Industrial clusters in the long run: Evidence from Million-Rouble plants in China*

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Abstract

We identify the negative spillovers exerted by large, successful plants on other local production units in China. A short-lived cooperation program between the U.S.S.R. and China led to the construction of 156 "Million-Rouble plants" in the 1950s. The identification exploits the ephemeral geopolitical context and the relative position of allied and enemy airbases to isolate exogenous variation in location decisions. We find a boom-and-bust pattern in hosting counties and show that (over-) specialization explains their long-run decline. During the boom, the local economy becomes highly clustered around Million-Rouble plants. Linked establishments are locked in and do not innovate, which limits technological spillovers that would benefit new industries, reduces the supply of entrepreneurs, and the economy shrinks in the long run.

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The structural transformation of agrarian economies involves high spatial concentration of economic activity (Kim, 1995; Henderson et al., 2001). Regions that attract industrial clusters during this process typically experience a boom followed by a bust, as illustrated by declining factory towns in the United States (Detroit and the "Rust Belt"), the United Kingdom (Manchester and other mill towns), the Ruhr region in Germany, or the Northeast of France. Explanations for such a decline usually rely on external, macroeconomic factors: further structural change, as employment shifts away from industry (Ngai and Pissarides, 2007; Desmet and Rossi-Hansberg, 2014), exposure to import competition (Autor et al., 2013), or changes in trade policy (Pierce and Schott, 2016).

This paper takes a different perspective and focuses on factors *within* the local economy that contribute to the bust. Our analysis exploits an unprecedented industrial policy that involves the most comprehensive technology transfer in modern industrial history and constitutes the foundation stone of China's industrialization (Lardy, 1987; Naughton, 2007). As part of the *Sino-Soviet Treaty of Friendship, Alliance and Mutual Assistance*, the U.S.S.R. helped China build "Million-Rouble Plants" (MRPs) in the 1950s. The average investment per plant was equivalent to USD 160 million (in 2010) and gave China access to frontier technology. We follow locations that received these jump-start investments and investigate the dynamics of the industrial clusters. We present causal evidence that these industrial investments generated positive spillovers in the short run (a "boom"), as documented by previous research (e.g., Greenstone et al., 2010), but exerted strong negative production spillovers in the longer run (a "bust"). This decline is observed in spite of the constant, continuous success of the MRPs themselves (as recently documented in Giorcelli and Li, 2021). The bust is also orthogonal to the local composition of industries and products, thus discarding *external*, macroeconomic trends as the factors underlying the downturn. This leads us to focus on spillovers *within* the local economy, as drivers of the marked decline.

The decline of industrial clusters started in the 1990s and our micro data provide three key insights about the local economic environment since that time. (i) The economy is highly clustered: a large share of firms operate through the production chain of MRPs. (ii) Firms upstream or downstream the MRPs are not innovative: linked firms appear productive because they set high mark-ups but they are not innovative; non-linked firms are unproductive and non-innovative. (iii) Entrepreneurs leave the region to start their business elsewhere. These facts help us rationalize the rise and subsequent fall of counties hosting large plants. During the rise, there are positive spillovers associated with the adoption of industrial technologies. This explains the emergence of a specialized production structure that is dominated by MRP(s). In the longer run, the increasing degree of specialization comes at the cost: linked firms are locked in with little incentives to innovate; this limits between-industry spillovers that would benefit new industries.

Identifying agglomeration spillovers is a challenge. In our framework, it requires exogenous variation in the allocation of large plants across space. In an ideal setting, actual project sites would have a natural set of counterfactual sites, e.g., a list of candidate locations as in Greenstone et al. (2010), and exogenous variation in the selection process among these sites. We emulate this setup. We first rely on the *economic* criteria that policy makers used to select a set of suitable counties (Bo, 1991).[1] We then exploit the ephemeral *geopolitical* context—the short-lived Sino-Soviet Treaty of Friendship, Alliance and Mutual Assistance—to isolate temporary, exogenous variation in the probability to host a large factory in the subset of suitable counties. After the Korean war, Chinese planners were wary of the new factories' vulnerability to enemy bombing; this had a marked effect on location choices.[2] To exploit this variation, we combine novel information about airplane technologies with the location of enemy and allied air bases and derive a measure of vulnerability to aerial attacks from major U.S. bases for the period between 1950 and 1960. We use this measure as an instrument for the probability to host a MRP. To rule out possibly confounding effects from later place-based policies and industrial investments, we condition our analysis on similar measures of vulnerability computed after the Sino-Soviet split in 1960.[3] One remaining concern is that the instrument may be correlated with other geographic factors underlying recent economic growth. We present a variety of robustness checks to alleviate such concerns. Among others, we show that our findings are robust to controls for geography, for the current spatial distribution of economic activity and for other spatial policies such as the Special Economic Zones (see, e.g., Wang, 2013) or the Third Front Movement (Fan and Zou, 2019). We also consider a different identification strategy that compares locations with operational MRPs to a set of locations where "MRP plans" were abandoned

[1]In stark contrast with the Third Front Movement, this program was efficiently implemented. The location choice was economically sound (e.g., based on market access and access to natural resources) and attention was paid to production efficiency, including material incentives for managers (Eckstein, 1977; Selden and Eggleston, 1979) and technology transfers (Giorcelli and Li, 2021).

[2]Senior generals were directly involved in siting decisions to protect the state-of-the-art factories from enemy airstrikes, using intelligence maps of the U.S. and Taiwanese air bases (Bo, 1991). Historical U.S.S.R. documents report the same strategy to locate Soviet Science Cities out of the reach of enemy bombers (Schweiger et al., 2018).

[3]After the Sino-Soviet split in 1960, the set of protected locations shrunk, which called for directing new industrial investments to the interior during the Third Front Movement ("close to the mountains, dispersed, and hidden in caves").

due to the unexpected Sino-Soviet split.

Our research combines data on economic activity over time at the county level with a census of manufacturing firms that we complement with patent applications, productivity measures, and markups. We show that counties hosting MRPs experience a rise and a fall. Treated counties emerge to be more industrialized and two to three times more productive than control counties by 1982. Subsequently, the treated counties experience a steady decline (in relative terms) over the following decades. By 2010, the employment share in industry is *lower* in treated counties, and there is no longer any difference in average productivity even though the (large) MRPs remain very productive and innovative. Within an industry or product category and conditional on age or ownership structure, the (other) manufacturing establishments in treated counties are indeed far less productive, innovative, and competitive than establishments in control counties.

To identify spillovers from local MRP(s), we have to overcome an econometric challenge. With treatment heterogeneity, i.e., with MRPs operating different technologies to produce different products and drawing on different factor markets, a procedure based on a difference-in-differences cannot be implemented: it would require us to observe the sub-population of firms likely to be affected in control counties. We specifically develop a two-step procedure to address this issue where (i) we stratify counties by their propensity to receive a MRP, and (ii) we run Monte-Carlo simulations and draw—for each control county—one treated county (and its MRPs) from the same stratum. We then hypothetically attribute the associated MRP(s) to the control county. To infer linkages between firms, we rely on a procedure developed in Imbert et al. (2020) which associates a product code to textual product descriptions provided by manufacturing establishments. In a first step, we use this product classification to construct a measure of *production (line) concentration* at the county level. In the cross-section, the relationship between production concentration and productivity is bell-shaped. We find that treated counties become highly concentrated in production; this shift in specialization is thus associated with a drop in productivity. In a second step, we identify the role of production linkages at a more granular level, and show that treated counties are highly concentrated *along the production chain of the MRPs*. The large cluster of linked firms, upstream and downstream of the MRP(s), is quite productive but not innovative—registering almost no patents—and not competitive—charging a higher markup. Local firms outside the cluster are neither productive nor innovative. In a third step, we further characterize the role of production spillovers by looking at *missing industries*: we find that emigrants from treated counties are much more likely to be high-skilled entrepreneurs and to operate in other sectors than the MRP(s) in their home county.

This paper is the first to identify *negative* production externalities in the long run through a careful analysis of innovation, productivity, and production linkages at the firm level. We thus relate to the large literature discussing the benefits and costs of agglomeration. The following paragraphs place our paper in the existing literature on the benefits and costs of agglomeration and discuss other research on negative spillovers which is less directly aligned with our findings.

Our contribution is close to Greenstone et al. (2010) who look at the effect of Million-Dollar plants in the U.S., and to recent contributions analyzing the positive effects of early, large industrialization (Mitrunen, 2019; Fan and Zou, 2019; Garin and Rothbaum, 2020; Méndez-Chacón and Van Patten, 2019).[4] The identification of agglomeration economies is also the focus of a recent body of research on place-based policies, reviewed in Neumark and Simpson (2015), and including Busso et al. (2013), Kline and Moretti (2014), von Ehrlich and Seidel (2018), Schweiger et al. (2018), Austin et al. (2018), and Fajgelbaum and Gaubert (2020). Within this literature, numerous contributions analyze the (positive) effect of recent spatial policies on the distribution of economic activity in China, e.g., Special Economic Zones and industrial parks (Wang, 2013; Crescenzi et al., 2012; Alder et al., 2016; Zheng et al., 2017). During the rise of local economies receiving private or public investment, these economies tend to specialize (Kim, 1995; Henderson et al., 1995; Ciccone, 2002). The distinct aspect of our study is to look at a long time horizon which reveals negative production spillovers of industrial investments related to specialization.

Our findings at the micro scale are consistent with a literature discussing the negative effects of specialization (Duranton and Puga, 2001; Faggio et al., 2017). Our micro-analysis shows that linked establishments, by operating along the production chain of a large and productive factory, tie their production to the larger factory, thereby enjoying a technological rent, and face little incentive to innovate. This production structure leads to minimal between-industry spillovers (see Carlino and Kerr, 2015, for a review of their role as drivers of innovation and development in the long run), which stifles the entry of new industries (Glaeser et al., 1992; Henderson et al., 1995). The observation that new industries are not entering in treated counties is closely related to Chinitz (1961) and Glaeser et al. (2015), who argue that early industrialization induces a downward shift in the local supply of entrepreneurs.

Our preferred mechanism operates through negative *production* spillovers. However, other research points to the role of credit (Hsieh and Klenow, 2009; Song et al., 2011; Brandt et al., 2016), land (Brueckner et al., 2017; Yu, 2019) and labor mar-

[4]See Duranton and Puga (2014) for a more comprehensive review.

ket frictions (Brandt et al., 2013; Tombe and Zhu, 2019; Mayneris et al., 2018) in China. Counties hosting a large plant may thus experience a form of Dutch disease with an inefficient provision of factors across production units and high production costs (Duranton, 2011). We find little evidence that factor market distortions play a major role: labor costs are indeed dispersed, but they are low; firms competing for the same local factors as MRPs are not smaller or less numerous than similar industries in control counties (in contrast with Falck et al., 2013); the accumulation of human capital is not negatively distorted (in contrast with Glaeser, 2005; Polèse, 2009; Franck and Galor, 2017); and our findings are robust to controlling for local land prices or pollution (Chen et al., 2017a). A second concern is that the MRPs may affect the local political environment. Corruption and political interventions have been found to influence the competition for resources at the local level (Chen et al., 2017b; Wen, 2019), and MRPs may benefit from favoritism and preferential access to capital (Fang et al., 2018; Harrison et al., 2019). Again, we find little support for such an interpretation: the other manufacturing establishments in treated counties are capital-abundant, and the provision of subsidies does not appear to be distorted towards public or linked establishments. Last, there are macroeconomic trends which may underlie the rise and fall of treated counties. However, the rise-and-fall pattern is not driven by the dynamics of State-Owned-Enterprises (SOEs, see Brandt et al., 2016) or the dynamics of specific industries over the period. Indeed, SOEs in treated counties appear to be productive and innovative, we further control for industry and product fixed effects to clean our findings from the boom and bust of certain production sectors, and our findings are orthogonal to the life cycle and demographics of firms (Mueller, 1972).

The remainder of the paper is organized as follows. Section 1 describes the historical context. Section 2 details the data and the empirical strategy. Section 3 presents empirical facts about the rise and fall of early-industrialized counties. Section 4 provides evidence about the mechanisms behind the relative decline of treated counties with more granular establishment-level data. Section 5 briefly concludes.

1 Historical context and the "156" program

The "156" program is a unique experiment to study agglomeration spillovers in the long run. First, the geopolitical context introduces unique exogenous variation in the decision to locate projects. The "156" program was unanticipated before 1950; and strategic considerations behind the opening and location of plants became irrelevant a few years later, after the Sino-Soviet Split. Second, the program constitutes a large push shock for an agrarian economy (Rawski, 1979), and very different types of factories were built across a wide range of sectors.

1.1 The historical context

This section provides a brief account of the historical context; a comprehensive description can be found in Appendix A.1.

Sino-Soviet cooperation (1950–1958) In 1949, after the Sino-Japanese and Chinese civil wars, Chinese leaders studied the possibility of international economic cooperation to transform China's agrarian economy and foster the development of an independent industrial system (Dong, 1999; Lüthi, 2010). The Chinese government engaged in economic cooperation with the Soviet Union for ideological, but also geopolitical reasons. The possibility of economic cooperation with the U.S.S.R., which was not based on strong pre-existing economic ties, indeed became credible after the Sino-Soviet Treaty of Friendship and Alliance of 1950—already including a large loan. In August 1952, Chinese Premier Zhou Enlai visited Moscow to formalize the involvement of the U.S.S.R. in the long-delayed First Five-Year Plan (1953–1957): The U.S.S.R. agreed to cooperate and assist China in the creation of state-of-the-art industrial sites, with the purpose of extending its influence in the region.

Sino-Soviet Split (1958–1960) Rapid ideological and geopolitical divergence however precipitated a Sino-Soviet split that ended the cooperation between the two countries. The split formally unfolded in 1960 with an abrupt termination of industrial collaboration and heightened military tensions. The termination of industrial collaboration materialized in the sudden withdrawal of experts and engineers from China, the repatriation of Chinese students from the U.S.S.R., and the cancellation of ongoing industrial projects. The only remnants of the short-lived Sino-Soviet alliance were 150 plants that had been completed and were operational by 1960.

1.2 The "156" program

This section summarizes the key features of the "156" program.[5]

An industrial collaboration As part of the First Five-Year Plan (1953–1957), the U.S.S.R. committed itself to assisting China in the construction of 50 industrial sites. In May 1953, 91 new projects were agreed on and an additional 15 in October 1954. Overall, about 150 state-of-the-art factories would be constructed between

[5]We provide: a more detailed description of the program in Appendix A.2; a description of later place-based policies in Appendix A.3; and descriptive statistics about the plants in Appendix A.4.

1953 and 1958; the factories were huge investments and benefited from economic and technological assistance from the Soviet Union.

The U.S.S.R. actively participated in the design and construction of these factories. First, the economic aid from the U.S.S.R. extended beyond large loans; the U.S.S.R. provided more than half of the required equipment. Second, the collaboration involved the exchange of information, human capital, and technology, which in some cases was the best in the world (see Giorcelli and Li, 2021). During the peak of the cooperation, 20,000 scientific, industrial and technical experts from the Soviet Union lived and worked in China to design the construction of factories and rationalize production (Zhang, 2001; Wang, 2003). As part of the technology transfer, 80,000 Chinese students were trained in Soviet universities and technological institutes. While some blueprints were destroyed, the existing technology could be imitated and represented a large shift in the technological frontier (Bo, 1991).[6]

Chinese scholars credit the "156" program with having laid the foundations for the development of other industries, boosted production capacity, shifted the technological frontier, and promoted an even spatial development by industrializing central and western provinces (Dong and Wu, 2004; Zhang, 2009; Shi, 2013; He and Zhou, 2007). While these factories are known as the "156" in China, we rather refer to them as the "Million-Rouble Plants" (MRPs). Indeed, at the time of the Sino-Soviet Split, six factories were not yet viable and were forcefully closed; only 150 plants had been completed and were operational by 1960.

Location decisions The MRPs were regarded as iconic factories, and planners put much thought in siting decisions. First, planners selected locations using economic criteria. These criteria, detailed in Bo (1991), are: (i) connection to the transportation network and access to markets, (ii) access to natural resources through existing roads and rail, and (iii) belonging to an agrarian province, as the investments were seen as an opportunity to foster economic development outside of the few developed provinces. We will use these criteria to identify a relevant set of suitable counties.

Second, this period was an era of heightened geopolitical tensions that culminated in the Korean War—where U.S. soldiers and Chinese "volunteers" directly confronted. Planners were concerned that these large, key factories might become the target of enemy attacks. The decision process involved senior military officials to decide where factories should be built, accounting for the locations of enemy air bases (in Japan, South Korea, and Taiwan) and allied air bases (in U.S.S.R. and

[6] The last 15 projects agreed on in 1954 even benefited from state-of-the-art equipment that few Soviet factories enjoyed (Goncharenko, 2002; Giorcelli and Li, 2021).

North Korea). Enemy air bases were remnants of U.S. air bases used during World War II, the Korean War, and bases used by the United States Taiwan Defense Command. Most of the Chinese territory was in the range of U.S. strategic bombers; the decision process thus heavily relied on the locations of *allied* air bases able to intercept them. The Sino-Soviet split made this criterion redundant for later industrial investment: while proximity to military U.S.S.R. air bases would help against aerial attacks before the Sino-Soviet Split, U.S.S.R. air bases would be considered another threat after the Sino-Soviet Split, thereby explaining the peculiar features of later strategic decisions (e.g., the Third Front Movement).

Million-Rouble Plants and economic growth For the first 30 years of their existence, the MRPs developed in a planned economy. These factories and their local economies were fueled by the provisions of the plan. Factor movement was not free, and if more workers or capital could be productively employed, the plan would reallocate resources. The command-economy era as a whole will be considered as the treatment: treated counties enjoy a head start at the onset of the reform period.

Reforms to deregulate the economy were introduced in the 1980s. Private firms could be set up, and a dual price system allowed market transactions alongside the old quota requirements. In the 1990s, restrictions on labor mobility were gradually loosened, and migration began to rise as a major feature of Chinese economic growth. The MRPs successfully adapted to the market economy and remained leaders in their respective industries.[7] These industrial clusters have diversified their activities, their products ranging from computer screens to carrier-based aircraft.

2 Data and empirical strategy

This section discusses the data, the empirical strategy, and descriptive statistics.

2.1 Data

One requirement for estimating the dynamic agglomeration effects of large plants is to collect data on the local economy, ideally covering production dynamics from their openings to the current day. In this paper, we mobilize the following main data sources: (a) information on the Million-Rouble Plants and their evolution over time,

[7] We provide evidence for the continued success of MRPs in Appendix A.4. Note, however, that a small number of firms went bankrupt. Nine factories have been closed, all coal or non-ferrous metal mines. Two other firms, a paper mill and a former military electronics plant, were partly restructured and continue to operate. When construction plans were made in the 1950s, most plants were built in the city center. As pollution issues and the need for expansion had not been anticipated, nine plants were moved to the suburbs, within the same counties.

(b) county-level data on population and production (1953–2010), (c) establishment-level data in recent years (1992–2008), linked with patent applications and other product-level information, and (d) information on entrepreneurship.[8]

The Million-Rouble Plants In order to characterize the local treatment induced by the presence of MRPs, we collect information on their location, timing of construction, initial investment, original industry, and evolution of production over time. These pieces of information are extracted primarily from Bo (1991) and Dong and Wu (2004), as well as from historical archives, while the recent activity of these factories is retrieved using establishment-level data (see Appendix A.4).

County-level data We rely on Population Censuses in 1953, 1964, 1982, 1990, 2000, and 2010, nested at the county level.[9] The 1953 data only provide population and household counts, but subsequent censuses capture the agricultural status of households. At the time of the command economy, the household registration (*hukou*) type is a faithful reflection of both activity and the environment of residence. This piece of information offers us the opportunity to start tracking the evolution of urbanization and economic sectors from 1964 onward. Additional county-level information is available in 1982, most notably a disaggregation of employment by broad sectors and measures of output. In 1990, precise data are collected on the sector and type of employment and occupation, as well as on housing and migration, a phenomenon that mostly involved agricultural-*hukou* holders moving to cities in search of better earning opportunities. The 2000 and 2010 Censuses further include information on the place of residence five years earlier, timing of the last migration spell, reason for migrating, and place and type of household registration.

Establishment-level data We rely on the National Bureau of Statistics (NBS) "above-scale" firm data, which constitute a longitudinal census of all state-owned manufacturing enterprises (SOEs) and of all non-SOEs manufacturing establish-

[8]County gazetteers, which provide information on industrial and agricultural production, population, education, age, gender, and broad sector of activity, are currently being digitized and harmonized as part of the China Gazetteer Project—see `https://scholar.harvard.edu/freeman/china-gazetteer-project`.

[9]Data collected by statistical offices—gazetteers, censuses, surveys, and yearbooks—rely on official administrative divisions at the time of data collection. County boundaries are subject to frequent and sometimes substantial changes in China. To deal with this issue, we use the 2010 administrative map of China as our benchmark and re-weight the data collected in other years to match the 2010 borders. More precisely, we overlay the 2010 map with the map for every other year y and create a new map with all the polygons defined by the 2010 and year-y divisions. We then compute the area-weighted value of the variable of interest for each polygon and collapse the values at the level of the 2010 counties.

ments, as long as their annual sales exceed RMB 5 million, over the period 1992–2008.[10] We use the establishment data to: (i) infer linkages between establishments and create measures of product concentration; (ii) estimate factor productivity; (iii) observe technological innovations; and (iv) create measures of markups to capture product competition. We first rely on a text analysis based on the description of products in order to associate a 6-digit product code to each establishment (following Imbert et al., 2020, see Appendix B.1). We further complement the establishment data with product-level information, in particular a benchmark input-output matrix (United States, 2000), measures of technological closeness using patenting in the United States (Bloom et al., 2013), and the revealed factor intensity using the factor endowments of countries producing each good (Shirotori et al., 2010). We use the production functions derived in Imbert et al. (2020) to measure factor productivity (see Appendix B.2). We use the link provided by He et al. (2018) to match establishments with patent applications across three categories of patents (utility, invention, and design), and we rely on the procedure of De Loecker and Warzynski (2012) to estimate markups (see Appendix B.3).

2.2 Empirical strategy

This section describes the two steps of the empirical strategy: we select counties based on their suitability for hosting a Million-Rouble Plant; and we use vulnerability to enemy bombings in order to explain location choices among suitable counties.

Propensity score and suitable locations We first isolate a group of suitable counties by implementing a propensity-score matching based on the eligibility criteria described in Bo (1991). This step is not crucial for identification, and our findings will be robust to its exact specification. It however disciplines the empirical strategy: reducing the sample of control counties helps the identification of production spillovers through linkages between firms, as we will show in Section 4.

The first suitability criterion is market access and connectedness to the transportation network. In the baseline matching procedure, we rely on: an indicator variable that equals 1 if the county belongs to the prefecture in which the provincial capital was located at the time of the First Five-Year Plan; population at baseline (measured by the 1953 Census); county area; and a measure of proximity to

[10] These data cover contain accounting information at the level of "legal units." A legal unit can be a subsidiary of a firm, but has its own name and is financially independent (Brandt et al., 2014). Nearly 97% of legal units in our data corresponded to single plants; we will refer to these units as establishments. We construct a panel spanning the period 1992–2008 thanks to the algorithm designed by Brandt et al. (2014) and extended in Imbert et al. (2020).

a railroad hub using the existing railroad network in 1948. The second criterion is access to resources, which we proxy with measures of travel time to coal, ore, and coke deposits through the transportation network in 1948 (see Appendix C.1). As apparent in Appendix Figure C1, the historical development of the railway network and the location of natural resources induces that a crescent of counties are prone to receiving large industrial infrastructure. This crescent, located a few hundred kilometers from the Eastern coasts and borders, may be interpreted as a Second Front for industrialization; the later Third Front Movement will go deeper into the hinterland—a decision that will be rationalized by our empirical strategy.[11]

We regress the treatment, i.e., being in the close neighborhood of a MRP (within 20 kilometers), on the location determinants described above, $\mathbf{H}_c$, to generate a propensity measure $P_c = P(\mathbf{H}_c)$ for each county. We define the set of suitable locations $C = \{c_1, \ldots, c_N\}$ by matching treated counties with the five nearest neighbors in terms of the propensity P_c. We restrict the matching procedure to counties with a measure P_c in the support of the treated group. We impose that matched control counties be selected outside the immediate vicinity of treated counties, in order to avoid spillover effects into the control group. In the baseline, we exclude counties whose centroids lie within a 4-degrees $\times$ 4-degrees rectangle—roughly 2-3 times the size of the average prefecture—centered on a treated county. We provide a more comprehensive description of the matching procedure in Appendix C.1, where we show the distribution of propensity scores and the balance of matching variables within the selected sample of suitable counties.

