is negative in the first instance, then it is all but impossible to construct a reasonable statistical argument that government subsidies cause higher productivity. So, while our results are descriptive, we nevertheless think they cast strong doubt on the notion that Chinese industrial policy is bringing about enhanced efficiency and productivity growth. While many economists may be naturally skeptical that such a result could obtain, top policymakers in China, the United States, and elsewhere appear to be making large investments of public funds predicated on the notion that Chinese industrial policy is working well and is either worthy of emulation or requires powerful countermeasures to offset. We think our results are therefore useful for the research community and, potentially, the policy community.

4.3. Robustness

The negative association between subsidies and productivity may be due to shocks that affect both subsidies and productivity, but in opposite directions. To address potential endogeneity issues, we conduct a mathematical analysis to identify the possible inference challenges generated by omitted variable bias. Our analysis suggests that these biases are unlikely to have a significant impact on our conclusion that subsidies are given to less productive firms. This analysis is presented in Appendix E.

5. Conclusion

Over the past one and a half decades, the Chinese government has made significant efforts to promote innovation-driven growth through the use of industrial policy and corporate subsidies. But the determents and effects of these subsides have been rarely studied. In this paper, we estimate total-factor productivity for listed firms in China and investigate the relationship between the allocation of direct government subsidies and firm productivity in China, using information on total firm subsidies and disaggregating this total into different subsidy types. We find little evidence that the Chinese government picks winners—if anything, the evidence suggests that direct subsidies tend to flow to less productive firms rather than more productive firms. In addition, we find that, overall, the receipt of direct government subsidies is negatively correlated with subsequent firm productivity growth over the course of our data window, 2007 – 2018. Even subsidies given out by government in the name of R&D and innovation promotion or industrial and equipment upgrading do not show any statistically significant evidence of positive effects on subsequent firm productivity growth.

The paper contributes to a growing literature exploring the effect of government subsidies on firm productivity, and relates to a strand of literature examining the effect of R&D related government subsidies in China on firm innovation and performance. The study is limited in the sense that it only covers one dimension of government support to corporate firms—direct subsidies—and it only measures that support for listed enterprises.

That said, based on the results of this study, we find little evidence that the allocation of subsidies has improved the productivity of Chinese firms. There is more robust evidence that subsidies support slightly higher levels of employment, at least temporarily. This is consistent with the view that political and social considerations might outweigh efficiency considerations in the allocation of direct subsidies. In the longer run, this approach is unlikely to promote the kind of significant productivity improvements the Chinese economy will need to maintain growth in the face of an aging population, a declining workforce, and mounting evidence of diminishing returns to capital investment.

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Supplementary materials

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