The geographic dispersion of the treated and control counties is shown in Figure 1: most treated and control counties are located along this "Second Front" crescent; treated counties are however less likely to be located in East China.

Vulnerability to aerial attacks To isolate exogenous variation in the decision to select counties, we construct an instrument based on vulnerability to airstrikes from U.S. and Taiwanese air bases, accounting for the shield provided by allied bases.

To this end, we geo-locate active U.S. Air Force bases and Taiwanese military airfields (enemy air bases), as well as major U.S.S.R. and North Korean air bases (allied air bases). We then compute a measure of local travel cost accounting for

[11] Although they do not feature among the list of explicit determinants, other geographical and economic factors may have entered siting decisions, e.g., distance to major ports, and we condition our analysis on factors susceptible to affect long-term economic growth in the baseline strategy and in robustness checks. In the baseline matching procedure, a few county characteristics are targeted thus leaving many variables available for balancing tests. By contrast, more variables could be used to refine the initial matching, thereby leaving fewer characteristics to compare across treatment and control groups in an "over-identification" check.

the vicinity of U.S.S.R. and North Korean bases. The procedure, discussed in Appendix C.2, is disciplined by the technical characteristics of enemy jet fighters at that time, most notably their range. It produces a map of local travel cost for enemy airplanes covering any given point of the Chinese territory. Our instrument (vulnerability to aerial attacks) is defined, for each county, as the minimum across enemy bases of total travel cost from the base to the county centroid.

We illustrate the spatial variation in vulnerability to aerial attacks in Figure 2. Before the Sino-Soviet split, military concerns would favor the Northeast at the expense of East China (see Panel A showing vulnerability in 1953). The set of suitable and protected locations however became much smaller after the split, and investment during the Third Front had to be targeted toward interior provinces (see Panel B showing vulnerability in 1964). The paths of surveillance flights between 1963 and 1965 (Panel D) provides external validation for the decision to shield the MRPs and the later Third Front factories: after the Sino-Soviet split, the "Second Front" lost its locational advantage and U.S. reconnaissance aircraft appeared to target these factories. Our empirical strategy uses the pre-split measure as an instrument for siting decisions, conditioning for the post-split measure, thereby leveraging the ephemeral alliance between China and the U.S.S.R. as the source of identification.

Figure 3 provides a representation of the relationship between the vulnerability to aerial attacks and factory location choices. The distribution of travel cost across treated counties has a much fatter right tail than that of the control group, which shows that factories were preferably established at a (penalized) distance from enemy threats. This relationship constitutes the first stage of our empirical specification, and Table 1 shows that vulnerability to aerial attacks is quantitatively relevant in explaining siting decisions. One standard deviation in travel cost from enemy bases increases the propensity to host MRPs by about 26 percentage points among suitable counties. The average difference in travel cost between treated and control counties is about three quarters of a standard deviation; our instrument thus explains $0.75 \times 26 \approx 20\%$ of the allocation of MRPs among suitable counties.[12]

Importantly, while there is a strong relationship between our treatment (i.e., a place-based policy between 1953 and 1958) and the vulnerability to aerial attacks in 1953, the treatment is not correlated with vulnerability measures as computed

[12]Table 1 displays three specifications, one without any controls (column 1), one with the propensity controls only (column 2), and one with the full set of controls (baseline specification, column 3). All specifications are restricted to the set of treated and control counties defined by matching on access to natural resources and the additional economic and geographical determinants. The full set of controls is used to condition the analysis on characteristics that may directly affect outcomes of interest in the second stage; it is however reassuring that the first stage is not dependent on their inclusion.

in 1964 and 1972. Furthermore, vulnerability to aerial attacks in 1953 does not strongly correlate with later place-based policies. The geography of our place-based policy is unrelated to the geography of later investments (see Appendix D.1).

Benchmark specification Let c denote a county and T_c the treatment variable indicating whether a county is in the close proximity of a MRP. We estimate the following IV specification on the sample of suitable counties:

$$Y_c = \beta_0 + \beta_1 T_c + \mathbf{X}_c \beta_{\mathbf{x}} + \varepsilon_c \tag{1}$$

where the treatment, T_c, is instrumented by the vulnerability to aerial attacks, V_c, and Y_c is a measure of economic activity at the county level. The controls include the propensity controls, a set of propensity score dummies (stratifying the sample along the propensity score), and a set of additional controls: travel cost to major ports, proximity to cities in 1900, proximity to Ming-dynasty courier stations, distance to military airfields, and the post-split vulnerability to air strikes. Standard errors are clustered at the level of 4-degree $\times$ 4-degree cells.

A key assumption underlying the empirical strategy is that the instrument has no effect on outcomes of interest other than through the location of the Million-Rouble plants. We now discuss possible concerns with this assumption. First, the respective locations of military bases could have influenced investment at later stages of the Chinese structural transformation. Conditioning by later vulnerability to aerial attacks—after the Sino-Soviet Split and the start of the Vietnam War rebalanced the geographic distribution of military power in the region—should reduce this concern. We also provide a sensitivity analysis and control for other spatial policies (e.g., Third Front Movement, Cultural Revolution, Special Economic Zones and industrial parks, etc.). Second, vulnerability may correlate with unobserved county amenities, which would both explain the decision to locate factories and be correlated with later patterns of economic growth. We control for elevation, ruggedness, soil quality, and expected crop yield in robustness checks. Third, vulnerability may correlate with the general geography of the recent growth patterns in China. For instance, China's Southeast was considered vulnerable but widely benefited from the opening of Chinese ports to trade in the reform era.[13] Such a violation of the exclusion restriction would induce a spurious negative correlation between economic growth

[13]Note, however, that the vulnerability measure does not overlap with the coast-interior divide that characterizes the spatial distribution of economic activity in China. Some factories were indeed set up on the coast, first and foremost in Dalian, but not on the southern shore, too exposed to American or Taiwanese strikes.

and the presence of MRPs. To deal with this concern, we will run a series of robustness checks, most notably excluding a buffer around the Pearl river delta, excluding all Chinese counties below a certain latitude, or controlling for distance to the coast. Fourth, we can repeat our exercise by replacing actual factories with unfinished projects. While the first stage still applies, the second stage shows no differences between placebo locations and other suitable locations.

2.3 Descriptive statistics

The MRPs expanded and modernized the Chinese industry in a wide range of sectors, but with a bias towards heavy, extractive, and energy industries (e.g., coal mining or power plants, see Table 2).[14] Construction started between 1953 and 1955, and was achieved at the latest in the first quarter of 1959. The last two columns of Table 2 show planned and actual investment; the figures attest the scale of the program for an agrarian economy like China in the 1950s. The average planned investment by factory was about 130,000,000 yuan, which amounted to 20,000,000 Soviet roubles in 1957 ($160,000,000 in 2010 U.S. dollars); total investment was of the order of a fourth of annual production in 1955.

Table 3 provides key descriptive statistics for treated and control counties. About 5% of Chinese counties are defined as being treated, and we use 15% of Chinese counties as suitable control counties in our baseline specification. As expected from a context of heightened international tensions following the Korean War, treated counties are located at a much greater distance from U.S.A.F. and Taiwanese bases. The difference in vulnerability between control and treated counties is about 75% of a standard deviation. Note, however, that control and treated counties do not differ markedly in their exposure to enemy raids *after* the Sino-Soviet split.

Differences in terms of population are small at baseline (1953), jump in 1964, and stabilize somewhat afterwards. Descriptive statistics about urban registration show a similar gradient between treated and control locations, albeit more persistent. Households in treated counties are more likely to hold an urban registration even after the reform. These differences are, however, not indicative of economic activity from 1990 onward, given the large number of rural migrants working in cities.

The bottom panels of Table 3 describe possible differences in matching variables and additional controls used in the baseline. Consistent with the propensity matching procedure, differences in topography and connectedness are less pronounced

[14] The "156" program follows the "Russian model" of industrialization (Rosenstein-Rodan, 1943), with coordinated and large investments across industries to modernize agrarian economies. These upstream factories were expected to irrigate the economy downstream.

among suitable locations. Treated counties exhibit slightly lower travel costs to coal, coke, and ore deposits. These differences are nonetheless accounted for by propensity-bin dummies and matching weights in Specification (1). Two historical control variables appear as being important in explaining the allocation of treatment, even though they do not explicitly feature among location criteria: proximity to cities in 1900 and proximity to Ming stations. This is why we include these variables as controls in the baseline specification.

3 The rise-and-fall pattern

This section presents the implications of early industrialization in counties hosting MRPs, with an aggregate rise and fall, and a marked fall of non-MRPs plants.

3.1 Baseline results

The influence of the MRPs on their local economy spans two periods: the rise and the fall, which we first capture with cross-sectional analyses in 1982 and 2010.[15]

The rise We first describe empirical facts about the local treatment effect of MRPs in 1982; the analysis and the choice of outcomes are unfortunately limited by the availability of information at the county level. Table 4 shows OLS (Panel A) and IV estimates (Panel B) of the relationship between the presence of a MRP and population, share of urban residents, output per capita, and the employment share in industry (in 1982 and in 2010).

We find that industrial investment under the "156" program has a positive and significant impact, albeit small, on population in the earlier period. Treated counties are 16% more populated than control counties (column 1, Panel B). The treatment effect on urbanization is much larger; the share of the population that has non-agricultural household registration is about 34 percentage points higher (column 2, Panel B). The impact of the MRPs thus shows a large reallocation of labor, which could be interpreted as evidence of structural transformation and urbanization. The higher share of urban residents is associated with a much higher output per capita, and a higher industry share in the local economy (columns 3 and 4, Panel B). GDP per capita is more than twice larger in treated counties, and the employment share

[15]Note that these cross-sections also coincide with the end of the command-economy and the end of the reform period. In effect, reforms in the non-agricultural sector were introduced gradually. Private firms were allowed to develop and compete with state-owned enterprises (SOEs) from the mid-1980s onward, which was instrumental in introducing market discipline in state-owned enterprises. Nonetheless, the large privatization wave did not start until the 1990s.

in industry is 23 percentage points higher. The magnitude of these differences is far beyond the mere output of the average MRP (see Appendix A.4), indicating that counties are richer and more developed—this effect is equivalent to the difference between the median and the top 10% of the control-group distribution.

A few remarks are in order. First, the IV estimates are larger than the OLS estimates, possibly reflecting the fact that places selected to host a MRP were less likely to host major industrial developments prior to the First Five-Year Plan (Bo, 1991). Second, the observed rise of industrial clusters may have limited external validity. Before the advent of the reforms, the government would instruct workers where to live and where to work to accommodate rising demand for labor and ensure the growth of the plants and local economy.[16] Changes in labor allocation mostly reflect government intervention, which may temper agglomeration effects. The population increase, while larger than the expected labor force of the MRP itself, remains limited and probably lags behind labor demand in treated counties.

To summarize the impact of the "156" program between 1953 and 1982, we find a moderate effect on urban population, but a very large effect on the local structure of production. The substantial productivity gap between treated and control counties indicates that treated areas enter the subsequent period with a substantial head start. Lower mobility costs and the liberalization of the economy should allow agglomeration economies to operate, and one could expect treated counties to grow even further apart from the rest of the economy. As we see next, we find the opposite.

The fall There is (more than) a full catch-up between 1982 and 2010 (see Table 4). We find that population is still higher in treated counties (column 1, Panel B); treated locations also continue to have a higher share of urban population (column 2, Panel B). In stark contrast with the treatment effect in 1982, however, output per capita and the industry share are now slightly lower in treated counties (columns 3 and 4, Panel B). The significant gap in industrialization before the transition has thus fully eroded: treated counties are slightly less productive as control counties and the employment share in industry is 13 percentage points lower.

This fast reversion to the mean is puzzling for two reasons. First, it does not result from a swift decline of MRPs themselves; they remain very large and extremely productive (Giorcelli and Li, 2021). Second, their own influence on aggregate productivity is non-negligible: the previous results thus indicate that other firms must

[16]While some free movement of labor still occurred after the advent of "New China" in 1949, mobility was subject to authorization from the late 1950s onward. The government had tightened its grip on labor movement in the wake of the Great Leap Forward, when famines threatened the sustainability of urban food provision systems.

be quite unproductive.[17] Before turning to the characterization of these other establishments in treated counties, we provide a series of robustness checks.

3.2 Robustness checks and sensitivity analysis

The empirical strategy exploits temporary, exogenous variation in the probability to host a MRP among suitable counties. The geographical variation induced by the vulnerability to bombing between 1950 and 1960 may however coincidentally correlate with other geographic determinants of later economic growth. We provide a comprehensive sensitivity analysis to reduce concerns that the rise and the fall are related to other factors than hosting MRPs. This section summarize these robustness checks and a detailed discussion of the results can be found in Appendix D.1.

We interpret the previous estimates as the effect of MRPs on the local economy. One concern is that the instrument, which relies on the distribution of air bases across space, may correlate with other geographic factors that have independent effects on the distribution of economic activity across China over time. In Appendix D.1, we first condition the baseline specification on measures capturing an environment that is (un)favorable to economic take-off (e.g., land supply restrictions, pollution, connectedness, trade routes, access to ports, distance to the coast, natural amenities, elevation, soil characteristics, and crop yield) to reduce concerns about biasing effects from unobserved county characteristics. Second, we exclude the Pearl river delta and the South of China to show that our results are not driven by the overall geography of the economic take-off in China. Third, we control for later place-based policies that could reduce the gap between treated and control counties (e.g., Third Front Movement, Special Economic Zones, industrial parks), for factors underlying these later decisions (e.g., vulnerability to U.S.S.R. strikes), and for other policies driving the economic evolution of China (e.g., the Cultural Revolution).

We also consider variations in our matching procedure: we extend the set of variables used for matching by adding proximity to Ming courier stations, distance to military airfields, and access to the main trading ports; we then restrict the set to a minimum set of variables (travel cost to coal mines, proximity to a rail hub, whether the county is a provincial capital, population in 1953, and county area); we further restrict the choice of control counties by considering a one-to-one matching procedure without replacement; we enlarge the exclusion zone around

[17] Appendix A.4 provides a comparison between the MRPs and similar "above-scale" manufacturing establishments, shows the dynamics of employment and patenting in these MRPs, and derives estimates of their employment shares in their local economies. In Appendix D.1, we exclude the few counties hosting closed and displaced factories to show that the fall is not related to the fall of MRPs themselves—we also better account for MRP type (e.g., extracting industries).

treated counties. We also provide a sensitivity analysis around the construction of the vulnerability instrument and the treatment of spatial correlation.

Finally, we consider alternative measures of economic activity, including a more precise sectoral analysis and the use of nighttime luminosity in 1993 and in 2013.

3.3 The (dramatic and dynamic) fall of *other* establishments

This section sheds light on the marked fall of non-MRPs plants and provides a better account of the dynamics within counties hosting MRPs.

Production in *other* establishments Treated counties experience a swift reversion to the mean in *aggregate* output, including MRP(s). To understand the county-level reversion pattern, we now rely on micro-data, which allows us to better characterize the structure of production in the average *other* establishment. The analysis relies on: measures of factor productivity at the establishment level, identified using an exogenous labor supply shifter (see Imbert et al., 2020, and Appendix B.2); patents linked to establishments (He et al., 2018); and markups computed following De Loecker and Warzynski (2012) (see Appendix B.3).[18] In Panel A of Table 5, we estimate Specification (1) at the establishment-level, pool all establishment × year observations between 1992 and 2008, and regress an outcome on the treatment T_c, instrumented by V_c. We exclude the MRPs from the sample, and we cluster standard errors at the level of 4-degree × 4-degree cells.

Factor use is different in treated and in control counties (columns 1 and 2): establishments in treated counties are more capital-abundant than in control counties; real capital is 40% higher, while employment is 30% higher. Labor cost sharply differs in treated counties. We find that the average compensation per employee is about 32% lower in treated counties (column 3). In line with this finding, total factor productivity is 30% lower in treated counties than in control counties (column 4).[19] This could either indicate that the treatment generates differences in technology adoption or differences in price setting between control and treated counties. We investigate these two aspects next. We find that establishments in treated counties produce fewer patents.[20] The treatment effect is of the order of magnitude of the

[18] In this section, we describe the treatment effect on the structure of production using a selection of outcomes, and we leave the detailed analysis of factor use, factor productivity, firm characteristics, investment and subsidies, patenting behavior, and price setting to Appendix D.3.

[19] Labor cost and factor productivity appear to be low in treated counties, but dispersed (see Appendix D.3).

[20] While we distinguish three patent categories in Appendix D.3 (design, innovation, and utility—the latter categories being the most relevant to capture technological progress), we only report the treatment effect on the total number of registered utility patent applications in column 5.

yearly number of patents produced in the average establishment: very few patents are thus registered in treated counties. Finally, the TFP effect cannot be explained by markups; they are on average higher in treated counties (column 6): the probability for a firm to charge a markup above median in a given year is 13 percentage points higher in treated counties.

The previous results could theoretically be tied to compositional differences induced by the local industrial composition, local products, the presence of public and subsidized enterprises (Harrison et al., 2019), and the age of establishments. We thus clean for year interacted with 4-digit industry fixed effects (Panel B), year interacted with 6-digit product fixed effects (Panel C) and for year interacted with firm ownership type and age (Panel D). Controlling for the local industry structure (industry or product fixed effects) is innocuous for factor productivity and factor use but quite important for patenting behavior. Indeed, the presence of the MRP(s) tilts the local industrial fabric toward innovative sectors; these innovative sectors are however far less innovative in treated counties. Our results are however orthogonal to the life-cycle of local firms and to the demise of public establishments.[21]

The dynamics of counties and *other* establishments We now provide some insight on the dynamics of treated counties from 1980 onward. In Figure 4, we show the evolution of counties hosting MRPs across a set of variables which can be consistently harmonized over time: employment share in agriculture (1982–2010); employment share in industry (1982–2010); nighttime luminosity (1993–2010); and urban extent (1993–2010). More specifically, we estimate Equation (1) separately for different years and we report the treatment effect. There is a gradual decrease in economic activity in treated counties, with a clear inflection during the 1990s.

The dynamics of the local economy could be driven by the dynamics of the MRPs themselves; the MRPs however experience an *increase* in patenting activity in the recent period, as documented in Appendix A.4. Instead, we show that there is a clear, negative dynamics in firm size and innovation among *other* establishments than MRPs in Panels E and F of Figure 4 (see Appendix D.2 for a more systematic analysis of firm outcomes, including productivity measures and mark-ups). The next section identifies the spillovers within the local economy which drive this marked decline in production and innovation.

[21]Public establishments in treated counties are not relatively less innovative or less productive than in control counties. If anything, their likelihood to register a patent and their total factor productivity are larger. We provide a comprehensive analysis of compositional effects in Appendix D.4, in which we analyze how differences in production structure may reflect differences in the industrial fabric, differences in the ownership structure, or the presence of establishments at different stages of their life cycle.

4 Mechanisms behind the fall of treated counties

This section analyzes the negative spillovers exerted by MRP(s) on the local structure of production in four steps. In a first step, we study the relationship between treatment, productivity and product concentration at the county level. This exercise explores various aspects of the tangle of economic interactions between establishments and shows that production is very concentrated in treated counties with implications for average productivity. In a second step, we zoom on the production chain of MRPs with micro-level data and characterize these industrial clusters. In a third step, we better identify the effect of hosting a MRP on *missing industries* through the local supply of entrepreneurs. In a last step, we discuss the possible role of other externalities than production spillovers, e.g., a form of Dutch disease affecting the provision of factors or political favoritism.

4.1 Product concentration at the county level

In this section, we derive aggregate measures of product concentration at the county level and estimate how (over-)concentration may explain the average firm performance in treated counties.

We construct Herfindahl measures of concentration at the county level, using the product classification into HS 6-digit product codes from the textual description provided by our manufacturing establishments. Letting p denote a certain product category, we construct a vector $\mathbf{S}_c = (s_{p,c})_p$ of the employment share in each HS 6-digit product category for a given county c. A Herfindahl measure of product concentration can be obtained by considering:

$$h_c(\mathbf{M}) = \mathbf{S}_c'\mathbf{M}\mathbf{S}_c$$

where $\mathbf{M} = (m_{p,p'})_{p,p'}$ is a matrix in the product $\times$ product space capturing the degree of similarity between two product codes. The baseline Herfindahl index is usually obtained by considering $\mathbf{M} = \mathbf{I}$, where a pair of product codes is allocated a weight equal to one if they are the same, and zero otherwise. A production-based Herfindahl index can be created by using input-output accounts in the United States (Stewart et al., 2007) and considering $m_{p,p'}$ as the input share of product p into product p'. A technology-based Herfindahl index can be created by using the intensity of (cross-)patent citations in the United States (Bloom et al., 2013).[22]

[22] A language-based Herfindahl index can be created by using a language similarity score between HS 6-digit descriptions in Chinese (Imbert et al., 2020). We provide a detailed description of these measures and additional results in Appendix D.5.

Figure 5 displays the relationship between product concentration and total factor productivity at the county level, and the distribution of product concentration in treated and control counties, over the period 2004–2008. Panel A plots the correlation between: (i) the residual of (log) product concentration, $log(h_c(\mathbf{I}))$, at the county level in each year over the period 2004–2008 and (ii) the residual of (log average) total factor productivity, both obtained from running a regression on the controls $\mathbf{X}_c$ used in Equation (1). One can observe a small positive correlation for low levels of concentration, and a marked negative correlation for high levels of concentration: a 10% increase in the concentration index above the average level is associated with a decrease in total factor productivity of 2.5%. Panel B shows that the distribution of product concentration in treated counties significantly tilts towards high concentrated indices: the average difference in $log(h_c(\mathbf{I}))$ between treated and control counties is 0.24, and 0.59 when treatment is instrumented by the vulnerability measure. These differences could explain a difference in (average) total factor productivity of up to 15-20% between control and treated counties. Panels C and D replicate the previous analysis with the production-based Herfindahl index. Again, the clear n-shape of the relationship between product concentration and total factor productivity and the drift in product concentration in treated counties could explain a drop in (average) total factor productivity of up to 15% in treated counties. Panels E and F, using the technology-based Herfindahl index, however provide a different picture. While treated counties are more concentrated along this measure as well, this may not penalize productivity as the relationship between technological concentration and total factor productivity is quite flat.

These findings suggest that (over-)specialization in production may explain the observed differences in firm performance across counties. We investigate next how this (over-)specialization relates to concentration around MRPs themselves.

4.2 Production structure around MRPs

In this section, we focus on linkages between establishments to better understand the concentration *around the MRP(s)* and the characteristics of linked plants.

Product concentration around MRPs The use of establishment-level data implies that we can identify differences in the local structure of production from observing potential links between establishments and the local MRP(s), or from the interaction of the treatment with linkages to the local MRP(s). For instance, one may compare the activity of downstream establishments in a treated county with similarly defined establishments in control counties, relative to the same difference for non-downstream establishments. A difference-in-difference specification cannot however be implemented as such, due to treatment heterogeneity, and we rationalize the use of a more involved empirical strategy in Appendix C.3, where we (counterfactually) allocate MRPs of our sample to control counties in a Monte-Carlo fashion.

In order to capture potential linkages between establishments and the local MRP(s), we rely on the previously-defined measures of input/output linkages, $\mathbf{M} = (m_{p,p'})_{p,p'}$, and we define a dummy, *Downstream*, equal to 1 if $m_{p,P}$ is higher for an establishment producing p than the 95%-quantile across all establishments of the sample, and where P is one of the products produced by the local MRP(s). We define a dummy, *Upstream*, in a similar way to characterize upstream establishments. We define an indicator, *Same product*, equal to 1 if the establishment produces at least one good (6-digit level) also produced by a local MRP. We proceed in a similar fashion to define: (i) a measure of technological closeness based on the intensity of patent citations across different industries; (ii) and a measure of competition on factor markets based on revealed factor intensities as predicted by trade patterns in 2000 (see Shirotori et al., 2010, for the construction of factor intensities).[23]

Table 6 (Panel A) reports the relative presence of establishments operating downstream, upstream, and in the same product market as the local MRP(s). In column 1, we report the result of a specification in which the measure of downstream linkages at the establishment level is regressed on the treatment, instrumented by vulnerability to air strikes.[24] We find that the treatment increases the probability for an establishment to operate downstream of the MRP by about 5 percentage points (this probability is about 2% in control counties). Columns 2 and 3 of Table 6 report the relative incidence of upstream linkages and horizontal linkages in treated counties. The treatment effect on the probability for an establishment to operate upstream of the MRP is non-negligible, even though MRPs tend to operate early in the production chain. The treatment does also affect the probability to operate in the same product market, which increases by 5 percentage points—an effect that we can attribute to economies of scale (Ciccone, 2002). Overall, the production chain of

[23](i) We define a dummy, *Tech. clos.*, as being equal to 1 if technological closeness is higher than the 95%-quantile across all establishments. (ii) Letting f_p denote the revealed factor intensity for factor f (human capital, physical capital, or land) and good p, we define a dummy, *More F-intensive*, equal to one if the average f_p over the goods produced by an establishment is higher than the average f_P over the goods produced by local MRPs. The rationale is that MRPs may have a higher bargaining power on factor markets, e.g., because of lower search frictions; their privileged access to resources may affect those firms whose needs for this production factor are more pressing.

[24]As the estimation procedure relies on multiple draws, we report here the average effect and the average standard error over 100 simulations. Correct inference would require us to bootstrap standard errors. Note that we exclude the MRPs from the estimation, that we control for year and 4-digit product fixed effects, and that standard errors are clustered at the level of 4-degree × 4-degree cells.

the MRP(s), excluding the MRP(s), would represent about 5% of all establishments in the average control county against 20% in the average treated county.

Table 6 (Panel B) reports the relative presence of establishments with more acute demand for human capital (column 1), physical capital (column 2), and land (column 3) than the local MRP(s). The differences between treated and control counties are minimal—a few percentage points, to be compared with averages at around 50 percentage points. These findings provide little support for the existence of spillovers in factor markets. Finally, Table 6 (Panel C) reports the relative presence of establishments with a technology closeness measure above the 95%-quantile. The difference between treated and control counties is small, albeit imprecisely measured, possibly reflecting treatment heterogeneity across MRP types.

Production in linked and non-linked establishments The previous table has identified the change in the structure of production induced by the presence of the MRP(s): there are many more establishments operating along the production chain. We now characterize these establishments, by interacting treatment with production linkages, and looking at treatment heterogeneity on the following selected outcomes: total factor productivity, the number of registered (utility) patents, and markups.

The gap with control counties in patenting intensity is surprisingly *more* pronounced for downstream/upstream establishments (see column 2, Panel A of Table 7). The (negative) treatment effect on utility patents is five times larger for these establishments than for other establishments. This effect illustrates that linked establishments usually operate in very innovative industries; they do not, however, innovate in treated counties. This result sharply contrasts with our finding on productivity (and markups, to a lesser extent—see columns 1 and 3 of Table 7): establishments along the production chain of MRP(s) are slightly more productive than their counterparts in control counties. The same general patterns can be observed for establishments in the same product market (Panel B).[25]

Our interpretation of these findings is that establishments along the production chain of MRP(s) enjoy a technological rent from their proximity with a highly productive and innovative factory. These establishments extract part of the final value added when operating at one point of the production chain, whether upstream or downstream, and they do not need to incur innovation efforts.[26] This technological

[25]Establishment characteristics do differ across treatment and along the production chain. Compositional effects cannot however explain the patenting behavior of those establishments: SOEs are more innovative than other establishments in these counties. See Appendix D.4 for a proper investigation of compositional effects.

[26]The effect of a large, innovative establishment on the markup set by intermediaries could be ambiguous. On the one hand, the production chain probably generates high rents, which should

rent provides incentives for establishments and entrants to tie their production to the MRP technology, thereby explaining the very large cluster of specialized production units around the MRP.

With a highly concentrated structure of production and non-innovative nucleus of firms, treated counties do not benefit much from the externalities in local technological progress, whether it be within or across industries (Glaeser et al., 1992; Beaudry and Schiffauerova, 2009). One question remains: why are there so few establishments outside the production chain of MRPs?

4.3 Missing industries and entrepreneurial supply

We shed some light on missing industries and a shift in entrepreneurial supply by comparing the creation of firms by emigrants from treated and control counties.

We rely on the 1% Population Survey of 2005 and a selection of outcomes (education, employment status, county of *hukou* registration) to compare the profiles of emigrants from treated and control counties.[27] We use Specification (1) and regress the average emigrant characteristic Y_c at the county level on T_c (where c denotes the "origin" county), instrumented by V_c. The average emigrant characteristic Y_c is constructed as the standardized share of emigrants from county c with a given characteristic in 2005, normalized by the population share with the same characteristic in the 2000 Population Census.

Table 8 investigates the treatment effect on the profile of emigrants, focusing on educational attainment, occupation, employment type, and income. Column 1 shows that emigrants from treated counties are more likely to be positively selected in terms of education than emigrants from control counties: the share of emigrants with a tertiary degree is 77% of a standard deviation higher in treated than control counties. Migrants from treated counties are more likely to hold a manager position at destination, although the coefficient is not statistically significant (column 2). Columns 3 and 4 show that they are much more likely to be self-employed workers or employers in their counties of residence. Finally, column 5 shows that emigrants from treated counties are more likely to be in the top 20% of the income distribution than emigrants from control counties. These results suggest that the treatment

influence the markup set by intermediaries. There may also exist a hold-up problem if the final good requires all intermediary inputs to be produced. On the other hand, the large establishment may benefit from a more advantageous bargaining position when negotiating with intermediaries.

[27] A second data source is the firm registry of the Administration for Industry and Commerce, which can shed light on the migration patterns of entrepreneurs in treated and control counties. These administrative data cover the universe of Chinese firms (Shi et al., 2018) and contain information on the paid-in capital, date of creation, years in operation, and location of the firm, as well as the origin or place of registration (*hukou*) of the firm's legal representative.

generates a local environment that is not conducive to firm creation outside the production chain of MRPs. Even when potential entrepreneurs are produced, they prefer to export their skills to and set up firms in other counties.

4.4 Other local spillovers

The previous section presents findings that are consistent with negative *production* spillovers. This section describes alternative mechanisms through which the MRPs may affect the local business environment.

Dutch disease and misallocation of factors In China, recent research discusses labor market imperfections (Brandt et al., 2013; Tombe and Zhu, 2019; Mayneris et al., 2018), credit market imperfections (Hsieh and Klenow, 2009; Song et al., 2011; Brandt et al., 2016) and land market imperfections (Brueckner et al., 2017; Yu, 2019). The presence of a large factory may distort the allocation of resources and factors (labor, credit, land) across production units. For instance, treated counties may experience a form of Dutch disease (Corden and Neary, 1982), whereby production costs become prohibitive for smaller firms to enter (Duranton, 2011).[28] We provide evidence in Appendix D.3 that: (i) labor costs are lower in treated counties, in spite of a more educated and experienced workforce, the accumulation of human capital is higher (in stark contrast with Glaeser, 2005; Franck and Galor, 2017) and parents appear to have high aspirations about their children's education (Appendix D.6); (ii) access to capital and public subsidies do not seem particularly difficult for the average (other) establishment; (iii) we control for spatial externalities exerted on land markets or on local amenities by showing that our findings are orthogonal to local land prices and local pollution.

Communist spirit and local political environment The influence of the factory may affect the business environment through less observable channels. For instance, there may be a tight link between the MRPs and the local political environment, which could operate two ways. First, MRPs may use their influence on the local business environment to gain preferential access to resources (Fang et al., 2018; Harrison et al., 2019). Second, the MRPs may be used by local leaders to alleviate social unrest (Wen, 2019). We have very limited data to shed light on these issues, and we look at two indirect indicators about the local business environment and its "fairness": the provision of subsidies (Appendix D.3) and a survey

[28]We also investigate the dispersion of factor productivity, and the entry and exit of establishments. We do find some evidence of a higher misallocation of capital and labor across and within sectors and a lower firm dynamics.

about entrepreneurial values and fairness (Appendix D.6). While we do not find evidence that subsidies are differently allocated in treated and control counties, we do find evidence that individuals have different beliefs about returns to hard work and different "Communist values." The less dynamic business environment is thus accompanied by an adjustment of priors.

Public sector, life cycle of establishments and obsolete sectors The presence of a large (initially public) factory may affect the involvement of the state in other, linked establishments. The boom and bust of treated counties could then reflect the boom and bust of the state sector over the period 1950–2015 in China (Brandt et al., 2016). We show in Appendix D.4 that our findings are robust to controlling for: (i) the percentage of Communist Party members and "red categories" within the population, (ii) the share of subsidized housing, and (iii) the incidence of the state sector within counties. Importantly, public establishments in treated counties are not more likely to be linked to the MRPs, and they are more productive than in control counties.

Our findings might not be driven by direct negative spillovers, but by the boom and bust of the MRPs themselves, the life cycle of (old) linked firms, or the marked change in sectoral activity over the period. We show in Appendix A.4 that MRPs experience an opposite dynamics in patenting and employment to other establishments over the period 1998–2008: these factories are still innovative and not on the decline. Our findings are also robust to controlling for the age of manufacturing establishments, which are indeed slightly older in treated counties (more so along the production chain of MRPs), and robust to controlling for industry or product fixed effects at the 6-digit level, thereby cleaning the analysis from the differential sectoral returns in the more recent period (see Appendix D.4).

5 Conclusion

Industrialization and the concentration of large industrial clusters may have long-lasting effects on local economies. This paper provides evidence of a rise-and-fall pattern in the long run, even without *aggregate* manufacturing decline and despite the success of the initial investments at the origin of the clusters. We identifies the production spillovers supporting this effect using granular data on production.

The paper relies on a unique experiment in which large factories (MRPs) were (quasi-)randomly allocated across suitable counties in China, and it follows the evolution of these locations in the long run. While the large plants were effective in spurring transformation from agriculture to manufacturing and in raising local living standards, this head start failed to generate positive agglomeration economies in the later period. Low mobility costs and the liberalization of the economy would have been expected to widen the gap between treated places and the rest of the economy. We find the opposite.

The large productivity gains observed in the 1980s fully vanish in the period 1990–2010. This reversal of fortune occurs even though the MRPs are still productive, innovative, and dynamic. Treated areas did not merely revert to the path followed by control areas; the (other) production units in control counties are less productive, competitive, and innovative than in treated counties. The structure of production is too concentrated along the production chain of the MRPs, with linked firms extracting rents without incentives to innovate, and technological spillovers appear to be minimal. Potential entrepreneurs born in treated counties are more likely to leave and set up firms elsewhere. Through these two channels, early industrialization has a persistent, albeit now adverse, influence on local economies.

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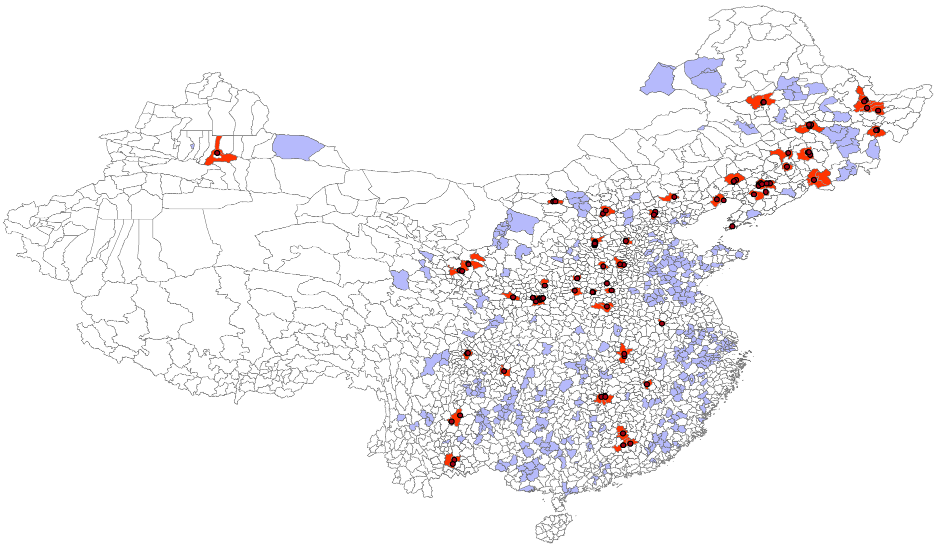
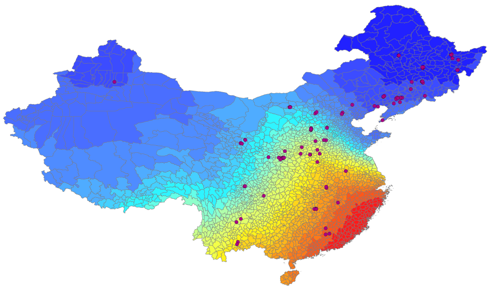
A Figures and tables

Figure 1: Treated counties and the group of control counties.

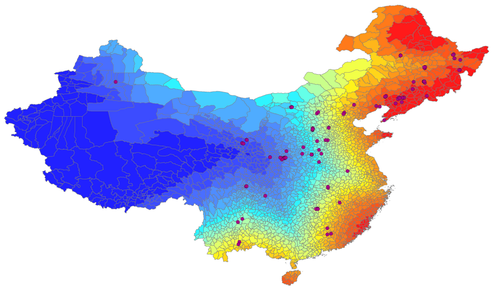


Notes: This map show counties that host at least one "156"-program factory (red) and the control group of counties (blue). The control group is selected through the matching procedure described in Section 2.

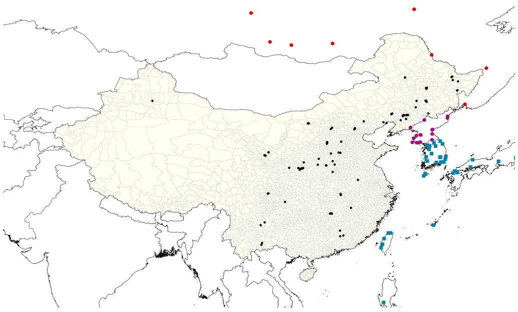
Figure 2: Vulnerability to airstrikes, bases, and surveillance flights.



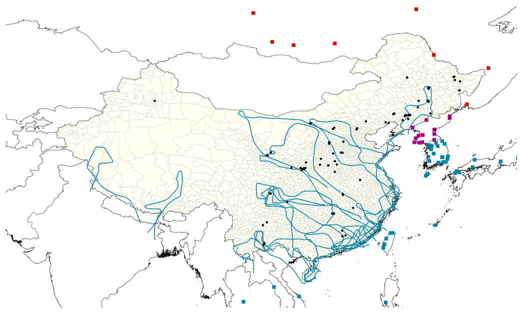
A. Vunerability (pre-1960 split)



B. Vunerability (post-1960 split)



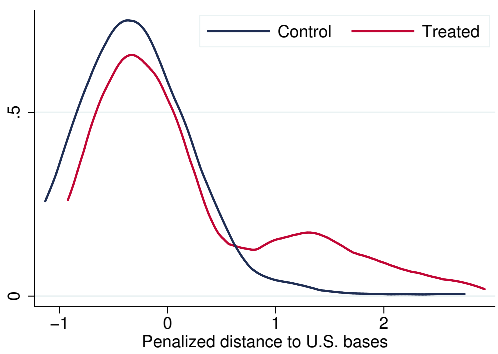
C. Bases (pre-1960 split)



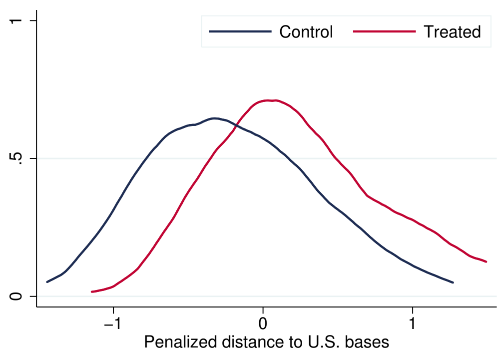
D. Surveillance flights (post-1960 split)

Notes: Panels A and B represent the travel cost from enemy airfields (red: low, blue: high; the color gradient corresponds to deciles) in 1953 and in 1964. Panel C shows the distribution of enemy and allied air bases in 1953. U.S. airbases are indicated with a green rectangle; North Korean airbases are indicated with a purple circle/rectangle; Soviet airbases are indicated with a red circle/rectangle; the locations of MRPs are indicated with a dark circle. Panel D adds the paths of surveillance flights between 1963 and 1965.

Figure 3: Vulnerability density within treated and control counties.



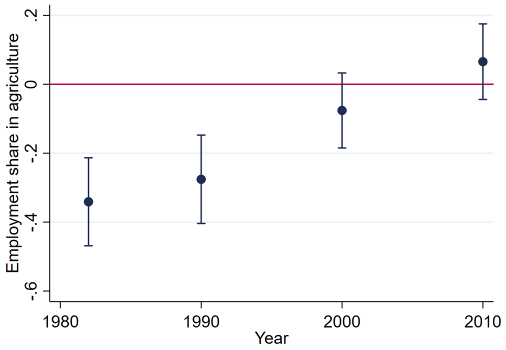
A. Unconditional



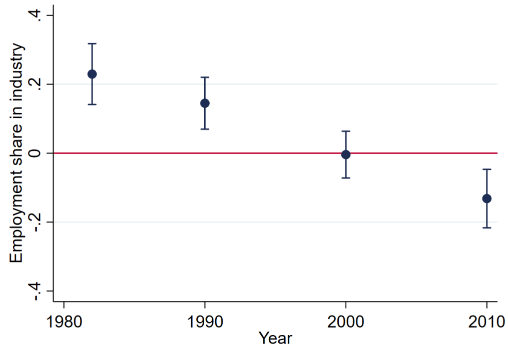
B. Conditional

Notes: This Figure displays the density of the unconditional and conditional vulnerability measure. *Penalized distance to U.S. bases* is the standardized distance to the main military U.S. or Taiwanese airfields penalized by the proximity to U.S.S.R. and North Korean airfields. Treatment is defined as a dummy equal to 1 if a county centroid lies within 20 km of a factory and 0 otherwise. The control group is selected through the matching procedure described in Section 2, and the extended controls are those of Table 1, column 3.

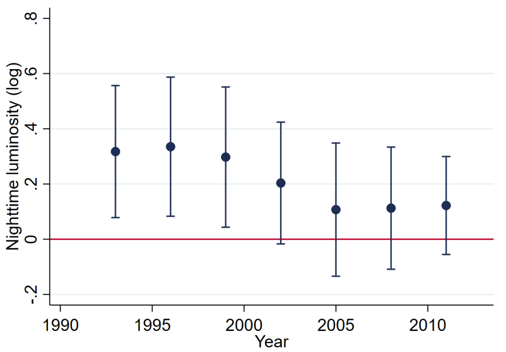
Figure 4: The dynamics of counties hosting MRPs.



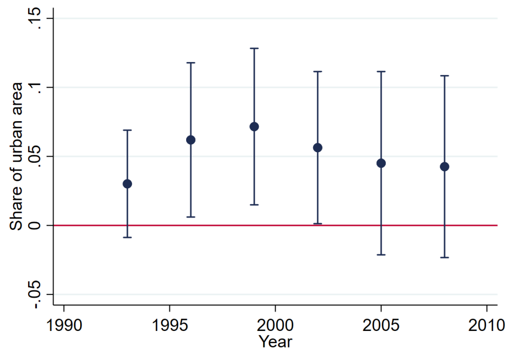
A. Employment share in agriculture



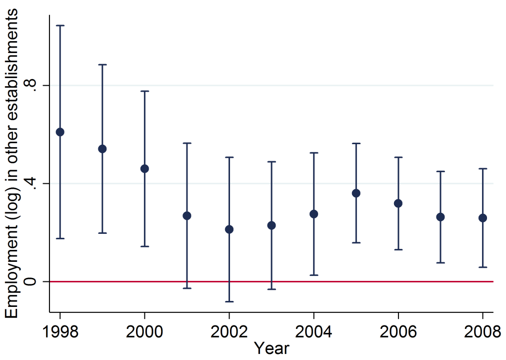
B. Employment share in industry



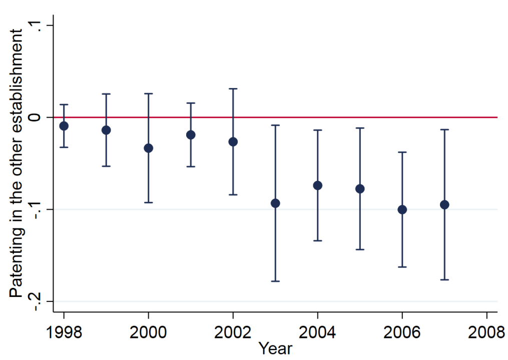
C. Nighttime luminosity



D. Urban extent



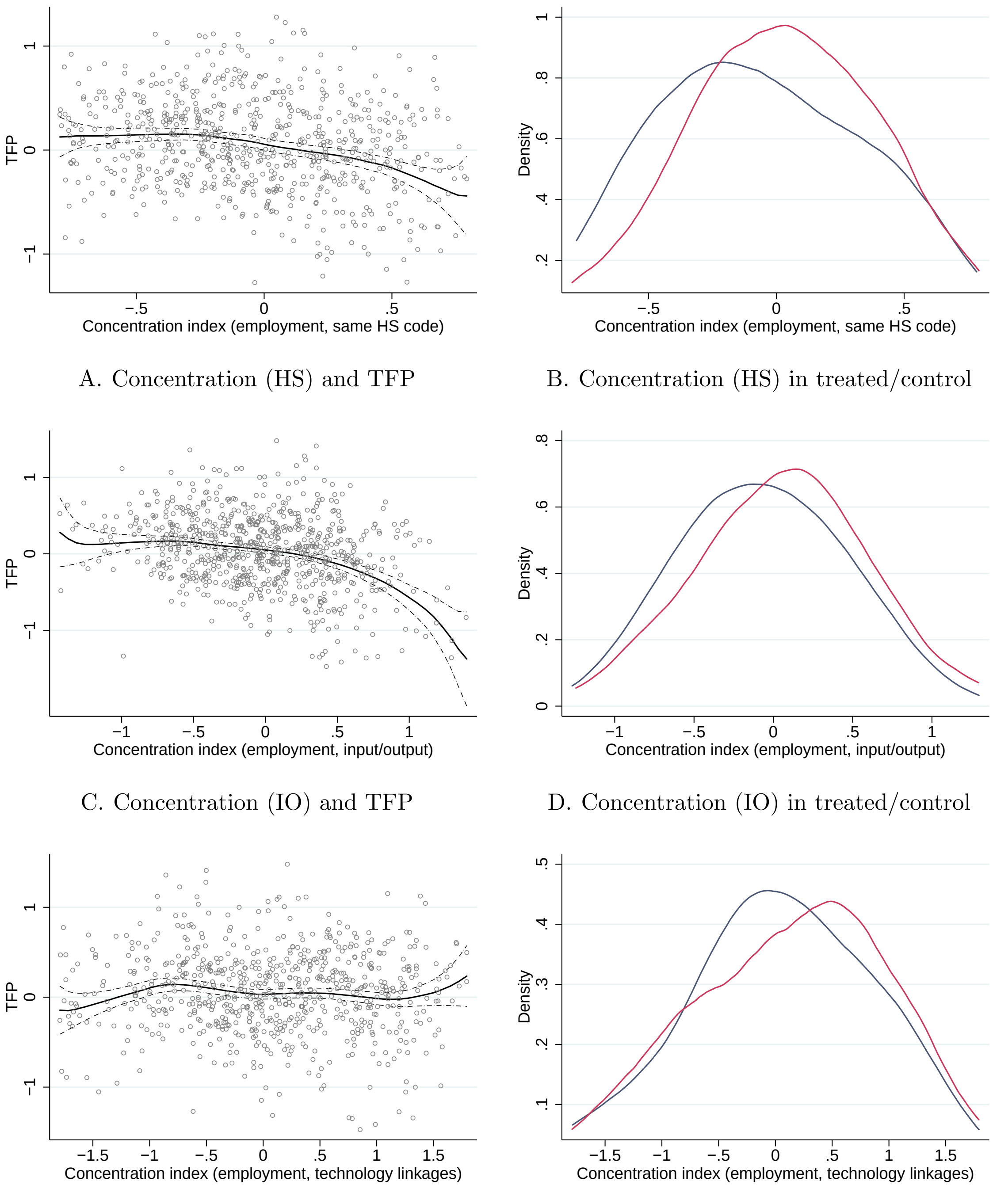
E. Employment in other establishments



F. Patents in other establishments

Notes: Panels A-D display the treatment effect for the employment share in agriculture and industry (1982, 1990, 2000, 2010) and nighttime luminosity and the share of urban area in the county, as computed using impervious surface recognition (1993, 1996, 1999, 2002, 2005, 2008). Panels E-F display the treatment effect for establishments size (1998–2007), and patenting behavior (utility, 1998–2007).

Figure 5: Product concentration and TFP in treated and control counties.



A. Concentration (HS) and TFP

B. Concentration (HS) in treated/control

C. Concentration (IO) and TFP

D. Concentration (IO) in treated/control

E. Concentration (TEC) and TFP

F. Concentration (TEC) in treated/control

Notes: These Figures represent the relationship between product concentration and total factor productivity at the county level (left panels), and the distribution of product concentration in treated and control counties (right panels), over the period 2004–2008. More specifically, the x-axis is the residual of (log) product concentration at the county level in each year over the period 2004–2008, obtained from running a regression of the (log) concentration measure, $log(h_c(\mathbf{M}))$, on the controls $\mathbf{X}_c$ used in Equation (1). In left panels, the y-axis is the residual of (average) total factor productivity at the county level. Panels (a) and (b) use the baseline Herfindahl index, obtained by considering $\mathbf{M} = \mathbf{I}$. Panels (c) and (d) use a production-based Herfindahl index where $\mathbf{M}$ contains the input shares of a given product code into another product code. Panels (e) and (f) use a technology-based Herfindahl index based on (cross-)patent citations in the United States (Bloom et al., 2013).

Table 1: Treatment and vulnerability to aerial attacks (1953).

Treatment	(1)	(2)	(3)
Penalized distance	0.140	0.143	0.272
	(0.032)	(0.032)	(0.043)
Observations	420	420	420
Propensity bins	No	Yes	Yes
Extended controls	No	No	Yes

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a county. *Penalized distance* is the normalized travel cost from the military U.S. and Taiwanese airfields penalized by proximity to U.S.S.R. and North Korean airfields. Extended controls include all matching controls, i.e., travel cost to resources (coal, coke, ore), proximity to a rail hub, whether the county is a provincial capital, population in 1953 (log), county area (log), and additional controls, i.e., travel cost to major ports (through the river network), proximity to Ming-dynasty courier stations, cities in 1900, distance to military airfields and penalized distance to enemy airfields in 1964.

Table 2: The 156 Million-Rouble Plants: sector, construction period and initial investment.

		Construction		Investment	
Sector	Number	Start	End	Planned	Actual
Aviation	14	1953.9	1957.3	7271	7204
Chemical	7	1955.3	1958.4	15291	15474
Coal mining	25	1954.3	1958.5	5323	5832
Electronic	10	1955.5	1957.9	5661	4752
Iron and Steel	7	1953.9	1959.0	78361	84586
Machinery	23	1954.8	1958.2	9972	10336
Nonferrous Metals	13	1955.1	1959.0	15018	15451
Powerplants	23	1954.0	1957.9	13039	9023
Weapons	16	1955.1	1958.4	13533	12262
Other	12	1955.3	1959.3	11751	12513

Notes: Other industries are shipbuilding, pharmaceutical and paper-making industries. Investment is in 10,000 yuan. The average planned investment by factory was about 130,000,000 yuan, which amounts to 20,000,000 Soviet roubles in 1957 ($160,000,000 in 2010 U.S. dollars).

Table 3: Descriptive statistics (control and treated counties, weighted by matching weights).

VARIABLES	Mean	Std dev.	Factory	No factory
Vulnerability to air strikes				
Penalized distance (1953)	0.151	1.139	0.522	-0.219
Penalized distance (1964)	-0.282	0.806	-0.262	-0.302
Population				
Population (1982, log)	12.94	0.845	13.08	12.81
Population (2010, log)	13.27	0.930	13.42	13.13
Urban registration				
Share non agr. (1982)	0.352	0.261	0.434	0.269
Share non agr. (2010)	0.355	0.236	0.432	0.277
Economic development				
Employment share (ind, 1982)	0.227	0.193	0.286	0.168
Employment share (ind, 2010)	0.245	0.140	0.243	0.248
Matching controls				
Travel cost to coal mines (log)	13.20	0.750	13.18	13.22
Travel cost to coke (log)	13.06	0.809	12.98	13.15
Travel cost to ore (log)	14.88	0.887	14.78	14.98
Proximity to rail hub	0.011	0.107	0.017	0.005
Province capital	0.275	0.447	0.267	0.283
Area (log)	7.23	0.762	7.24	7.22
Additional controls				
Proximity to city (1900)	0.816	0.387	0.919	0.714
Proximity to Ming stations	0.366	0.482	0.455	0.278
Proximity to rivers	0.558	0.497	0.428	0.689
Distance to military airfields (log)	10.41	1.038	10.28	10.54
Travel cost to major ports (log)	13.88	0.881	14.03	13.73
Later economic shocks				
Third Front Movement	0.232	0.423	0.214	0.251
Victims (Cultural Revolution)	0.166	0.246	0.198	0.134
Industrial parks (log, 1990–2010)	1.649	0.928	1.560	1.739
Observations	430		110	320

Notes: Penalized distance is standardized (mean 0 and variance 1 over all counties in China).

Table 4: Treatment effect on employment, output and urbanization in 1982 and 2010.

VARIABLES	Population (1)	Share urban (2)	GDP p.c. (3)	Share industry (4)
Panel A: OLS specification				
Treatment effect (1982)	0.164	0.147	0.311	0.108
	(0.050)	(0.030)	(0.096)	(0.022)
	[420]	[420]	[420]	[420]
Treatment effect (2010)	0.168	0.130	-0.105	0.011
	(0.069)	(0.028)	(0.088)	(0.020)
	[420]	[420]	[420]	[420]
Panel B: IV specification				
Treatment effect (1982)	0.167	0.341	0.777	0.230
	(0.106)	(0.065)	(0.244)	(0.045)
	[420]	[420]	[420]	[420]
	40.634	*40.634*	*40.634*	*40.634*
Treatment effect (2010)	0.256	0.311	-0.152	-0.132
	(0.139)	(0.048)	(0.211)	(0.043)
	[420]	[420]	[420]	[420]
	40.634	*40.634*	*40.634*	*40.634*

Notes: Each cell is the outcome of a separate regression. Standard errors are clustered at level of 4-degree × 4-degree cells (reported between parentheses). The unit of observation is a county (Administrative level 3); the number of observations is reported between square brackets. The instrument is the distance to the main military U.S. and Taiwanese airfields penalized by the proximity to U.S.S.R. and North Korean airfields; we report the first-stage F-statistics in italic. All specifications include (i) propensity score bins, (ii) matching controls, i.e., travel cost to resources (coal, coke, ore), proximity to a rail hub, whether the county is a provincial capital, population in 1953 (log), county area (log), and (iii) the additional controls, i.e., travel cost to major ports (through the river network), proximity to Ming-dynasty courier stations, cities in 1900, distance to military airfields) and penalized distance to enemy airfields in 1964. *Population* is the logarithm of total population in the county and *Share of urban* the share of the population that has a non-agricultural household registration (*hukou*).

Table 5: Structure of firm production in the other establishment.

VARIABLES	Labor (1)	Capital (2)	Wage (3)	TFP (4)	Patents (5)	Markup (6)
Panel A: Baseline						
Treatment	.301	.406	-.320	-.304	-.023	.130
	(.096)	(.133)	(.078)	(.104)	(.008)	(.062)
Observations	432,202	432,202	432,202	432,202	432,202	301,198
Panel B: Industry fixed-effects						
Treatment	.301	.406	-.320	-.304	-.023	.130
	(.096)	(.133)	(.078)	(.104)	(.008)	(.062)
Observations	432,202	432,202	432,202	432,202	432,202	301,198
Panel C: Product fixed-effects						
Treatment	.301	.406	-.320	-.304	-.023	.130
	(.096)	(.133)	(.078)	(.104)	(.008)	(.062)
Observations	432,202	432,202	432,202	432,202	432,202	301,198
Panel D: Age and ownership						
Treatment	.301	.406	-.320	-.304	-.023	.130
	(.096)	(.133)	(.078)	(.104)	(.008)	(.062)
Observations	432,202	432,202	432,202	432,202	432,202	301,198

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a firm × year. We exclude the MRPs from the sample. All specifications include the extended controls of Table 4 (column 3). Panel B further includes 4-digit industry × year fixed effects; Panel C further includes 6-digit product × year fixed effects; Panel D further includes age and firm type × year fixed effects. *Labor* is the logarithm of the number of workers; *Capital* is the logarithm of real capital; *Labor cost* is the logarithm of total compensation per employee; *TFP* is the logarithm of firm-specific total factor productivity as computed in Imbert et al. (2020); *Patents* are the number of patent applications registered by the firm; *Markup* is a dummy equal to one if the markup is above-median within a 4-digit industry × year cell, computed following De Loecker and Warzynski (2012)—see Appendix B.

Table 6: Production linkages with the MRPs.

VARIABLES	Downstream	Upstream	Same product
	(1)	(2)	(3)
Panel A: Production linkages			
Factory	.050	.067	.050
	(.025)	(.023)	(.014)
Observations	432,202	432,202	432,202
VARIABLES	More H-intensive	More K-intensive	More T-intensive
	(1)	(2)	(3)
Panel B: Factor demand			
Factory	.004	-.038	.093
	(.085)	(.072)	(.065)
Observations	261,328	261,328	261,328
VARIABLES	Tech. clos.	Tech. clos. (Mah.)	
	(1)	(2)	
Panel C: Technology closeness			
Factory	.019	-.023	
	(.037)	(.040)	
Observations	293,174	293,174	

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a firm × year. We exclude the MRPs from the sample. All specifications include the baseline controls (Table 4), 4-digit industry × year fixed effects and firm type × year fixed effects. *Downstream* (resp. *Upstream*) is a dummy equal to one if the firm is down (resp. up) the supply chain with respect to one of the 156 factories; *Same product* is a dummy equal to one if the firm is in the same product market as one of the 156 factories (see Section 4 for a description of the empirical strategy and the definition of these dummies in control counties). *More F-intensive* is a dummy equal to 1 if the revealed factor intensity of factor F (using product codes) is higher than that of the average associated MRP. *Tech. clos.* is a dummy equal to one if sectors in which the establishment and the MRP(s) operate are linked through patent applications.

Table 7: Productivity, innovation, and pricing in establishments along the production chain of MRPs.

VARIABLES	TFP	Patents	Markup
	(1)	(2)	(3)
Panel A: Downstream/Upstream			
Treatment	-.335	-.018	.127
	(.105)	(.009)	(.064)
Treatment × Linkage	.459	-.095	.088
	(.219)	(.055)	(.136)
Observations	432,202	432,202	301,198
Panel B: Same product			
Treatment	-.316	-.023	.133
	(.106)	(.009)	(.063)
Treatment × Same product	.443	-.062	.160
	(.346)	(.152)	(.095)
Observations	432,202	432,202	301,198

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a firm × year. We exclude the MRPs from the sample. All specifications include the baseline controls (Table 4), 4-digit industry × year fixed effects and firm type × year fixed effects. *Downstream/Upstream* is a dummy equal to one if the firm is down (or up) the supply chain with respect to one of the 156 factories; *Same product* is a dummy equal to one if the firm is in the same product market as one of the 156 factories (see Section 4 for a description of the empirical strategy and the definition of these dummies in control counties).

Table 8: Emigrant profiles in treated and control counties.

VARIABLES	University degree (1)	Manager position (2)	Self-employed (3)	Top income (4)
Panel A: Selection and employment at destination				
Treatment	0.950	0.633	0.773	0.510
	(0.242)	(0.247)	(0.273)	(0.248)
	[420]	[420]	[420]	[420]
	39.260	*39.260*	*39.260*	*39.260*

VARIABLES	Industry (1)	Agriculture (2)	Services (3)
Panel B: Sector of activity at destination			
Treatment	-0.617	0.656	0.970
	(0.284)	(0.211)	(0.247)
	[420]	[420]	[420]
	39.260	*39.260*	*39.260*

Notes: Standard errors are clustered at the level of 4-degree × 4-degree cells. The unit of observation is a county. All specifications include the baseline controls (see Table 4). The dependent variable Y is the share of emigrants with characteristic Y. All dependent variables are standardized. We report the number of observations between square brackets and the first-stage F-statistics in italic. *University degree* is the share of emigrants with a tertiary degree. *Manager* is the share of emigrants in category 24 ("Managers of Enterprises, Institutions and Related Work Units") of the Chinese Standard Classification of Occupations. *Self-employed* is the share of emigrants who are own-account workers. *Top income* is the share of emigrants with incomes in the top quintile of the income distribution in their counties of registration. *Industry*, *Agriculture*, and *Services* are the shares of emigrants working in manufacturing, agriculture, and services, respectively. All outcomes correspond to the emigrant's situation at destination.

ONLINE APPENDIX—not for publication

A The Million-Rouble plants in context

In this section, we provide additional information about the Million-Rouble plants. First, we summarize the historical context and geopolitical background. Second, we present the Sino-Soviet cooperation during the First Five-Year Plan and the characteristics of the plants built under the program, and discuss how the sites were selected. Finally, we review the evolution of the Million-Rouble Plants (MRPs) and other place-based policies after the end of the First Five-Year Plan.

A.1 Historical context

Leaning to one side When the People's Republic was established in 1949, World War II and the civil war had left China a poverty-stricken agrarian country. The new Communist regime was isolated, as the Western world recognized Chiang Kai-shek's Taiwan-based power as the legitimate representative of China. To ensure national security and economic prosperity in such a context, Chinese leaders planned to industrialize the economy rapidly, prioritizing heavy industry as the basis of production.[29] China lacked resources to develop its industry, and turned to the Soviet Union. Despite ideological proximity, economic cooperation with the U.S.S.R. was not obvious. Pre-1949 economic relationships between the two countries were thin, and the Komintern had repeatedly talked the Chinese Communists into supporting the Nationalists, which they then saw as the only political force able to rule China. The Soviet Union was however the only advanced economy China could turn to in the 1950s. First, because it was sympathetic to the new regime's revolutionary agenda. Second, because of that regime's isolation: Washington and its allies imposed an embargo that prevented Communist China from importing the technology and resources needed to develop its industrial base (Zhang, 2001). The subsequent alliance with the U.S.S.R., which Chairman Mao called "leaning to one side" in a famous speech,[30] was further reinforced by the Korean War, which the U.S.S.R. fought vicariously through a Chinese "People's Volunteer Army" of 250,000 men.

Sino-Soviet cooperation On February 14, 1950, the Treaty of Friendship and Alliance was signed between China and the U.S.S.R. A series of agreements ensued, paving the way for a comprehensive economic and scientific cooperation that spanned China's First and half of its Second Five-Year Plans (1953–1957 and 1958–1962).

[29] In the words of future Premier Zhou Enlai, "without heavy industry, there will be no foundation for the national industry" (January 1942).

[30] "On the People's Democratic Dictatorship" (June 30, 1949)

The cooperation between China and the Soviet Union assumed two main aspects: scientific and economic, both embodied in the "156" program. Soviet experts were dispatched to China to advise Chinese planners and supervise investments in the field. At the peak of the Sino-Soviet alliance, 20,000 experts were present in China (Zhang, 2001; Wang, 2003). Although Soviet experts were involved in all aspects of central planning, in particular during the First Five-Year Plan, their presence was crucial for the "156" program. They were responsible for the design and construction of the plants, and they trained Chinese cadres and workers to run the factories and operate and maintain equipment. To ensure the sustainability of the program, 80,000 Chinese students were sent to Soviet universities and technological institutes, with the perspective of a position in one of the plants upon return.

Economic cooperation involved technology and financial transfers. Technology transfer was a major component of the "156" program in particular. The equipment supplied by the U.S.S.R. was among the most advanced at the time (Lardy, 1987).[31] Blueprints and technical documents for production were shared with Chinese engineers free of charge,[32] allowing China to gradually absorb and adapt Soviet technologies (Xiao, 2014). In the agreements that created the "156" program, the Soviet Union committed to carrying out all the design work, from choosing the sites to implementing the design, providing the required equipment and supervising construction, as well as overseeing new product manufacturing and training ordinary workers, technicians, and all necessary cadres.[33]

The financial resources provided to China by the U.S.S.R. mostly consisted of loans. During his first visit to the U.S.S.R., Chairman Mao negotiated a $300,000,000 loan (in 1955 prices, corresponding to $2.9 billion in 2020 prices) at the preferential rate of 1% per annum, which financed part of the "156" program. China was also to reimburse the Soviet Union for the construction of the plants by providing 160,000 tons of tungsten concentrate, 110,000 tons of tin, 35,000 tons of molybdenum concentrate, 30,000 tons of antimony, 90,000 tons of rubber, and other produce including wool, rice or tea. Some low-skilled workers were also sent to Siberia. Besides loans, Soviet cooperation did however involve an aid component. Technological cooperation implied free transfers of blueprints and documents, the monetary value of which should not be downplayed. The U.S.S.R. also granted China product manufacturing

[31] The last 15 projects agreed on in 1954 as part of the "156" program benefited from state-of-the-art equipment that few Soviet factories enjoyed (Goncharenko, 2002).

[32] See "Agreement on aid from the U.S.S.R. government to the P.R.C. government to develop the Chinese national economy" (May 15, 1953).

[33] The U.S.S.R. provided between 50% and 70% of the value of the equipments necessary to build the plants (Dong, 1999). The remainder could be produced locally and was not covered by the cooperation.

patents that alone represented a value of about 3–3.5 million roubles (Dong, 1999).

A.2 The Million-Rouble plants

Chronology The "156" program was decided through three agreements. The first 50 plants were negotiated during Chairman Mao's first visit to the U.S.S.R. (Winter 1949/50). On May 15, 1953, Li Fuchun and Anastas Mikoyan signed the "Agreement on aid from the U.S.S.R. government to the P.R.C. government to develop the Chinese national economy." The parties agreed on building 91 additional industrial projects, and the 141 plants were to be built between 1953 and 1959.[34] In October 1954, Khrushchev visited Beijing and signed with his Chinese counterpart a protocol to build 15 additional industrial plants, completing the Soviet-sponsored "156" program. A total of 150 plants were complete and operational by 1960 (Dong and Wu, 2004). Because 156 projects had initially been touted, speeches and reports continued to refer to the "156" program.

Characteristics of the plants The industrial cooperation spanned a wide range of sectors (including aircraft, machinery, electronic industry, and weapons), with a priority for heavy industry. Table 2 summarizes the distribution of the plants by industrial sector. A majority of plants operate in the heavy, extractive and energy sectors. China had the experience and capacity to build most light-industry factories, so that Soviet cooperation concentrated on sectors and tasks that China lacked the skills and wherewithal to develop (see Giorcelli and Li, 2021). Military-related industries made up a fifth of the plants, reflecting geopolitical concerns.

The MRPs brought about a large technological shift. The sheer size of the investments and their focus on industry was meant to transform China from a subsistence-farming to an industrial economy. The average plant constituted an investment of about 130,000,000 yuan or 20,000,000 Soviet roubles in 1957, which is the equivalent of $160,000,000 in 2010 U.S. dollars. Some plants "produced many new products that China had never produced in history" (Li, 1955a), e.g., the Luoyang Truck Factory which produced China's first truck (see Figure A1 for a view of what is now YTO Group Corporation).

Location decisions One of the main tasks of the Soviet experts was to help determine the optimal location for the plants (Li, 1955b). Bo Yibo, a prominent leader personally involved in the design of the "156" program, outlines four main

[34] Construction work began on average in 1954 and was completed in 1958. Mean start and end dates by sector are provided in Table 2.

Figure A1: Contemporary view of the Luoyang Truck Factory.

Note: This figure reproduces a contemporary view of the Luoyang Truck Factory, now YTO Group Corporation. In the foreground, we can see the buildings of the Luoyang Truck Factory, constructed as part of the "156" program. Source: YTO Group Corporation website [http://www.yituo.com.cn/; accessed September 11, 2018].

criteria guiding the location decision process (Bo, 1991). Plants had to be built close to natural resources to reduce transportation costs and avoid waste. Places easily accessible through the road and railway network should be favored, so as to reach down- and upstream firms and end-consumer markets at a lower cost. Regions with no pre-existing industrial base would be given priority. Conditional on meeting these first criteria, the MRPs were to be built out of the reach of U.S. and Taiwanese bombers. The first two criteria were meant to select optimal locations from an economic point of view. Numerous Soviet textbooks on factory location choice were translated and adapted in 1950s China, and the text of the First Five-Year Plan contains a whole section on rational plant location based on geography. A Russian-Chinese thesaurus with a special focus on factory location choice was also published. Soviet plant location textbooks emphasized the importance of pre-selecting several locations, comparing them based on a list of objective criteria, and making field trips to the short-listed sites. Among the main criteria were easy access to natural resources, transportation network and market access. The third criterion does not appear as a goal in its own right in other sources. A significant share of the MRPs were built in previously agrarian regions, but possibly because the threat of U.S. and Taiwanese air strikes called for industrializing the hinterland. This third criterion is however a common feature of place-based policies, as policy makers are often willing to correct perceived inequalities in the spatial distribution of economic activity.

Soviet experts recommended, in order to minimize costs, that priority be given to expanding existing plants. Stalin expressed this idea himself in a 1952 conversation with Zhou Enlai,[35] although he also advised the Chinese to build *new* plants, in

[35] "Minutes of Conversation between I.V. Stalin and Zhou Enlai," September 03, 1952, History and Public Policy Program Digital Archive, APRF, f. 45, op. 1, d. 329, ll. 75-87. Translated by

particular defense industry factories, far away from the coast and borders, a lesson the U.S.S.R. had bitterly learnt in World War II. Chairman Mao was apparently responsible for making military security a major tenet of the "156" program (Xia, 2008).[36] An example of the attention paid to military security is the Rehe Vanadium and Titanium Factory, originally located at Nü'erhe, near Jinzhou, Liaoning province. On May 16, 1955, the Heavy Industry Department issued a report arguing that this location, about 10 kilometers from the Gulf of Bohai, did not follow closely enough the "not building, not expanding in coastal areas" principle. They instead recommended that Soviet experts reconsider the site. The plant was eventually built in Shuangtashan, near Chengde, Rehe (today, Hebei) province, 100 kilometers away from the sea (Chinese Academy of Social Sciences and State Archives Administration, 1998). Most MRPs were constructed along this "Second Front."

In 1953, China's aviation was non-existent, which explains the importance of Soviet military protection.[37] The People's Liberation Army only developed an aviation thanks to Soviet support and because of the pressing needs of the Korean War. One of its pioneer pilots and later vice-commander of the Nanjing Air Command recalled that "when Chairman Mao declared that China would join the Korean War, the Chinese air force did not have one operational unit that could [be] put into the air" (Bergin, 2013). Even after the Korean War, China's air force was recognized as woefully inadequate.[38] The Chinese government would thus shelter the brand new "156" plants close to allied airbases. The 1950 Treaty of Friendship and Alliance indeed assured them that the Soviet Union would defend China in case of foreign aggression. Bo, who was personally involved in plant location decisions, reports that senior military officials took part in the deliberations: "when examining plant locations, [they] would place plant sites on a map", along with all U.S. bases in Taiwan, South Korea and Japan, to determine "which types of American planes could attack which sites" (Bo, 1991).

Danny Rozas. Available at http://digitalarchive.wilsoncenter.org/document/111242.

[36] The concern with enemy attacks of the new plants can also be seen from the pages of the *Russian–Chinese Technical Thesaurus: with reference to factory location choice* (1954): "Shelter, air-raid dugout" unexpectedly features among the characteristics that a factory must have.

[37] Whatever was left from World War II was either taken to Taiwan or sabotaged by the Nationalists before their exile. Chongqing's Baishiyi airfield, for instance, fell victim to such scorched-earth policy and could not be used between 1949 and 1959, when it was eventually rebuilt.

[38] Another of China's first pilots interviewed by Bergin, and later chief pilot of China's first indigenous aircraft, recounts that "Soviet Premier Nikita Khrushchev said that without Soviet help, the Chinese air force would become a Chinese ground force in three months" (Bergin, 2013).

A.3 Evolution of the plants and later place-based policies

This paper studies the effect of the MRPs over the long run; it is thus critical to understand what they became after the end of the First Five-Year Plan (1953–1957). In what follows, we describe the evolution of the MRPs through the end of the First Five-Year Plan, the Sino-Soviet split, the Cultural Revolution and the introduction of economic reforms.

End of the First Plan The Sino-Soviet cooperation survived beyond the First Five-Year Plan: 102 of the "156"-program plants became operational during the Second Five-Year Plan, not so much due to delays as to the original agreements between Beijing and Moscow. Two similar agreements were signed on August 8, 1958 and February 7, 1959 to expand Sino-Soviet cooperation and build 125 additional large plants, which were to be built during the Second and Third Five-Year Plans. The 1960 split however curtailed this second wave of investments. The MRPs constitute the only large-scale industrialization program carried out in China thanks to Soviet cooperation.

Sino-Soviet split Sino-Soviet relations were strained in the late 1950s by rapid ideological divergence. After Stalin's death, ideological and political tensions started to rise with Khrushchev's condemnation of his predecessor's crimes in 1956 and his policy of "peaceful coexistence with the West." As China kept encouraging a Stalin-like cult of Mao's personality and pursued aggressive foreign policy, the normalization of the Soviet regime and prospect of *détente* between the two superpowers could only worry Chinese leaders.

The Sino-Soviet split materialized in 1960 when Soviet experts and Chinese students were suddenly repatriated. Incomplete projects that were not viable were abandoned, while future investments were canceled. Six of the MRPs were not operational and could not be completed without Soviet support and were closed. The split induced a dramatic shift in China's alliances and conception of national security. The sites that had been carefully selected because they could benefit from Soviet or North Korean protection now appeared vulnerable. Subsequently, Mao launched in 1964 the "Third Front Movement" (*Sanxian jianshe*), a new wave of industrial investments (mostly in heavy industry) directed at remote inland areas.

Third Front Movement The Third Front Movement, which covers the period 1964–1980, is notorious for the costly moving of plants and workers, from sensible locations to places "close to mountains, dispersed and hidden" (*kaoshan, fensan,* *yinbi*). Such spectacular moves were however the exception rather than the norm: they were to be restricted to strategic military industries, remain exceptional, and not be carried out on a large scale.[39] "First-front" industries (on the coast and in major cities) would be affected, as they were deemed the most vulnerable to foreign attacks, while the "second-front" industries, to which the MRPs belong, had been recently built. The motto for the MRPs was therefore to continue developing them as previously planned. Three plants built under the "156" program were however entirely or partly moved. A first check of the robustness of the rise and fall pattern observed in the paper is to exclude these displaced investments (see Appendix Table D3, Panel A). In this exercise, we also exclude 15 MRPs that closed down during the reform era; almost all of them operated in the extractive sector and went into liquidation because of the depletion of the natural resource they exploited.

A concern with the Third Front Movement is that, although second-front industries, and the "156" plants in particular, were largely unaffected, massive investments were directed toward other provinces, which may have hurt the economic environment of the MRPs. To check whether Third Front investments diverted resources away from the treated counties and explain their decline in the second period, we use the list of Third Front provinces from Fan and Zou (2019). Table D3, Panel F, controls for concurrent policies and includes an indicator variable equal to 1 if a county belongs to a such a province and 0 otherwise. We find that this control does not alter the results.

The Third Front Movement and "156" program both incorporated military imperatives in plant location decisions, but they were designed in different geopolitical situations. We show the induced variation in vulnerability in Figure 2, and we condition for the later vulnerability in our baseline specification.[40]

Cultural Revolution A few years after the construction of the MRPs had been achieved, Chairman Mao launched the "Great Proletarian Cultural Revolution." This movement, which officially lasted between 1966 and 1976, triggered a period of political turmoil that mostly affected urban areas and large enterprises. Industry valued added dropped from 44.6 to 12.6 million Chinese yuan (in constant 1990 prices) between 1966 and 1967, and it would not recover until 1980 (Dong and Wu,

[39] *Comrade Fuchun's summary report to the National Planning Meeting*, October 20, 1964.

[40] In the right panel of Figure 2, we measure vulnerability in 1964, at the onset of the Third Front Movement. The effects are similar if we control for a milder version of 1964 vulnerability, considering U.S.S.R. and North Korean as neutral rather than as threats. We also find the same rise-and-pattern if we control for vulnerability to U.S. or Taiwanese bombings in 1990, i.e., following the collapse of the Soviet Union and using the locations of airbases in that year. (Results available upon request.)

2004). Because they were more industrialized, the counties treated under the "156" program may have suffered disproportionately from the Cultural Revolution, and the disorganization of production may have affected their trajectory beyond 1976, leading to the rise-and-fall pattern that we observe.

To control for the effect of the Cultural Revolution, we use data collected from 2,213 local annals (*difang zhi*)—see Walder (2014). Information about the number of "casualties" from the Cultural Revolution was culled from the historical narratives included in the annals. "Casualties" can be divided into two categories: the number of "unnatural deaths" and number of "victims," which may refer to any type of political persecution from expulsion to public beatings. Because the county annals were encouraged but not required to publish any figures about Cultural Revolution violence, assumptions need to be made to deal with missing information. We follow Walder (2014) and code missing values as 0 even if the narrative does refer to casualties but without stating a figure.[41] Appendix Table D3, Panel F, uses the casualty data to condition for Cultural Revolution violence. Including these controls does not alter the results; the disruption created by the Cultural Revolution does not explain the decline of treated counties.

Economic reforms The transition from central planning to a more market-oriented economy may have dealt a severe blow to the state-owned "156" plants.

The MRPs weathered the economic regime change quite well. Only 15 plants closed down, and the decline of treated counties between 1982 and 2010 is not due to Million-Rouble plants going bust (see Appendix Table D3, Panel A). About a third of the "156" plants evolved into large, diversified industrial groups (*jituan*). Examples of such *jituan* include Ansteel, which evolved from the Anshan Iron and Steel Company and is now listed on the Shenzhen and Hong Kong Stock Exchanges. Figure A2 displays a picture of the main plant in 2016.

We further rely on the NBS above-scale survey (1992–2008) to shed light on the evolution of the MRPs—see Appendix A.4 for a description of the procedure followed to match plants with firms and a comparison of the MRPs with other firms in the same county. We find that (i) most plants are still active today (94 of the 125 MRPs that operated in the manufacturing sector could be identified) and (ii) they are on average four times as productive as other above-scale firms (controlling for size; see Table A1 and the detailed discussion in Appendix A.4).

Another major feature of China's development since the 1980s is the creation of

[41] Alternatively, we can (i) restrict the sample to counties with non-missing data, or replace missing values by (i) the provincial average, (ii) the maximum in the province, or (iii) the minimum in the province. Results are not affected by these various imputation rules.

Figure A2: Entrance of the main Ansteel group plant in 2016.

Source: Ansteel Group Corporation (2016).

Special Economic Zones and various types of industrial parks. These may have attracted production factors because of the promise of superior returns despite treated counties being productive and still growing. To test for this factor, we use industrial parks data from Zheng et al. (2017). The data are at the prefecture level and provide us with the number of industrial parks extant in a prefecture at some point in five-year intervals, covering the period 1980–2005. Appendix Table D3, Panel F controls for the total number of industrial parks in the prefecture and shows that the results are robust to this place-based policy.

A.4 MRPs today [update]

The rise-and-fall pattern experienced by treated counties could potentially reflect the experience of the MRPs themselves. Local economies may have thrived following the physical capital investments of the "156" program and then declined as this capital depreciated. Such a co-evolution of the MRPs and local economies may have obtained because of (i) the sheer size of the "156" plants in the local economies and (ii) spillover effects.

In this Appendix, we investigate the evolution of the MRPs and whether they might have dragged other firms down. To this end, we identify the "legal units" (*faren danwei*) descended from the MRPs in the annual firm survey data described in Section 2. We develop a fuzzy matching algorithm based on firm names, locations, and creation dates, and check manually the quality of the results through archival research. We can match 94 or 75% of the 125 Million-Rouble plants that operated in the manufacturing sector.

Size in the local economy Table A1 relies on the identification of the MRPs in the "above-scale" firms to compute the share of the MRPs in the economies of treated counties. Over the period 1992–2008, MRPs accounted for a moderate share of the economic activity in treated counties: they represent 2.6% of manufacturing employment, 4.3% of the total wage bill in that sector, 6.0% of revenue, 4.4% of value added and 2.8% of profits.[42]

Table A1: Share of the Million-Rouble plants in local economies.

	Employment (1)	Compensation (2)	Revenue (3)	Value added (4)	Profits (5)
Share	0.026	0.043	0.060	0.044	0.028
	(0.169)	(0.273)	(0.378)	(0.304)	(1.654)
Observations	938	938	938	938	938

Notes: Standard deviations are reported between parentheses. The sample consists of all treated counties where at least one firm in the NBS annual "above-scale" surveys was identified as descended from one of the "156" factories. It covers the period 1998–2007, for which the dependent variables are available. For each variable, the table displays the share of such factories, e.g., *Employment* is the share of those factories in local manufacturing employment (1992–2008). *Revenue* refers to total sales. It is available in 1996–2007, except for 1997. *Compensation* (1996–2008, except for 1997) combines wages, housing subsidies, pension and medical insurance, and welfare payable. *Value added* is available between 1998 and 2007, 2004 excluded. *Profits* are defined as value added minus total compensation. They are available from 1998 to 2007, except for 2004. The unit of observation is a prefecture × year × industry (2-digit, Chinese Industrial Classification).

Structure of production Table A2 compares the MRPs with other firms within treated counties along various measures of productivity. As productivity may be systematically correlated with firm size, all regressions control for employment. We further include county, year and two-digit industry fixed effects in all specifications.

Establishments descended from the MRPs differ significantly from other establishments of similar size, and these differences are economically large. First, they exhibit a much higher share of high-skill (i.e., college-educated) employees.[43] This share is 12 percentage points higher in MRPs, from an average of 22% among the other firms. Column 2 shows that compensation per worker is also (albeit not significantly) higher, which probably reflects the quality of the workforce.[44] Second, value added per worker is four times higher. Third, we look at factor productivity measures developed by Imbert et al. (2020). These measures, based on industry-specific CES production functions identified using an exogenous labor supply shifter, show a large and consistent productivity differential. The Million-Rouble plants are

[42]Not all "156" factories have been matched to firms in the "above-scale" data. These figures are thus lower bounds.

[43]The disaggregation of the workforce by educational attainment is available only for 2004 (year of the Economic Census, when additional variables were collected).

[44]This result also holds when looking at wages. In addition to wages, compensation includes housing subsidies, pension and medical insurance, and welfare payable.

three to four times as productive as other firms in treated counties in terms of the marginal product of labor, marginal product of capital and total factor productivity. Finally, a large literature (e.g., Song et al., 2011) highlights the lower productivity of state-owned enterprises during the transition in China. Column 7 looks at an indicator variable for public ownership. We find that the Million-Rouble plants do not significantly differ from the other firms in treated counties in terms of ownership.

Table A2: Comparison of MRPs and other manufacturing firms within treated prefectures.

	High-skilled	Compens.	VA per worker	MPL	MPK	TFP	Public
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
MRP	0.120	0.125	1.436	1.439	1.180	1.413	-0.019
	(0.046)	(0.163)	(0.608)	(0.745)	(0.556)	(0.557)	(0.190)
Observations	12,786	77,147	77,147	77,147	77,147	77,147	77,147
County FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Robust standard errors are reported between parentheses. All regressions are estimated with Ordinary Least Squares and include industry (2-digit CIC), county and year fixed effects. The main explanatory variable, *MRP*, is a dummy equal to 1 if the firm was originally founded under the "156" program, and 0 otherwise. The sample consists of all firms in the treated counties where at least one firm in the NBS annual "above-scale" surveys was identified as descended from one of the "156" plants. We further restrict the sample to observations with non-missing data on compensation, value added and factor productivity. *High-skilled* is the share of college-educated employees in the firm's work force (only available in 2004). *Compensation* (1996–2008, except for 1997) combines wages, housing subsidies, pension and medical insurance, and welfare payable, divided by total employment. We take the natural logarithm. *Value added* is available between 1998 and 2007, 2004 excluded. It is expressed in logarithms and normalized by employment. *MPL*, *MPK* and *TFP* are marginal product of labor, marginal product of capital and total factor productivity measures, respectively, estimated using a CES production function with industry-specific elasticity of substitution between capital and labor—see Imbert et al. (2020). *Public own.* is an indicator variable equal to 1 if the firm is publicly owned, and 0 otherwise. The unit of observation is a firm$\times$year.

B Data description

In this section, we describe: the firm data and the measures of concentration; the construction of factor productivity at the establishment level (identified using industry-specific CES production functions and an exogenous labor supply shifter, see Imbert et al., 2020); the linkages between patent applications and manufacturing establishments (He et al., 2018), and the identification of markups (De Loecker and Warzynski, 2012).

B.1 Data description, product codes, and measures of concentration

This section provides a quick description of the firm survey, describes how we associate a product code to each firm in every year, and details how we produce measures of concentration.

Data description Our main analysis in Sections 3 and 4 relies on a survey of manufacturing firms conducted by the National Bureau of Statistics (NBS), which collects basic accounting information for state-owned manufacturing enterprises (SOEs) and for private manufacturing establishments. Reporting is mandatory for the former, and is conditional for the latter on annual sales: above RMB 5 million, private manufacturing establishments are expected to fill the survey (compliance is fairly high, as shown in Imbert et al., 2020). The available information includes: (i) all accounting variables—capital is reported at face value without accounting for depreciation, so that it requires adjustments, but the other variables are standard; (ii) size of the workforce; (iii) names and addresses of the establishment, which allows us to geo-locate it at the postcode level and to link establishments over time (see Imbert et al., 2020, for a description of the linking procedure). The output is a standard survey of establishments, which covers the vast majority of the manufacturing production in China from 1992 to 2008.

One major issue with the survey—given the purpose of our analysis—is that every establishment reports a 4-digit industry code, but only reports a textual description of its products: there is a need to classify products in a more systematic way.

Product codes Manufacturing establishments report a textual description of up to three products, together with all the other accounting variables. This reporting process is not disciplined by the National Bureau of Statistic in any way. The descriptions do not include any code and do not follow any standards: how to describe the final product(s) is entirely up to the establishment manager (or to the establishment representative who is responsible for filling the survey). We rely on a systematic text analysis that we develop in Imbert et al. (2020) to exploit this undisciplined information and classify products in a similar fashion as in other, more standard establishment data (e.g., Bureau of Labor Statistics Micro-Data).

The procedure follows three steps. In the first step, we collect a standard product classification—the Harmonized Commodity Description and Coding Systems (HS)—which comes with (i) a hierarchical code and (ii) a textual description in Chinese. We "tokenize" these descriptions, i.e., we transform both the latter description and the product information provided by establishment managers into lists of relevant words. This step produces two data sets: one containing lists of words which uniquely characterize a HS code at the 6-digit level; and one containing lists of words which summarize the product descriptions provided by establishments. In the second step, we project these sentences, or list of words, using "word2vec" (Mikolov et al., 2013) trained on the Wikipedia corpus. The third step uses these projections across the two data sets to identify the closest HS code at the 6-digit level for each product description (typically based on a similarity score). The outcome of this three-step procedure is a list of the ten closest HS product categories at the 6-digit level and available for up to three product descriptions provided by each establishment in any given year. We describe next how we exploit this product information to identify possible linkages across establishments.

Measures of concentration The characterization of products in the NBS survey is instrumental to identifying linkages across establishments and the concentration of production within Chinese counties. Consider two establishments (i, j) within a given county and let (p_i, p_j) denote their respective "best-matched" product codes. Assume that we can characterize the proximity between two establishments by a function of their products, $\alpha(.,.)$, e.g., capturing whether they operate along the same production chain or whether they use similar technologies. The quantity $\alpha(p_i, p_j)$ thus represents the proximity between the previous two establishments.

To construct a measure of product concentration at the county level, we build upon the previous measures and aggregate employment (a measure of firm size) across product categories: $\alpha(p, q)$ represents the proximity between products p and q which needs to be weighted by their respective employment shares, s_p and s_q. A measure of concentration is thus,

$$h = \sum_{p,q} \alpha(p, q) s_p s_q.$$

This measure can be best understood as an Herfindahl index. Indeed, let the vector $\mathbf{S} = (s_p)_p$ denote the employment shares in each HS 6-digit product category and the symmetric square matrix $\mathbf{M} = (\alpha(p,q))_{p,q}$ represent the bilateral proximities between product codes. The previous measure can be written as,

$$h(\mathbf{M}) = \mathbf{S}_c' \mathbf{M} \mathbf{S}_c.$$

The standard Herfindahl index is typically represented by a matrix $\mathbf{M}$ equal to the identity matrix, $\mathbf{I}$: a pair of establishments is linked if, and only if they operate in the same product market. We create other measures of concentration by considering different matrices $\mathbf{M}$ and functions $\alpha(.,.)$. More specifically,

- we consider $\alpha(p,q)$ as the input share of product p into product q to construct a measure of "production-chain" concentration;
- we consider $\alpha(p,q)$ as the intensity of (cross-)patent citations in the United States between product codes p and q (Bloom et al., 2013) to construct a measure of "technology" concentration;
- we consider $\alpha(p,q)$ as the language proximity between product codes p and q to construct a measure of "product similarity" concentration which could better incorporate similarities as induced by the demand side.

We use these measures $h(\mathbf{M})$ in Section 4 and in Appendix D.5 to better characterize the concentration of economic activity in treated counties, and we directly use the different functions $\alpha(p,q)$ in Section 4 to identify establishments operating in product or technology markets close to MRP(s).

B.2 Measures of factor productivity

The measures of factor productivity used in Section 4 are taken from Imbert et al. (2020). The following discussion briefly describes the production model and its identification; the reader can refer to Imbert et al. (2020) for details of the implemented strategy.

Environment Consider establishments producing a differentiated variety of good using a CES production function with only two factors, labor and capital.

Let Y and P (resp. y_i and p_i) denote the aggregate output and prices within a product market (resp. for establishment i). We assume that there is monopolistic competition such that demand for the product variety i is,

$$\frac{y_i}{Y} = \left(\frac{p_i}{P}\right)^{-\sigma},$$

where σ captures the substitutability between product varieties. An establishment i produces along,

$$y_i = A_i \left[\alpha k_i^\rho + \beta l_i^\rho\right]^{\frac{1}{\rho}},$$

where $(\alpha, \beta = 1-\alpha, \rho)$ capture factor intensities and factor complementarity. Wages and returns to capital are taken as given.

Estimation There are three important parameters, (σ, α, ρ), which characterize production at the sector level. These parameters can be identified as follows: (i) a factor cost shifter helps identify the degree of substitutability between factors (ρ), (ii) given the estimate for ρ, α and σ can be retrieved through the observation of aggregate factor shares and profits to revenues within a sector.

We briefly describe the first, crucial step of this procedure. Firm-specific relative factor demand verifies:[45]

$$\ln\left(k_i/l_i\right) = \frac{1}{1-\rho}\ln\left(\frac{\alpha}{1-\alpha}\right) + \frac{1}{1-\rho}\ln\left(w/r\right) + \varepsilon_i,$$

where ε_i is a noise, possibly capturing measurement error or firm-specific technology. The parameter ρ can be identified, in the previous equation, by leveraging exogenous variation in relative factor prices across prefectures and across years in order to instrument the relative factor price. Imbert et al. (2020) rely on predicted immigration shocks, constructed from cropping patterns in rural hinterlands. These shocks are exogenous to factor demand in cities, including demand resulting from the presence of MRPs.

Once (σ, α, ρ) are estimated, the main firm-specific measure of productivity used in this paper, Total factor Productivity, is constructed using:

$$A_i = \frac{y_i}{\left[\hat{\alpha} k_i^{\hat{\rho}} + (1-\hat{\alpha}) l_i^{\hat{\rho}}\right]^{\frac{1}{\hat{\rho}}}}.$$

[45] One can combine the two first-order conditions of the firm, and show that the optimal factor use verifies:

$$\begin{cases} (1-1/\sigma)\dfrac{\alpha k_i^\rho}{\alpha k_i^\rho + \beta l_i^\rho} p_i y_i = r k_i \\ (1-1/\sigma)\dfrac{\beta l_i^\rho}{\alpha k_i^\rho + \beta l_i^\rho} p_i y_i = w l_i, \end{cases}$$

B.3 Registered patents and mark-ups

Patent applications The measures of patenting used in Sections 3 and 4 exploit the bridge constructed by He et al. (2018) to match firms with all patents submitted to the State Intellectual Property Office (SIPO).

There are three categories of patents submitted to SIPO. A patent can be categorized as "design"; this category mostly covers the external appearance of a product. A patent can be categorized as "innovation"; this category covers fundamental innovations either regarding the final product or the means of production. These patents offer significant protection but require to go through a long administrative process. A patent can be categorized as "utility" (utility model patent); this category covers changes in processing, shape or structure of products. The latter category has no equivalent outside of China; it often acts as a cheap, fast way to protect an idea—possibly with the objective of registering an innovation patent in the longer run. For these reasons, we construct our main "patent" variable as the number of utility and innovation patents registered by establishments in a given county and year.

Measures of markups We measure markups at the firm level using the strategy developed in De Loecker and Warzynski (2012). Intuitively, the markup can be estimated by comparing the growth of a flexible production input to the subsequent growth in output.

Consider an establishment i at time t. The establishment uses the following production technology:

$$y = f(x_1, \ldots, x_N, k, A),$$

where $\{x_1, \ldots, x_N\}$ are variable inputs, k is a dynamic input (i.e., capital) and A is a scalar Hicks-neutral (Total Factor) productivity term. The first-order conditions bring:

$$\varepsilon_i = \frac{\partial f(x_1, \ldots, x_N, k, A)}{\partial x_i} \frac{x_i}{y} = \frac{p}{\lambda} \frac{p_i x_i}{py},$$

where ε_i is the output elasticity to variable input i and $\mu = \frac{p}{\lambda}$ is the markup. Consequently, we can write,

$$\mu = \varepsilon_i / \alpha_i,$$

where $\alpha_i = \frac{p_i x_i}{py}$ is the share of expenditures on the variable input i.

We estimate the output elasticity to variable input i, using a control approach. This approach requires two assumptions on function f: (i) that the parameter A enters as a multiplicative term; and (ii) that there is a common set of technology parameters across producers. The estimation is described in De Loecker and

Warzynski (2012), and proceeds in two steps. In a first step, we estimate output as a flexible function of inputs (labor, capital and material). The residual of this estimation maps into the productivity term A. In a second step, we estimate the law of motion for productivity over time.

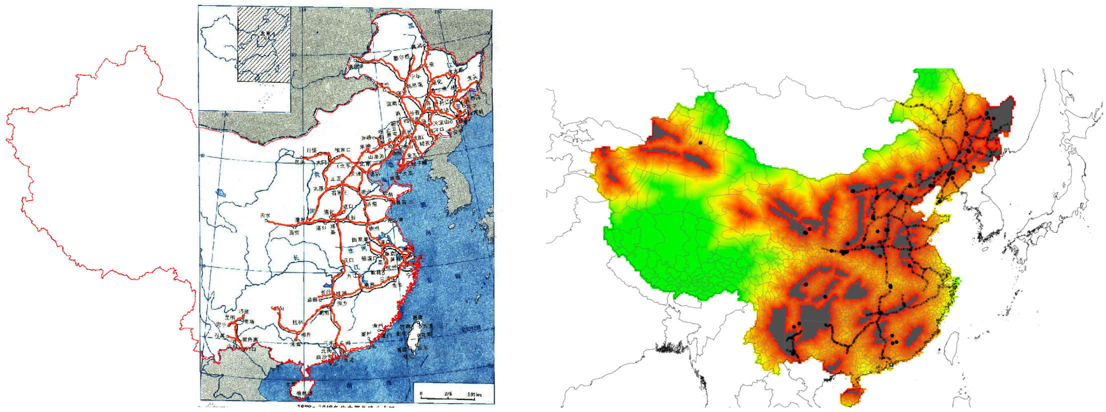
This procedure allows us to estimate the output elasticity to variable input i, which we transform into a markup by combining it with an estimate $\hat{\alpha}$ for the expenditure share α. This last correction replaces the output by the predicted output thereby cleaning for measurement error in the denominator of the expression for the mark-up μ.

C Complements to the empirical strategy

C.1 Matching procedure and complements to the baseline strategy

Description of matching and control variables We reproduce the transportation network in China at the time of the First Five-Year Plan using the existing railroad network in 1948 (see the left panel of Figure C1), and we construct a measure of proximity to a railroad hub to model connectedness.

Figure C1: Transport network in 1948 and access to natural resources.



A. Transport network in 1948. B. Access to natural resources (coal).

Sources: The left panel is a Railroad Map of China (1948, Joint Intelligence Committee). Black lines are from the original source; red lines are inferred poly-lines using current geocoded railroad lines and cities. The right panel represents the minimum travel time to coal-bearing areas using the railroad and road networks (red: low travel time, green: high travel time). Railroads and roads are geo-located from 1948 and 1962 maps, respectively. Factory locations are indicated with black dots, coal-bearing zones are highlighted with gray areas.

A second criterion is access to raw materials: coal, mostly, but also ore and coke deposits. We create a fine grid over China, allowing for different costs of crossing a cell depending on the means of transportation available. We derive the cost of transporting goods on roads by exploiting the road structure in 1962 and assuming the same cost ratio as Glaeser and Kohlhase (2004), who estimate costs of 28 cents per ton mile for trucks and 3 cents per ton mile for rail in the United States at the end of the 20^{th} century. The relative cost of transporting goods through cells that lie neither on a road nor on a railroad line is set at twice the transport cost by truck (Fogel, 1964). Waterways are omitted from the cost-minimization procedure, as only 2.5% of total freight traffic was carried out by barges (Rong, 2012). We then calculate the minimum travel cost from the closest mineral field for all points through the existing transportation network and collapse it at the county level. The spatial distribution of transport costs to coal fields is displayed in the right panel of

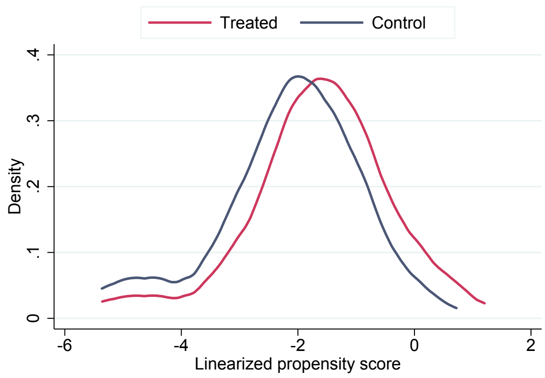
Figure C1.

Table C1: Description of control variables.

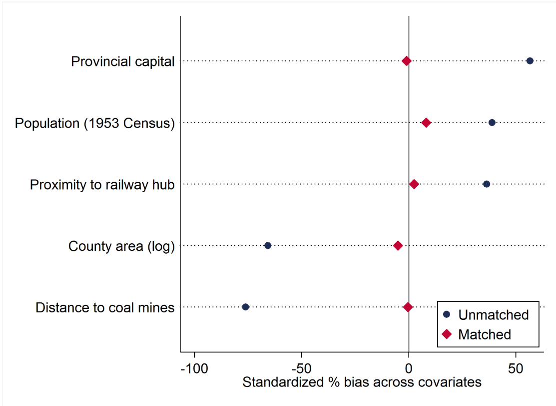
VARIABLES	Description
Population	
Population (1953)	Total population of the county in the First Chinese Population Census (1953).
Access to resources	
Travel cost to coal mines	Distance to coal mines following the 1948 railroad network.
Travel cost to ore	Distance to ore deposits following the 1948 railroad network.
Travel cost to coke	Distance to coke deposits following the 1948 railroad network.
Topographic controls	
Slope (degrees)	Average slope in the county.
Strong slope	Dummy equal to 1 if the average slope is greater than 10 degrees.
Elevation (mean; m)	Average elevation in the county (in meters).
Elevation (st. dev.; m)	Standard deviation of elevation in the county (in meters).
Market access controls	
Travel cost to ports	Dummy equal to 1 for a county whose centroid is lying within 500 km of a port following navigable waterways, and 0 otherwise.
Proximity to courier stations	Dummy equal to 1 if the county centroid is located within 10 kms of the closest Ming-dynasty courier station.
Proximity to 1900 city	Dummy equal to 1 if the county centroid is located within 10 kms of the closest city as of 1900.
Proximity to rivers	Dummy equal to 1 if the county centroid is located within 10 kms of a major river.
Proximity to railway hub	Dummy equal to 1 if the county centroid is located within 5 kms of a railway hub.
Dist. to the coast	Minimum distance to the coast.
Province capital	Dummy equal to 1 if the county belongs to the capital of the province.
Geomorphic controls	
Lake plain	Share of the county's area that consists of lacustrine plains.
Sand hills	Share of the county's area that consists of sand hills.
Tidal marsh	Share of the county's area that consists of tidal marshes.
Agricultural controls	
Expected yield: maize	Average potential yield (kg/ha) of maize under the high-input scenario (GAEZ model-based).
Expected yield: rice	Average potential yield (kg/ha) of rice under the high-input scenario (GAEZ model-based).
Expected yield: wheat	Average potential yield (kg/ha) of wheat under the high-input scenario (GAEZ model-based).
Other geographic controls	
Area	Total land area of the county.
Dist. to military airfields	Minimum distance to a Chinese military airfield.

Discussion of common support and propensity score Figure C2 shows the distribution of propensity scores in the group of treated counties and the control group (left panel), and the balance of a few matching variables within the whole sample and within the selected sample of suitable counties (right panel).

Figure C2: Matching and balance of covariates.



A. Common support (propensity score).



B. Balance of covariates.

Sources: The left panel displays the distributions of the propensity score within the set of treated counties (red) and control counties (blue). The right panel shows the bias in covariates in treated counties within the whole sample and the matched sample.

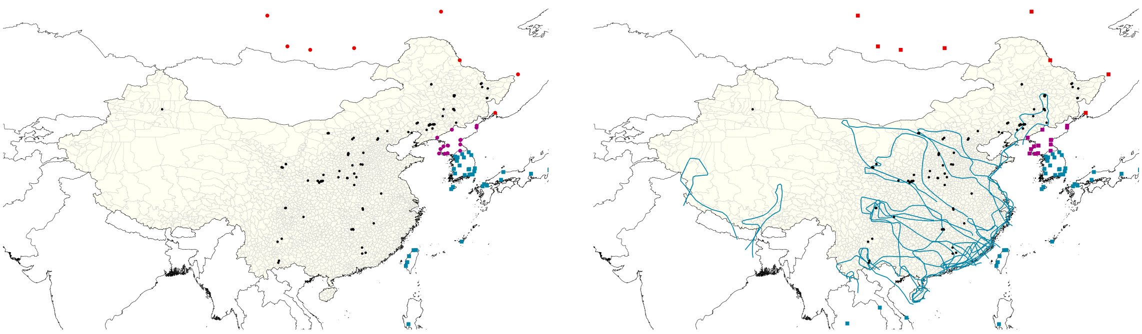
C.2 Vulnerability to air strikes

Allied and enemy airbases over time When the "156" program was being designed, China benefited from the 1950 Treaty of Friendship, Alliance and Mutual Assistance. Not only were the U.S.S.R. and North Korea friendly neighbors; China could count on their protection in case of American or Taiwanese aggression, as stipulated by the Treaty.

However, we also need to compute measures of vulnerability in later periods. Indeed, vulnerability to U.S. and Taiwanese air strikes at the beginning of the "156" program may be correlated with vulnerability in later periods, which may have motivated spatial policies that affected our outcomes of interest. After the Sino-Soviet split, China no longer enjoyed protection from Soviet and North Korean airbases against American or Taiwanese attacks. These formerly allied airbases now presented a threat. To reflect this new geopolitical situation, we consider not only former American and Taiwanese bases, but also Soviet and North Korean airbases as threats in addition to American airbases that were opened in Vietnam between the beginning of the "156" program and the onset of the Third Front Movement.

We display the distribution of enemy and allied airbases over time in Appendix Figure C3. We also display the surveillance flights from U.S. reconnaissance air-flights, as provided by declassified CIA technical intelligence studies. Even though U.S.S.R. airbases are not protecting the territory of China anymore, their presence affects the paths of these flights and the crescent formed by the Second Front of MRPs is far less visited than coastal areas. In the next section, we calibrate a simple model of travel cost to account for the role of allied airbases in shielding some locations in China against aerial attacks.

Figure C3: Distribution of enemy and allied airbases.



A. Pre-1960 split B. Post-1960 split

Notes: This map shows the distribution of enemy and allied air bases in 1953 and in 1964. U.S. airbases are indicated with a green rectangle; North Korean airbases are indicated with a purple circle/rectangle; Soviet airbases are indicated with a red circle/rectangle. In the right panel, we add the paths of surveillance flights between 1963 and 1965. The locations of MRPs are indicated with a dark circle.

Flying cost We assume a constant default flying cost over the Chinese territory and model allied airbases protection as an additional cost for enemy bombers. This penalty is defined as follows:

$$f(d, d') = \alpha(1 - e^{-gd'}) \cdot \frac{e^{a(\bar{x}-d)} - e^{-b(\bar{x}-d)}}{e^{a(\bar{x}-d))} + e^{-b(\bar{x}-d))}} + C,$$

where d is distance to the closest allied airbase and d' is distance to enemy airbases, in kilometers. The parameter α calibrates the maximum penalty in the immediate neighborhood of allied bases. The dependence of the penalty to distance to allied bases is modeled as a hyperbolic tangent: The penalty vanishes as distance d goes to infinity, increases as d decreases, and reaches a plateau near the airbase. The parameter a (b) disciplines the curvature of the hyperbolic tangent function for low (high) values of d. The inflection points are tied to the value of $\bar{x}$. Finally, the dependence of the penalty to distance to enemy bases is disciplined by g. This parameter determines how the cost paid by enemy bombers for traveling near allied bases is mitigated by the proximity to their own bases.

We set the key parameters based on declassified CIA technical intelligence documents from the early 1950s. Such documents show the information available to U.S. intelligence on Soviet military technology, obtained from spies and through the reverse-engineering of fighter jets downed during the Korean War. We assume perfect information: the Soviet similarly derived information about U.S. military technology, and expected the Americans to know theirs equally well. In keeping with the 1950 Treaty, Soviet military advisers shared their information with their Chinese counterparts, in particular to determine the location of the Million-Rouble plants.

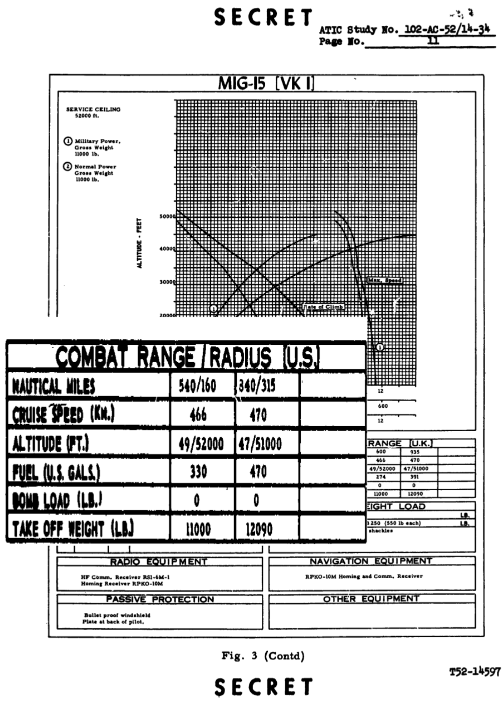
American bombers in the 1950s, like the B-52s, could technically reach any point in China without refueling. However, bombers could be neutralized by interceptors, stationed in allied airbases. Declassified CIA documents such as the one reproduced in Appendix Figure C4 provide us with information on the ranges of the main Soviet interceptor (used both in North Korea and the USSR), the MiG-15, and the main American jet fighter at the time, the F-86 Sabre. We use the maximum range of the interceptors under "military power" and we define $\bar{x}$ as half the maximum range of Soviet interceptors (840 nautical miles or 1,555.68 km—see the table in Figure C4) and determine a and b such that 95% of the decrease in flying cost occurs over that range. Similarly, g is set so that 95% of the protection enjoyed by American bombers close to their bases occurs within the maximum range of the F-86 Sabre. Finally, α and C are set equal and such that Chinese counties protected by Soviet and North Korean airbases are as safe as remote western counties.

Resulting variation In this section, we briefly describe how the distribution of airbases, combined with the previous parameterization of flying costs, translate into vulnerability maps across Chinese counties.

As shown in Figure 2 (Panel a), vulnerability to aerial attacks in 1953 favors Northern provinces. This vulnerability, combined with the existing transportation network and coal deposits, draws a crescent from Harbin (North-East) to Xi'an (Shaanxi province). Most MRPs can be found along this crescent, which forms a "Second Front" in the connected hinterlands. Few MRPs are located in Central China, in spite of the high risk of aerial attacks. These few factories however rely on very specific input, e.g., minerals, which can only be found in high-risk locations.

In Panel b of Figure 2, we display vulnerability to aerial attacks in 1964 after U.S.S.R. airbases become enemy threats. The set of suitable and protected locations then becomes small as all counties related to the transportation network are then in the range of enemy bombers. We see, in particular, that some areas that were

Figure C4: Declassified CIA technical intelligence studies—MiG 15.


SECRET

ATIC Study No. 102-AC-52/14-34
Page No. 11

MIG-15 [VK I]

SERVICE CEILING 52000 ft.

① Military Power, Gross Weight 11000 lb.

② Normal Power Gross Weight 11000 lb.

ALTITUDE - FEET

50000
40000
30000
20000

Max. Speed

Rate of Climb

COMBAT RANGE / RADIUS (U.S.)			
NAUTICAL MILES	540/160	340/315	
CRUISE SPEED (KN.)	466	470	
ALTITUDE (FT.)	49/52000	47/51000	
FUEL (U.S. GALS.)	330	470	
BOMB LOAD (LB.)	0	0	
TAKE OFF WEIGHT (LB.)	11000	12090	

RANGE (U.K.)		
600	935	
466	470	
49/52000	47/51000	
274	391	
0	0	
11000	12090	

EIGHT LOAD

3 250 (550 lb each) LB.

shackles

RADIO EQUIPMENT

HF Comm. Receiver RSI-6M-1
Homing Receiver RPKO-10M

NAVIGATION EQUIPMENT

RPKO-10M Homing and Comm. Receiver

PASSIVE PROTECTION

Bullet proof windshield
Plate at back of pilot.

OTHER EQUIPMENT

Fig. 3 (Contd)

T52-14597

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Sources: CIA technical intelligence study No. 102-AC-52/14-34, "Soviet Operational Interceptor Aircraft" (3 September 1952).

protected by the Soviet and North Korean allies, such as the northeast and to a lesser extent counties bordering Mongolia, are now extremely vulnerable. Central provinces, removed from both U.S./Taiwanese and Soviet bombing threats, are now the safest. This new vulnerability map rationalizes the Third Front Movement, targeted towards interior, remote provinces (see Fan and Zou, 2019).

C.3 Identifying treatment heterogeneity

We aim to estimate the externalities exerted by Million-Rouble plants on manufacturing establishments of the same county, through production linkages, factor market linkages, or technological linkages. For this purpose, we develop an empirical strategy to identify treatment spillovers across establishments in the presence of treatment heterogeneity. This procedure will also be useful in studying treatment heterogeneity across counties or across treatment type.

Without treatment heterogeneity, spillovers can be estimated as follows. Consider an establishment i located in county c. We would like to estimate the statistical model $E[Y_i|T_c, S_i]$ where Y_i is the outcome at the establishment level, $T_c \in \{0, 1\}$ is the treatment, and $S_i \in \{0, 1\}$ characterizes the sub-population of firms susceptible to be affected. The previous statistical model can be estimated through a simple difference-in-differences procedure, in which the instrument for treatment T_c would be interacted with the spillover measure S_i. With treatment heterogeneity, however, the latter cannot be constructed in *control* counties, where $T_c = 0$. Indeed, such a measure would crucially depend on the characteristics of the associated *hypothetical* Million-Rouble Plant. Let $T_c^\tau \in \{0, 1\}$ denote the MRP-specific treatment, equal to 1 if county c hosts the MRP indexed by τ, and $T_c = \max_\tau\{T_c^\tau\}$ the average treatment (i.e., hosting at least one MRP). We can define a measure of MRP-specific linkages in all counties, given the characteristics of an establishment and the characteristics of the MRP. We describe next how we attribute hypothetical MRPs to control counties.

We stratify control counties by their suitability to host Million-Rouble Plants. We define strata of counties based on deciles of the propensity score $P(\mathbf{H}_c)$, as produced by the propensity-score matching procedure described in Section 2 (relying on observable characteristics $\mathbf{H}_c$). In each stratum, there is a subset of treated counties and their associated MRP types. We assume that the probability to host any such MRP type τ is the same for all control counties in the stratum. Under this assumption, we can simulate Monte-Carlo draws of the distribution of MRP types within treated counties in control counties of the same stratum.[46] For each simulation, we calculate hypothetical links S_i, using the observed characteristics of establishments in these control counties.

For each Monte-Carlo draw, we estimate the following IV specification in difference-in-differences on the sample of all establishments surveyed in year t and located in suitable counties, excluding the MRPs themselves:

$$Y_{isct} = \beta_0 + \beta_1 T_c + \beta_2 T_c \times S_{sct} + \beta_3 S_{sct} + \mathbf{X}_c \beta_{\mathbf{x}} + \mu_s + \nu_t + \xi_{st} + \varepsilon_{isct} \qquad (2)$$

where $(T_c, T_c \times S_{sct})$ is instrumented by $(V_c, V_c \times S_{sct})$, and Y_{isct} is measured at the establishment level. The identification relies on the difference between linked and non-linked establishments in treated and control counties, using product market dummies μ_s to clean for omitted variation across sectors, as well as year (ν_t) and sector×year fixed effects (ξ_{st}). A similar specification can be estimated replacing S_{sct} by treatment characteristics.

The identification crucially hinges on a weaker version of the Conditional Independence Assumption. The allocation of a certain MRP of type τ needs to be in-

[46] We simulate these draws as follows. For each control county, we draw one treated county from the same stratum and attribute to the control county the MRP(s) present in the drawn county.

dependent of unobserved county characteristics that may directly affect outcome Y, conditional on the propensity score $\tilde{P}(\mathbf{H}_c)$.

D Robustness checks and sensitivity analysis

In this section, we first test for the robustness of the county-level results to variations around the baseline empirical strategy (D.1). We then provide additional firm-level results on dynamic outcomes (D.2), the structure of production (D.3), compositional effects (D.4), and firm linkages (D.5). Finally, we provide additional survey results on entrepreneurial values (D.6).

D.1 Identification, specification, and measurement

We describe here in greater detail the robustness checks of our empirical strategy, which we summarized in Sections 2 and 3. We provide additional evidence supporting the exclusion restriction assumption, we test for the sensitivity of the results to various specification choices, and we test for the robustness of the results to potential measurement issues.

Exclusion restriction We begin by providing evidence to support the exclusion restriction. Our empirical strategy relies on the following identifying assumption: vulnerability to enemy airstrikes in the 1950s affects the long-run development of Chinese counties only through the location of MRPs. This exclusion restriction would be violated if the allocation of MRPs, as induced by the vulnerability to enemy airstrikes, is correlated with fixed unobserved county characteristics influencing its economic development. However, as we look at a long-run impact, we need to verify additional assumptions, i.e., that the instrument is not correlated with later policies or with geographical characteristics of counties that influence their growth in the later period.

A crucial argument supporting the exclusion restric

The argument of the exogeneity of the instrument relies on the ephemeral geopolitical context that presided over MRP siting decisions. We first assess the validity of the instrument using two first stages. In Table D1, we replace our instrument by penalized distance to enemy airbases in 1964 (column 1) and 1972 (column 2)—after the Sino-Soviet split had thoroughly reshuffled international alliances and subsequently transformed the distribution of vulnerability to aerial attacks across Chinese counties. These placebo instruments could affect the evolution of treated counties, as they called for a reallocation of strategic investments to other areas. In both cases, the placebo instrument is not statistically significantly associated with the treatment. This lends support to the assumption that the treatment was determined by the ephemeral geopolitical context of the 1950s.

Table D1: Treatment and vulnerability to aerial attacks (1964, 1972).

Treatment	(1)	(2)
Penalized distance (1964)	0.078	
	(0.107)	
Penalized distance (1972)		-0.103
		(0.052)
Observations	420	420
Propensity bins	Yes	Yes
Extended controls	Yes	Yes

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a county (Administrative level 3). *Penalized distance* is the normalized distance to the main enemy airfields penalized by proximity to allied airfields (in 1964 and in 1972). Extended controls include all matching controls, i.e., travel cost to resources (coal, coke, ore), proximity to a rail hub, whether the county is a provincial capital, population in 1953 (log), county area (log), and additional controls, i.e., travel cost to major ports (through the river network), proximity to Ming-dynasty courier stations, cities in 1900, distance to military airfields).

In Table D2, we further check that the instrument does not predict later place-based policies, which could explain the rise-and-fall pattern observed in Section 3. We regress indicator variables for treatment under the Third Front movement in the 1960-70s (column 1) and by city parks (column 2) in the Reform era on our instrument. In both cases, the coefficient is small and not statistically significantly different from 0.

Table D2: Vulnerability to aerial attacks (1953) and place-based policies (Third-Front movement and city parks).

	Third-Front	City park
Treatment	(1)	(2)
Penalized distance	0.099	-0.595
	(0.021)	(0.764)
	432	432
Propensity bins	Yes	Yes
Extended controls	Yes	Yes

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a county (Administrative level 3). *Penalized distance* is the normalized distance to the main enemy airfields penalized by proximity to allied airfields (in 1953). Extended controls include all matching controls, i.e., travel cost to resources (coal, coke, ore), proximity to a rail hub, whether the county is a provincial capital, population in 1953 (log), county area (log), and additional controls, i.e., travel cost to major ports (through the river network), proximity to Ming-dynasty courier stations, cities in 1900, distance to military airfields) and penalized distance to enemy airfields in 1964. *Third-Front* is a dummy equal to one if the county is in a province chosen as part of the Third-Front movement; *City park* is the total number of city parks created between 1980 and 2005 per 10,000 inhabitants.

We next provide a sensitivity analysis designed to support the exclusion restriction hypothesis in our IV strategy (Appendix Table D3). There are two empirical concerns with Specification (1) and the rise-and-fall pattern: (i) the baseline specification does not account for the evolution of Million-Rouble plants themselves; and (ii) the specification relies on a geographic instrument that may correlate with the later spatial developments of the Chinese economy.

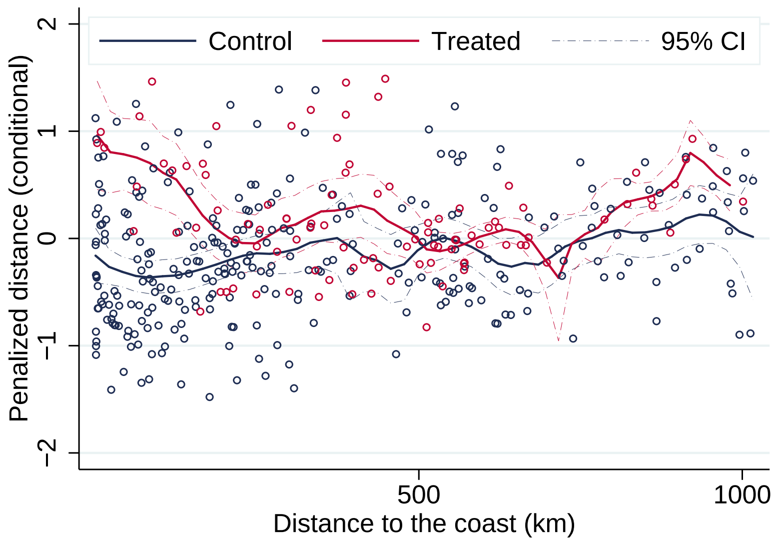
While we already document the healthy condition of Million-Rouble Plants in recent decades (see Appendix A.4), we further check for the robustness of the results in Appendix Table D3. In Panel A, we reproduce our main IV specification (from Table 4, Panel B) but exclude treated counties with either a closed or displaced MRP (Panel A1), and control for military (Panel A2) and extractive MRPs (Panel A3), which may have declined with the diversification of the Chinese economy and depletion of their natural resource base, respectively. The results show that the main empirical findings are not explained by the evolution of the MRPs.

In Appendix Table D3, Panels B-D, we investigate the role of three sets of factors that might spuriously drive the observed rise and fall of treated counties: (a) unobserved geographical factors, (b) the geography of future Chinese growth, and (c) place-based policies.

Some geographical features, e.g., terrain ruggedness, may have been seen favorably at the time the 156-program investments were made (because they offered protection against aerial attacks), but hampered economic development in the Reform era (by increasing transportation costs). In Table D3, Panel B, we add controls to our main IV specification to capture such time-invariant features of the geography. These features include elevation (minimum, mean, and maximum), ruggedness (or average slope in the county), minimum cost distance (through the 1950 railway network) to coke, oil, and major ore deposits, indicators of soil quality—lacustrine plains, sand hills, tidal marshes,—and crop yield (the maximum expected yield between the three most common crops: rice, wheat, and maize). Including these measures of natural amenities does not affect the rise-and-fall pattern that we observe.

We then investigate the potential confounding effect of the geography of Chinese growth during the Reform era. Fast-growing regions in the 1990s-2010s were indeed largely located along the coast and in the south, i.e., in regions that were extremely vulnerable to aerial attacks in the 1950s and subsequently received few MRPs. Conditional on the controls used in the baseline specification, penalized travel time does not appear to be systematically correlated with distance to the coast, and this relationship is statistically indistinguishable between treatment and control counties, expect within 200 km of the coast (Figure D1). In Table D3, Panels C1–C4, we test directly the robustness of our main empirical findings. In Panel C1, we control for (log) distance to the coast to capture a comparative advantage in an exporting economy. In Panel C2, we implement a more stringent test by excluding all counties in coastal provinces. In Panel C3, we exclude all (mostly control) counties within a 500-km buffer around the Pearl River delta, which spearheaded economic growth in the Reform era. In Panel C4, we finally exclude all counties south of the 28^{th} parallel. Although point estimates may vary as we restrict the sample, the boom-and-bust pattern that we identify in our baseline results is remarkably robust.

Figure D1: Relationship between exogenous variation and distance to the coast.



Notes: This graph plots the residuals from the regression of the penalized travel time shown in Panel (a) on the first-stage controls (see Table 1, column 3), for the treated (red) and control counties (blue). The fitted lines correspond to locally weighted regressions, in red for treated and in blue for control counties; 95% confidence intervals are materialized by dashed lines of the same colors.

The relative fall of treated counties may be due to later place-based policies that favored counties in the comparison group, or to severe disruptions due to pre-transition policy shocks in treatment counties. We control for such policies and events in Panels D1-D4: the Third Front movement (Panel D1; see Fan and Zou, 2019), which redirected strategic investments to the Western provinces after the Sino-Soviet split; the Cultural Revolution (Panel D2), which may have disproportionaly affected the most socially and economically advanced urban areas; Special Economic Zones and industry parks (Panel D3; see Wang, 2013; Crescenzi et al., 2012; Alder et al., 2016; Zheng et al., 2017), the main place-based policy of the Reform era; and the massive investments in transport infrastructures recently carried out (Panel D4), which may have targeted areas with few preexisting (industrial) investments and proxy for contemporary connectedness. Beyond these emblematic policies, the regime could have favored certain counties due to their strategic location, and these further investments may correlate with the vulnerability instrument. We already control for the general vulnerability to air strikes in 1964; we separately add the vulnerability to Soviet air strikes in 1972 in Panel D5. Neither alternative policies nor alternative measures of vulnerability affect our estimates. Since we do not know of any place-based policy that deliberately compensated control counties for not receiving MRPs, in the Mao era or in the Reform era, these results suggest that the rise-and-fall pattern experienced by treated counties is the effect of the treatment.

Finally, as described in Appendix A.3, the 1960 split put an abrupt end to industrial cooperation between China and the U.S.S.R. Beyond the 156 program proper, 98 additional investments had been planned and their sites already selected. Out of these, 63 plants were completed and 35 projects had to be abandoned. We use these investments, planned as part of the 2$^{\text{nd}}$ Five-Year Plan (FYP), in two ways. First, completed plants may affect our results as some counties in the control group were eventually treated. In Table D3, Panel E1, we control for such counties. We could also consider that our identification strategy ought to hold for 2$^{\text{nd}}$-FYP investments as well. In Panel E2, we replace our treatment variable, hosting a MRP from the 156 program proper, by an indicator equal to 1 if the county was planned to receive an investment in the 1$^{\text{st}}$ or 2$^{\text{nd}}$ FYP (regardless of whether the plants were completed by the time of the Sino-Soviet split), and redefine the control group based on this new treatment following the baseline matching strategy. The results in Panels E1-E2 show that the results are not sensitive to the treatment of 2$^{\text{nd}}$-FYP plants. Second, we can assume that the timing of the Sino-Soviet split is orthogonal to plant or county characteristics,[47] and directly compare treated counties (i.e., counties that received an operational plant as part of the 2$^{\text{nd}}$ FYP) and control counties (i.e., counties that had been selected and therefore should have been treated, but for which the investment never materialized). We implement this alternative identification strategy in Appendix Table D4. Because of observable (in terms of sectoral allocation) and potential unobservable differences (e.g., changes in the planners' objective function not recorded in historical accounts) between the two Five-Year Plants, we restrict the sample to counties targeted by planned investments under the 2$^{\text{nd}}$ FYP, for which the identification assumption is more likely to hold. Sample size subsequently reduces to 65. Despite large standard errors, Appendix Table D4 provides additional support for our main findings, with a similar rise-and-fall pattern in GDP per capita.

To conclude, these robustness checks show that our findings are not driven by the

[47] Giorcelli and Li (2021) provide evidence consistent with this assumption.

closure of unhealthy MRPs in some treated counties or by the correlation between our instrument and patterns of the overall development of the Chinese economy.

Table D3: Sensitivity to the empirical specification (exclusion restriction).

VARIABLES	Population (1982)	GDP p.c. (1982)	Population (2010)	GDP p.c. (2010)
Panel A1: Excluding closed and displaced factories				
Treatment effect	0.075	0.626	0.153	-0.260
	(0.113)	(0.231)	(0.145)	(0.165)
	[407]	[407]	[407]	[407]
Panel A2: Controlling for military factories				
Treatment effect	0.026	0.642	0.047	-0.110
	(0.119)	(0.261)	(0.143)	(0.232)
	[420]	[420]	[420]	[420]
Panel A3: Controlling for extractive factories				
Treatment effect	0.104	0.842	0.221	-0.121
	(0.137)	(0.294)	(0.188)	(0.253)
	[420]	[420]	[420]	[420]
Panel B: Controls for unfavorable environment (elevation etc.)				
Treatment effect	0.261	0.444	0.233	-0.501
	(0.133)	(0.227)	(0.142)	(0.194)
	[350]	[350]	[350]	[350]
Panel C1: Controls for distance to the coast				
Treatment effect	0.148	0.932	0.293	-0.074
	(0.123)	(0.294)	(0.164)	(0.261)
	[420]	[420]	[420]	[420]
Panel C2: Excluding coastal provinces				
Treatment effect	0.132	1.232	0.450	0.491
	(0.210)	(0.445)	(0.255)	(0.381)
	[245]	[245]	[245]	[245]
Panel C3: Excluding a buffer around the Pearl river delta				
Treatment effect	0.149	0.752	0.271	-0.143

	(0.111)	(0.240)	(0.148)	(0.214)
	[386]	[386]	[386]	[386]
Panel C4: Excluding the South of China				
Treatment effect	0.298	1.200	0.582	-0.357
	(0.182)	(0.416)	(0.245)	(0.331)
	[312]	[312]	[312]	[312]
Panel D1: Controlling for other policies – Third Front movement				
Treatment effect	0.156	0.711	0.230	-0.109
	(0.101)	(0.225)	(0.134)	(0.210)
	[420]	[420]	[420]	[420]
Panel D2: Controlling for other policies – Cultural Revolution				
Treatment effect	0.146	0.752	0.229	-0.153
	(0.097)	(0.243)	(0.126)	(0.208)
	[420]	[420]	[420]	[420]
Panel D3: Controlling for other policies – industry parks				
Treatment effect	0.162	0.976	0.291	0.001
	(0.125)	(0.257)	(0.160)	(0.221)
	[420]	[420]	[420]	[420]
Panel D4: Controlling for infrastructures				
Treatment effect	0.166	0.742	0.246	-0.167
	(0.111)	(0.248)	(0.152)	(0.219)
	[420]	[420]	[420]	[420]
Panel D5: Controls for vulnerability to U.S.S.R. strikes (1972)				
Treatment effect	0.543	0.946	0.710	-1.077
	(0.208)	(0.355)	(0.259)	(0.360)
	[420]	[420]	[420]	[420]
Panel E1: Controlling for 2$^{\text{nd}}$ FYP plants				
Treatment effect	0.081	0.664	0.115	-0.199
	(0.108)	(0.249)	(0.139)	(0.218)
	[420]	[420]	[420]	[420]
Panel E2: Including 2$^{\text{nd}}$ FYP plants in the treatment				

Treatment effect	0.185	0.849	0.207	0.072
	(0.109)	(0.209)	(0.139)	(0.189)
	[427]	[427]	[427]	[427]

Notes: Each cell is the outcome of a separate regression. Standard errors are clustered at level of 4-degree × 4-degree cells (reported between parentheses). The unit of observation is a county (Administrative level 3); the number of observations is reported between square brackets. The instrument is the distance to the main military U.S. and Taiwanese airfields penalized by the proximity to U.S.S.R. and North Korean airfields. All specifications include (i) propensity score bins, (ii) matching controls, i.e., travel cost to resources (coal, coke, ore), proximity to a rail hub, whether the county is a provincial capital, population in 1953 (log), county area (log), and (iii) the additional controls, i.e., travel cost to major ports (through the river network), proximity to Ming-dynasty courier stations, cities in 1900, distance to military airfields) and penalized distance to enemy airfields in 1964.

Table D4: Alternative identification strategy: abandoned plants.

VARIABLES	Population (1982)	GDP p.c. (1982)	Population (2010)	GDP p.c. (2010)
Treatment effect	0.389	0.509	0.648	0.078
	(0.276)	(0.236)	(0.305)	(0.251)
Observations	65	65	65	63

Notes: Each cell is the outcome of a separate regression. Standard errors are clustered at level of 4-degree × 4-degree cells (reported between parentheses). The unit of observation is a county (Administrative level 3); the number of observations is reported between square brackets. The instrument is the distance to the main military U.S. and Taiwanese airfields penalized by the proximity to U.S.S.R. and North Korean airfields. All specifications include (i) propensity score bins (except Panel A which includes province-fixed effects instead), (ii) matching controls, i.e., travel cost to resources (coal, coke, ore), proximity to a rail hub, whether the county is a provincial capital, population in 1953 (log), county area (log), and (iii) the additional controls, i.e., travel cost to major ports (through the river network), proximity to Ming-dynasty courier stations, cities in 1900, distance to military airfields) and penalized distance to enemy airfields in 1964. *Population* is the logarithm of total population in the county. In Panel B, we use proximity to Ming stations, distance to military airfields and access to the main trading ports as matching variables in order to select the group of control counties. In Panel C, we drop access to ore and coke from the set of matching variables.

Sensitivity We now test the sensitivity of our main results to various specification choices. We test the robustness of the findings to (a) alternative matching strategies, (b) reasonable variations in the parameterization of the flying cost used to penalize distance to enemy airbases, and (c) alternative weights. We also test the significance of the results under (d) a wide range of inference assumptions.

We start by analyzing variation along the baseline specification (Appendix Table D5). In Panel A1, we run a simple OLS regression with province fixed effects on the whole sample of counties in China. The identification thus relies on a comparison of treated counties with their immediate neighbors. The treatment effect in 1982, and the reversal of fortune in 2010, are found to be slightly smaller than in the baseline specification, possibly reflecting spatial spillovers. In Panels A2 to A5, we revert to the IV specification on the sample of counties selected through a matching procedure. In Panel A2, we add proximity to Ming stations, distance to military airfields, and access to the main trading ports to the matching process. In Panel A3, we restrict the matching process to a small set of variables: travel cost to coal mines, proximity to a rail hub, whether the county is a provincial capital, population in 1953 (log), and county area (log). In Panel A4, we use a one-to-one matching procedure without replacement between treated and control counties. Finally, Panel A5 doubles the exclusion zone around treated counties (see Section 2). The main result, i.e., the large difference in GDP per capita in 1982 and the subsequent catch-up, is qualitatively unchanged relatively to the baseline.

Our instrument for hosting a MRP is the minimum penalized travel time across enemy airbases in the 1950s. As explained in Appendix C.2, we set the key parameters governing this travel time using declassified CIA technical intelligence documents from the early 1950s. We however have some freedom in choosing other parameters. We test the robustness of the results to such choices in Appendix Table D5, Panel B, where we retain the functional form assumption but calibrate "free" parameters (α and C, g, and a and b, following the notation of Appendix C.2) differently. In Panel B1, ...

In the baseline specification, observations are weighted by the number of times a (control) county is matched to a treated county. Panel C1 of Appendix Table D5 provides the main estimates without any weights. Panel C2 provides alternative matching weights accounting for the extent to which the distribution of propensity scores coincides between treated and control counties. In both cases, results are similar to the baseline estimates.

The baseline inference strategy clusters standard errors at the level of a 4-degree $\times$ 4-degree cells. In Appendix Table D5, Panel D, we reproduce the baseline results but cluster standard errors at the prefecture (Panel D1), province (Panel D2), and 8-degree $\times$ 8-degree cell (Panel D3) levels, respectively. Panel D4 only uses heteroskedasticity-robust standard errors. Panels D5 through D9 allow for arbitrary spatial correlation in the errors (following Colella et al., 2019) within 50, 100, 200, and 300 km, respectively. The results are robust to these alternative inference strategies.

Measurement In the main results, we show a rise-and-fall pattern in GDP per capita at the county level. We now test for the robustness of this finding to changes in the outcome variable. We (a) focus on counties for which GDP per capita in 2010 is directly observed, (b) use alternative measures of economic development, and (c) investigate the treatment effect on local government finance.

Table D5: Sensitivity to the empirical specification (matching and weights).

VARIABLES	Population (1982)	GDP p.c. (1982)	Population (2010)	GDP p.c. (2010)
Panel A1: Local identification				
Treatment effect	0.142	0.427	0.242	0.033
	(0.045)	(0.080)	(0.060)	(0.064)
	[2321]	[2321]	[2321]	[2321]
Panel A2: Matching with extended variables				
Treatment effect	0.149	0.910	0.251	-0.053
	(0.136)	(0.218)	(0.149)	(0.202)
	[365]	[365]	[365]	[365]
Panel A3: Matching with fewer variables				
Treatment effect	0.159	0.626	0.075	-0.214
	(0.111)	(0.221)	(0.135)	(0.224)
	[432]	[432]	[432]	[432]
Panel A4: One-to-one matching				
Treatment effect	0.124	0.843	0.254	-0.005
	(0.099)	(0.206)	(0.131)	(0.196)
	[222]	[222]	[222]	[222]
Panel A5: Matching with larger exclusion zone				
Treatment effect	0.086	0.551	0.098	-0.208
	(0.098)	(0.220)	(0.149)	(0.159)
	[351]	[351]	[351]	[351]
Panel C1: No weights				
Treatment effect	0.154	0.721	0.173	-0.153
	(0.116)	(0.257)	(0.160)	(0.219)
	[420]	[420]	[420]	[420]
Panel C2: Alternative weights				
Treatment effect	0.184	1.116	0.200	-0.242
	(0.120)	(0.301)	(0.198)	(0.279)
	[420]	[420]	[420]	[420]

Notes: Each cell is the outcome of a separate regression. Standard errors are clustered at level of 4-degree × 4-degree cells (reported between parentheses). The unit of observation is a county (Administrative level 3); the number of observations is reported between square brackets. The instrument is the distance to the main military U.S. and Taiwanese airfields penalized by the proximity to U.S.S.R. and North Korean airfields. All specifications include (i) propensity score bins (except Panel A which includes province-fixed effects instead), (ii) matching controls, i.e., travel cost to resources (coal, coke, ore), proximity to a rail hub, whether the county is a provincial capital, population in 1953 (log), county area (log), and (iii) the additional controls, i.e., travel cost to major ports (through the river network), proximity to Ming-dynasty courier stations, cities in 1900, distance to military airfields) and penalized distance to enemy airfields in 1964. *Population* is the logarithm of total population in the county. In Panel B, we use proximity to Ming stations, distance to military airfields and access to the main trading ports as matching variables in order to select the group of control counties. In Panel C, we drop access to ore and coke from the set of matching variables.

GDP per capita in 2010 is available for a subset of counties. In the baseline results, we impute missing values as follows: if a county has no GDP data, we use the average in the prefecture; if all values are missing in a prefecture, we use the average in the province.[48] In Appendix Table D6, Panel A1, we reproduce the results from Table 4 but restrict the sample to counties with non-missing GDP in 2010. In Panel A2, we further show that the 2010 GDP per capita results are robust to using a local identification strategy instead of matching (column 1), to excluding all counties south of the 28$^{\text{th}}$ parallel (column 2), and to controlling for (log) distance to the coast (column 3)—these specifications are identical to the ones in Appendix Table D3.

Another issue that may affect the finding of convergence in terms of productivity is measurement error. We consider alternative measures of economic development in Appendix Table D6, Panels B1-B3. We look at two types of measures.

First, in Panel B1, we extract a few additional variables from the 1982 Census, i.e., labor force participation, illiteracy rate, and the male-to-female ratio. The illiteracy rate is much lower in treated counties (16 percentage points). There are no sharp differences in the male-to-female ratio, which shows that selected immigration, if any, was not strongly tilted toward males. In Panel B2, we shed additional light on the nature of the rise-and-fall pattern: we document the allocation of workers across sectors in 1990 and 2010. The observed difference in household registration (see Table 4) does reflect a difference in employment shares across sectors of the local economy: the employment share in agriculture is 27 percentage points lower in treated counties. The "released" labor force is equally absorbed by industry and services. In particular, a significant share of workers in the service sector are allocated to distribution and transportation (results not shown), two sub-sectors very likely to intervene in the production chain of a MRP. The magnitude of these estimates is large: the local allocation of workers in treated counties resembles the aggregate Chinese economy after the transition. In 2010, however, treated counties are less industry-intensive, a result mostly explained by a higher prevalence of services (distribution and transportation).

Second, Panel B3 of Appendix Table D6 provides additional support for the slowdown of economic activity in treated counties. We use remote sensing in order to derive alternative measures of living standards at the county level, and resort to nighttime luminosity between 1993 and 2012 ("Average Visible, Stable Lights, & Cloud Free Coverages") as a complement for census-based measures. Our find-

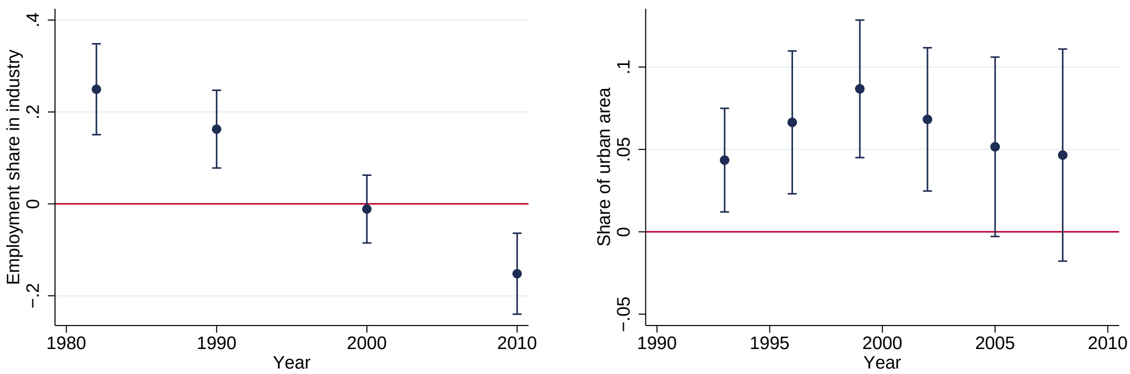
[48] Prefectures are the second administrative division in China, below the province. There were about 330 prefectures and 30 provinces in 2000.

ings show that luminosity is three times higher in treated counties in 1993, and a large share of this head start disappears by 2012 (column 2). Nighttime luminosity captures both economic activity and the degree of urbanization. We confirm in column 3, using a satellite-based measure of the share of urban land in the county,[49] that treated counties were significantly more urbanized in 1993; this share is not statistically significantly different in 2012 (result not shown).

Finally, we analyze the role of government expenditures and revenues in Panel C of Appendix Table D6. We do not find a strong impact on local government expenditures in 2010, but government revenues are significantly lower—possibly reflecting a combination of lower economic activity and lenient local taxation. The discrepancy between expenditures and revenues can only be sustained temporarily, or it would strongly affect the asset position of local governments. We do not find large differences in savings, which indicates that the gap appeared rather recently.

D.2 Dynamics and additional aggregate outcomes [update]

Figure D2: Illustration of the treatment effect over time (employment share in industry and share of urban area)).



A. Employment share in industry

B. Share of urban area

Notes: This Figure displays the treatment effect for the employment share in industry (1982, 1990, 2000, 2010) and the share of urban area in the county, as computed using impervious surface recognition (1993, 1996, 1999, 2002, 2005, 2008).

Dynamics [update]

[49]To determine the urban extent, we rely on a map of "impervious areas" produced by Beijing City Lab. See https://www.beijingcitylab.com/data-released-1/data1-20/ (accessed April 7, 2021).

Table D6: Sensitivity to other measures of economic development.

VARIABLES	Participation	Illiteracy rate	Male/female ratio
Panel A: Additional census variables			
Treatment effect (1982)	-.040	-.163	-.015
	(.022)	(.041)	(.017)
	[430]	[430]	[430]

VARIABLES	Agriculture	Industry	Services
Panel B: Precise sectoral decomposition (employment shares)			
Treatment effect (1990)	-.267	.126	.136
	(.067)	(.039)	(.034)
	[430]	[430]	[430]
Treatment effect (2010)	.042	-.129	.086
	(.060)	(.052)	(.033)
	[430]	[430]	[430]

VARIABLES	Nightlights (1993)	Nightlights (2012)	Urban (1993)
Panel C: Satellite data			
Treatment effect	1.21	.524	.043
	(.336)	(.258)	(.016)
	[430]	[430]	[423]

VARIABLES	Expenditures	Revenues	Savings
Panel D: Local governments			
Treatment effect	-.147	-.993	-.137
	(.217)	(.399)	(.284)
	[299]	[299]	[299]

Notes: Each cell is the outcome of a separate regression. Standard errors are clustered at level of 4-degree × 4-degree cells (reported between parentheses). The unit of observation is a county (Administrative level 3); the number of observations is reported between square brackets. The instrument is the distance to the main military U.S. and Taiwanese airfields penalized by the proximity to U.S.S.R. and North Korean airfields. All specifications include (i) propensity score bins (except Panel A which includes province-fixed effects instead), (ii) matching controls, i.e., travel cost to resources (coal, coke, ore), proximity to a rail hub, whether the county is a provincial capital, population in 1953 (log), county area (log), and (iii) the additional controls, i.e., travel cost to major ports (through the river network), proximity to Ming-dynasty courier stations, cities in 1900, distance to military airfields) and penalized distance to enemy airfields in 1964.

D.3 Detailed treatment effects on the structure of production

In this section, we first provide a comprehensive analysis of factor use, factor productivity, firm characteristics, patenting behavior, investment and subsidies in the average establishment. We then provide a set of robustness checks around the main results of Section 4.

Structure of production We report in Table D7 the average treatment effect on factor productivity (Panel A), firm type and characteristics of the workforce (Panel B), cashflows, subsidies and investment (Panel C), factor intensity (Panel D), patenting (Panel E) and markups (Panel F). The first and last columns of Panel A are already discussed in the main text. In addition, we find that labor productivity is lower in treated counties and consistent with the drop in labor cost (Table D7, column 2), capital productivity and TFP are 37 and 30% lower than in control counties.

Next, we characterize the establishment "type" in treated counties, specifically whether the average establishment is more likely to be publicly owned, older and biased towards a more educated and experienced workforce. Panel B of Table D7 shows that manufacturing establishments are 11 percentage points more likely to be publicly-owned, and more likely to be older than three years; these effects are however small. The composition of the workforce markedly differs between treated and control counties: the average employee in treated counties is *much* more likely to be a skilled worker, and 11 percentage points more likely to occupy a "senior" position within the firm (to be compared with the 28 percentage points share of senior workers). In view of this observation, our finding that wages are lower in treated counties is puzzling, and this finding is inconsistent with an explanation based on under-investment in human capital (Franck and Galor, 2017).

We describe the financing structure of establishments in treated counties, their investment, and the expenditures devoted to R&D in Panel C. The patterns from this analysis do not support a story based on political favoritism (Chen et al., 2017a; Fang et al., 2018): public subsidies appear to be non-significantly higher in treated counties (see column 1). The results are inconsistent with a privileged access to resources (Harrison et al., 2019): total liabilities are not higher than in control counties (column 2). Short-term investment is lower but not very strongly so (see column 3). The financing structure in the average (other) establishment in treated counties appear to be quite similar to that of control counties.

We characterize production in treated counties using product codes at the 4-digit level (Panel D). We regress the (log) factor intensity, as predicted by the 4-digit product code (following the classification of Shirotori et al., 2010), on the treatment T_c, instrumented by V_c. In this specification, we omit year interacted with 4-digit industry fixed-effects and only include year-fixed effects. The average product in treated counties is 6% more human-capital-intensive, 19% more physical-capital-intensive and 4% more land-intensive. These findings point toward some specialization of treated counties in capital-intensive production, but the extent of such specialization remains moderate.

We now turn to the more direct analysis of technological innovation through the analysis of patent applications across establishments (Panel E). We distinguish three categories: design (minor changes in design), innovation and utility, the latter categories being the most relevant to capture technological progress. We find that establishments in treated counties produce fewer patents: -0.031 (design), -.024 (invention) and -.023 (utility, used in the baseline), -.062 (all). These effects are of the order of magnitude of the yearly number of patents produced in the average establishment: there are very few patents that are registered in treated counties.

We now turn to the analysis of markups across establishments. We rely on a translog specification for the production function and consider two main strategies: A (without inputs in the control function), B (using direct materials as input in the control function). For both strategies, we construct two measures for markups: a dummy equal to one if the markup is above-median within a 4-digit industry × year cell and the (log) markup. As shown in Panel F, markups are slightly higher in treated counties.

Dynamics The empirical facts shown in Section 3 point to a relative slowdown of economic activity in treated counties between 1982 and 2010. The previous evidence is however cross-sectional and spans the whole period during which the reversal of fortune occurs. To shed some light on the the dynamics in the production structure during the transformation of the Chinese economy, we select two main outcomes, i.e., total factor productivity and the number of registered patent applications, and we estimate the treatment effect each year between 1998 and 2007.

Figure D3 reports these estimates. As apparent from Panel A, the average treated establishment is less productive in 1998, but the gap widens after 2000. These results are obtained with sectoral dummies and a set of dummies for each firm type in order to control for the slow demise of public enterprises and time variation in sectoral returns. The gap in patenting behavior between treated and control counties also widens after 2000, especially for the two most relevant categories of patents, i.e., invention and utility (reported here): the deterioration in productivity is accompanied by a stagnation in technological innovation.

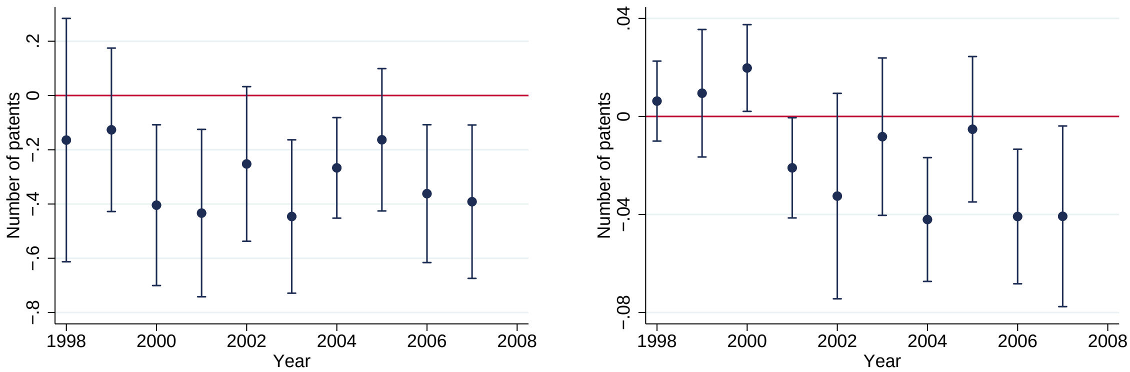
Table D7: Structure of firm production in the other establishment (detail).

VARIABLES	Labor cost	MPL	MPK	TFP
	(1)	(2)	(3)	(4)
Panel A: factor productivity				
Treatment	-.320	-.217	-.368	-.304
	(.078)	(.121)	(.117)	(.104)
Observations	432,202	432,202	432,202	432,202
VARIABLES	Public	Young	Emp. (skilled)	Emp. (senior)
	(1)	(2)	(3)	(4)
Panel B: firm characteristics (public ownership, unions, employment structure)				
Treatment	.110	-.074	.178	.094
	(.029)	(.036)	(.031)	(.027)
Observations	432,202	432,202	22,691	22,691
VARIABLES	Subsidies	Cash inflow (fin.)	Investment ST	R&D expenses
	(1)	(2)	(3)	(4)
Panel C: Financing, Investment, R&D and technology				
Treatment	-.016	.030	-.016	-.001
	(.034)	(.029)	(.010)	(.015)
Observations	281,778	281,778	215,142	215,142
VARIABLES	Human capital	Physical capital	Land	
	(1)	(2)	(3)	
Panel D: Factor intensity				
Treatment	.063	.194	.042	
	(.017)	(.047)	(.029)	
Observations	402,785	402,785	402,785	
VARIABLES	Design	Utility	Invention	All
	(1)	(2)	(3)	(4)
Panel E: Patents				
Treatment	-.031	-.023	-.024	-.062
	(.014)	(.008)	(.014)	(.022)
Observations	432,202	432,202	432,202	432,202
VARIABLES	Markup (A,m)	Markup (A,l)	Markup (B,m)	Markup (B,l)
	(1)	(2)	(3)	(4)
Panel F: Markups				
Treatment	.130	.086	.075	.070
	(.062)	(.042)	(.062)	(.049)
Observations	301,198	207,355	173,382	120,203

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. All specifications include the baseline controls (Table 4), 4-digit industry × year fixed effects, except in Panel D, and firm type × year fixed effects, except in Panel B. *Labor cost* is the logarithm of total compensation per employee; *MPL* (resp. *MPK*, *TFP*) is the logarithm of firm-specific labor productivity (resp. capital, total factor productivity) as computed in Imbert et al. (2020). *Public* and *Young* are dummies equal to 1 if the firm is a state-owned enterprise, and is younger than 3 years. All variables of Panel C are dummies equal to 1 if the associated accounting variable is positive. Factor intensities are the (log) factor intensity, as predicted by the 4-digit product code (following the classification of Shirotori et al., 2010). *Markup* (m) (resp. l) is a dummy equal to one if the markup is above-median within a 4-digit industry × year cell (resp. the log. markup), computed following De Loecker and Warzynski (2012)—see Appendix B.

Entry, exit and dispersion Factor cost and factor productivity appear to be low in treated counties, but dispersed. In Panel A of Appendix Table D8, we cal-

Figure D3: Illustration of the treatment effect over time (Total Factor Productivity, number of patents).



A. Total Factor Productivity

B. Patents

Notes: This Figure displays the treatment effect for establishments size (1998–2007), and patenting behavior (utility, 1998–2007).

culate the standard deviation in labor cost within county × year (weighted by firm employment), and regress the measure of wage dispersion on the treatment T_c, instrumented by V_c. We find a higher dispersion of about 14% in treated counties (Table D8, column 1). In columns 2, 3 and 4 of Appendix Table D8, we replicate the previous exercise with the standard deviations of productivity measures as dependent variables. Measures of labor productivity are more dispersed within treated counties than within control counties. The dispersion in labor cost and productivity indicates frictions in the allocation of resources across establishments. In Panel B of Appendix Table D8, we show that there is a higher concentration of production in large establishments of treated counties. In Panel C of Appendix Table D8, we show that there is no higher likelihood of exit in treated counties; this observation also holds for establishments not along the production chain of the local MRP(s).

D.4 Compositional effects [update]

In this section, we implement a set of robustness checks in order to discard competing explanations for the main findings of Section 4. These competing channels are: the demise of publicly-owned firms between 1992 and 2008—are they predominantly in treated counties, and along the production chain of MRPs?—, the misallocation of (public) resources—are they targeting unproductive firms in treated counties, and particularly so along the production chain of MRPs?—, lower dynamism related to the life-cycle of establishments—are they older in treated counties, and particularly

Table D8: Sensitivity analysis—dispersion, concentration and entry/exit at the county-level.

VARIABLES	Labor cost	MPL	MPK	TFP
	(1)	(2)	(3)	(4)
Panel A: Dispersion in labor cost and productivity				
Treatment	.137	.160	-.024	.041
	(.050)	(.103)	(.120)	(.103)
Observations	2,786	2,462	2,462	2,462
	Herfindahl		Large firms	
VARIABLES	Employment	Output	Employment	Output
	(1)	(2)	(3)	(4)
Panel B: Concentration in employment and output				
Treatment	.018	.054	.283	.212
	(.036)	(.045)	(.097)	(.090)
Observations	3,729	3,729	3,729	3,042
	Number of entrants		Number of exiters	
VARIABLES	All	Outside	All	Outside
	(1)	(2)	(3)	(4)
Panel C: Entry & exit				
Treatment	-.010	-.011	.015	.034
	(.014)	(.030)	(.020)	(.041)
Observations	3,729	3,729	3,729	3,729

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a county × year. We exclude the MRPs from the sample. All specifications include the baseline controls (Table 4) and year fixed effects.

so along the production chain of MRPs?

Control for firm type Table E3 and controls for product codes

In order to provide evidence for these possible compositional effects, we implement three main empirical strategies. The first strategy cleans for possible compositional effects in the baseline specification, i.e.,

$$Y_{it} = \beta_0 + \beta_1 T_c + \beta_2 T_c \times S_{it} + \beta_{\mathbf{x}} \mathbf{X}_c + \eta_{rt} + \nu_{st} + \varepsilon_{isct}$$

where η_{rt} is a set of time × firm-type (r) fixed effects.

Controlling for the presence/absence of public, subsidized, young firms in treated counties does not change the baseline findings. Treated establishments are less productive, less innovative and less competitive (Appendix Table D9).

Table D9: Sensitivity to additional controls (public, subsidized, young).

VARIABLES	TFP (1)	Patents (2)	Markup (3)
Treatment	-.288	-.024	.135
	(.104)	(.008)	(.062)
Observations	392,829	392,829	273,013

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a firm × year. We exclude the MRPs from the sample. All specifications include the baseline controls (Table 4), 4-digit industry × year fixed effects and firm type × year fixed effects. *Labor* is the logarithm of the number of workers; *Capital* is the logarithm of real capital; *Labor cost* is the logarithm of total compensation per employee; *TFP* is the logarithm of firm-specific total factor productivity as computed in Imbert et al. (2020); *Patents* are the number of patent applications registered by the firm; *Markup* is a dummy equal to one if the markup is above-median within a 4-digit industry × year cell, computed following De Loecker and Warzynski (2012)—see Appendix B.

Characteristics of linked firms The second strategy analyzes the prevalence of public, subsidized, young firms along the production chain of MRP(s) by running the baseline specification with respective dummies as dependent variables (and no fixed effects for the different firm types).

Firms which are downstream/upstream of MRP(s) are not very different from the average establishment in treated counties: they are slightly more likely to be public and younger but none of these effects are really large (Panel A, Appendix Table D10). Establishments in the same product market as MRPs are however much older and much more likey to be publicly-owned (Panel B, Appendix Table D10).

Outcomes for public firms in treated counties The third strategy controls for the possible heterogeneous treatment effects on firms of different types,

$$Y_{it} = \beta_0 + \beta_1 T_c + \beta_2 T_c \times S_{it} + \beta_3 T_c \times \mathbb{1}_{R_{it}=r} + \beta_{\mathbf{x}} \mathbf{X}_c + \eta_{rt} + \nu_{st} + \varepsilon_{isct}$$

where $\mathbb{1}_{R_{it}=r}$ is a dummy equal to 1 if firm i is of type r.

The previous compositional effects cannot however explain the main findings of Section 4: public establishments in treated counties are indeed relatively productive and innovative compared to their counterparts in control counties (Panel A, Appendix Table D11).

Using these strategies, we provide below a comprehensive analysis of compositional effects, i.e., we analyze how differences in production structure may reflect

Table D10: Characteristics of establishments along the production chain of MRPs.

VARIABLES	Public (1)	Subsidized (2)	Young (3)
Panel A: Downstream/Upstream			
Treatment	.104	-.010	-.073
	(.030)	(.028)	(.036)
Treatment × Linkage	.084	-.024	.035
	(.065)	(.075)	(.060)
Observations	432,202	392,829	432,202
Panel B: Same product			
Treatment	.103	-.008	-.068
	(.030)	(.028)	(.035)
Treatment × Same product	.339	-.154	-.292
	(.142)	(.135)	(.114)
Observations	432,202	392,829	432,202

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a firm × year. We exclude the MRPs from the sample. All specifications include the baseline controls (Table 4) and 4-digit industry × year fixed effects. *Downstream/Upstream* is a dummy equal to one if the firm is down (or up) the supply chain with respect to one of the 156 factories; *Same product* is a dummy equal to one if the firm is in the same product market as one of the 156 factories.

differences in the industrial fabric, differences in the ownership structure or the presence of establishments at different stages of their life cycle.

D.5 Complements on firm linkages [update]

Additional measures of concentration [update] language, technology, number of firms/output

Results on technological linkages or production factors [update]

Heterogeneity along treatment intensity Before analyzing heterogeneous treatment effects across establishments of the same county, we study a simpler aspect of treatment heterogeneity: the heterogeneity in treatment effects across treatment intensity (i.e., expected spillovers and co-agglomeration).

We report the analysis of treatment heterogeneity in Table D12. We focus on the following baseline outcomes, total factor productivity, the number of registered (utility) patents, and markups, and restrict the analysis to two simple measures of treatment "intensity": (i) the average I/O intensity (summing the shares of input and output linkages in the U.S. input/output matrix at the 4-digit industry level)

Table D11: Sensitivity analysis—compositional effects (public, subsidized, young).

VARIABLES	TFP (1)	Patents (2)	Markup (3)
Panel A: Public			
Treatment	-.401	-.045	.135
	(.123)	(.019)	(.070)
Treatment × Public	.439	.061	-.026
	(.251)	(.034)	(.070)
Observations	432,202	432,202	301,198
Panel B: Subsidized			
Treatment	-.295	-.026	.154
	(.109)	(.016)	(.069)
Treatment × Subsidized	.042	-.010	-.104
	(.091)	(.045)	(.054)
Observations	392,829	392,829	273,013
Panel C: Young			
Treatment	-.256	-.037	.143
	(.110)	(.017)	(.060)
Treatment × Young	-.133	.012	-.048
	(.120)	(.024)	(.051)
Observations	432,202	432,202	301,198

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a firm × year. We exclude the MRPs from the sample. All specifications include the baseline controls (Table 4), 4-digit industry × year fixed effects and firm type × year fixed effects. *Downstream/Upstream* is a dummy equal to one if the firm is down (or up) the supply chain with respect to one of the 156 factories; *Same product* is a dummy equal to one if the firm is in the same product market as one of the 156 factories

to capture the expected extent of the production chain and (ii) a dummy equal to one if there are different products produced by local MRP(s) to capture local diversification or the co-agglomeration of different industries.

Treatment characteristics do seem to matter, at least for patenting. The average I/O intensity aggravates the drop in patent applications (Panel A), while diversification tempers the observed drop in innovation (Panel B). Having MRPs operating in only one 4-digit industry decreases the probability to submit a patent by 2.6 percentage points; having MRPs operating in at least two distinct industries increases the probability to submit a patent by 0.8 percentage points. Co-agglomeration patterns appear to foster technological adoption in the local economy.

These heterogeneous effects suggest that the specialization and high needs for production integration of MRPs may explain the aggregate fall in economic activity. In the next section, we investigate the patterns of agglomeration of establishments around the MRP(s) and the characteristics of linked versus non-linked firms.

Table D12: Treatment heterogeneity along treatment intensity.

VARIABLES	TFP (1)	Patents (2)	Markup (3)
Panel A: Production linkages			
Treatment	-.234	.041	.003
	(.318)	(.031)	(.428)
Treatment × Production linkages	-.027	-.031	.031
	(.160)	(.016)	(.065)
Observations	386,047	386,047	268,868
Panel B: Different products			
Treatment	-.201	-.026	-.000
	(.188)	(.012)	(.095)
Treatment × Different products	-.267	.034	.099
	(.278)	(.019)	(.117)
Observations	386,047	386,047	268,868

Notes: Standard errors are clustered at level of 4-degree × 4-degree cells. The unit of observation is a firm × year. We exclude the MRPs from the sample. All specifications include the baseline controls (Table 4), 4-digit industry × year fixed effects, firm type × year fixed effects and the interaction of the measure of treatment intensity with year fixed effects.

D.6 Entrepreneurial values

We rely on the China Family Panel Survey (CFPS), a nationally representative survey of about 15,000 households carried out by the Institute of Social Science Survey at Peking University.[50] CFPS contains modules on aspirations and world outlook, in particular on effort and individualism, along with socioeconomic data. These modules provide us with rare information on entrepreneurial spirit.

The distortions in the local supply of entrepreneurs may discourage the *production* of entrepreneurs, or entrepreneurial spirit.[51] We investigate this possible effect

[50] CFPS is representative of 95% of the Chinese population—Inner Mongolia, Hainan, Ningxia, Qinghai, Tibet, and Xinjiang are not covered. CFPS consists of three waves: a baseline in 2010, and two follow-up surveys in 2012 and 2014; we focus on 2012 and 2014, when our modules of interest are included. Please refer to www.isss.edu.cn/cfps for further information about CFPS.

[51] A lack of entrepreneurial spirit may result from a composition effect—large industrial investments attract factory workers and lead to an emigration of entrepreneurs, as shown before. This mechanism was hypothesized by Chinitz (1961) to explain the demise of the Rust Belt.

using the China Family Panel Survey (CFPS) and its module on values and aspirations. Table D13 presents the estimates of specification (1), at the individual level and controlling for respondent and household characteristics.[52]

In Panel A of Table D13, we analyze aspirations, focusing on education and job prestige. The population in treated counties is significantly more likely to aspire to tertiary education: treated respondents are 8 percentage points more likely to aspire to a master's degree (for themselves or for their children), compared to an average response of 6% in the control group. Respondents in control counties are also more likely to report that no schooling is necessary, but the effect is small (column 2). In column 3, we show that job prestige is significantly more likely to be emphasized in households living near a MRP.

We investigate the treatment effect on values in Panel B of Table D13. We use the following survey questions from CFPS: "Do you agree that the most important factor that determines one's success is how hard she works?"; "Do you agree that for the economy to thrive, one needs to enlarge income inequality in the population?", "How important is talent to a child's future achievement?" We find that individuals in treated counties are less likely to think that hard work will be rewarded, that inequality is necessary, and that talent is important for success. These results are consistent with lower individualism and a decline in entrepreneurship. They may either reflect (i) a composition effect, as manufacturing industries predominantly attract factory workers who may be negatively selected in terms of entrepreneurial values, and (ii) a treatment effect on the local culture, potentially mediated by distortionary effects on entrepreneurs' location choices.

[52] We control for the age of the respondent in 2014, the gender, and for the household level of education, income, and urban status. Note that only a subset of the CFPS households live in our sample counties, reducing the sample to 420 individuals for the values module and 1,838 in the aspirations module—across 30 counties. The aspiration module applies to households with children aged 0–15, and answers are collected from parents. The values module applies to children aged 12–15.

Table D13: Values and aspirations in treated and control counties.

	Master's degree	No schooling necessary	Highly esteemed position
Panel A: Aspirations			
Treatment	.075	-.010	.123
	(.021)	(.005)	(.037)
Observations	1,838	1,838	1,838
F-stat. (first stage)	51.33	51.33	51.33
	Hard work is rewarded	Inequality is necessary	Talent is important for success
Panel B: Values			
Treatment	-.103	-.376	-.546
	(.061)	(.138)	(.241)
Observations	420	420	1,838
F-stat. (first stage)	39.64	39.64	51.33

Notes: Standard errors are clustered at the level of 4-degree $\times$ 4-degree cells. The unit of observation is an individual. All specifications include individual and household controls: respondent's age and gender, and household mean income and education (shares of household members at each level of education). The dependent variables are dummy-coded, except "Talent is important for success," which is expressed on a 0–10 scale. Some outcomes are only available for subsamples.