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

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December 18, 2020

Abstract

We identify the negative spillovers exerted by large, successful factories 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 exogenous variation in location decisions due to the relative position of allied and enemy airbases. We find a rise-and-fall pattern in counties hosting a factory and show that (over-) specialization explains their long-run decline. The analysis of production linkages shows that a large cluster of non-innovative establishments enjoy technological rents along the production chain of Million-Rouble plants. This industrial concentration reduces the local supply of entrepreneurs.

JEL codes: R11, R53, J24, N95

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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 transformation 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 cotton towns), the Ruhr region in Germany, or the Northeast of France. Explanations for such a decline usually rely on external, aggregate factors: (i) structural change, as employment shifts away from industry and into services (Ngai and Pissarides, 2007; Desmet and Rossi-Hansberg, 2014), or (ii) exposure to international competition (Pierce and Schott, 2016).

This paper presents causal evidence of a boom and a bust following successful industrial investments, without any external factor triggering a downturn. This allows us to focus on factors *within* the local economy that drive the bust. The local economy is unproductive, non-innovative, and very specialized. In order to shed light on the relationship between industrial concentration and firm performance, we exploit high-quality data on production, patent applications and possible linkages between manufacturing establishments (1992–2008). We find that the local economy is characterized by a hub and spoke structure where one large, successful industrial plant is linked to a network of rent-extracting firms along its production chain. This structure limits technological spillovers across industries and leads to the migration of entrepreneurs to other Chinese cities.

We exploit an unprecedented investment and technology transfer from the U.S.S.R. to China, which led to the construction of 156 "Million-Rouble Plants" (MRPs) between 1953–1958. These plants, equipped with advanced Soviet technology, constitute the foundation stone of China's industrialization (Lardy, 1987; Naughton, 2007). Identifying industrial spillovers requires exogenous variation in the initial distribution of these large industrial units. In an ideal setting, actual project sites would have a natural set of counterfactual industry locations, e.g., a list of candidate locations as in Greenstone et al. (2010), and an exogenous component in the selection process among these locations. We emulate this hypothetical setup as follows. We first rely on the historical site-selection criteria described in Bo (1991) to select a set of suitable counties based on economic factors (e.g., market access and access to natural resources) which were carefully considered by planners.[1] We then exploit

[1]In stark contrast with the Great Leap Forward or the Third Front Movement (whose investments had to be "close to the mountains, dispersed, and hidden in caves"), this program was efficiently implemented. The choice of locations for these plants was economically sound and spanned a wide range of locations in China; great attention was also given to production efficiency, including material incentives for managers (Eckstein, 1977; Selden and Eggleston, 1979) and technological transfers (as documented by Giorcelli, 2019, for the Marshall plan).

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 for suitable counties. After the Korean war, Chinese planners were wary of the new factories' vulnerability to enemy bombing; this had a marked effect on the location of MRPs.[2] We model the bombing threat by combining detailed information about airplane technologies with the location of enemy and allied air bases, and we instrument the probability to host a MRP by the vulnerability to air strikes from major U.S. bases as computed between 1950–1960, controlling for vulnerability after the Sino-Soviet split.[3] The instrument may still correlate with other geographic factors playing a role during the recent economic growth. We show that our findings are robust to controlling for: (i) current market access, distances to major (exporting) ports, to the Pearl River Delta, and to the coast; (ii) amenities and unfavorable geographic characteristics (e.g., ruggedness); (iii) other spatial policies, e.g., Special Economic Zones (see, e.g., Wang, 2013) or the Third Front Movement (Fan and Zou, 2019).

We show that counties hosting MRPs experience a rise-and-fall pattern. In 1982, treated counties were more industrialized and two to three times more productive than control counties.[4] However, these treated counties experienced a steady decline (in relative terms) over the following decades, even though the MRPs themselves remained very productive.[5] In 2010, the employment share in industry was *lower* in treated counties, and there was no longer any difference in average productivity. We then characterize production in the average (other) manufacturing establishment: within a given industry, the non-MRPs establishments in treated counties pay lower wages in spite of a more educated workforce, are less productive, less innovative, and less competitive than establishments in control counties.

To assess whether and how MRPs exert negative spillovers on other production units, we rely on a procedure developed in Imbert et al. (2020) which associates a

[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] The set of protected locations then became smaller, which called for directing new industrial investments to the interior in a policy called the Third Front Movement (see Fan and Zou, 2019).

[4] The research requires high-quality data on economic activity at the county level (about 2,400 in China). Aggregate data are available from the early stages of industrialization, with the 1953, 1964, 1982, 1990, 2000, and 2010 Censuses. In the recent period, we rely on a census of manufacturing firms, the National Bureau of Statistics "above-scale" annual establishment survey (1992–2008), which we link with patent applications (He et al., 2018) and complement with measures of factor productivity (Imbert et al., 2020) and markups (following De Loecker and Warzynski, 2012).

[5] We identify the MRPs in a census of manufacturing establishments and find that they are still outliers in terms of productivity and innovation—without any signs of decline.

unique HS6 product code to textual product descriptions provided by manufacturing establishments. We use this product classification to construct Herfindahl indices of product concentration, mitigated by input/output linkages or technological linkages (Bloom et al., 2013), and evaluate the role of (over-)specialization in explaining firm performance in treated counties. We find that treated counties are highly concentrated in production. As counties with a specialized production structure are less productive, this shift in specialization induces a drop in firm performance. We then look at the role of production linkages at a more granular level, and we show that treated counties are highly concentrated *along the production chain of the MRPs*. The large cluster of linked establishments, upstream and downstream of the MRP(s), is quite productive but not innovative—registering almost no patents—and not competitive—charging a higher mark-up. These establishments, by operating along the production chain of a large and productive factory, tie their production to the larger factory, enjoy a technological rent by doing so, and are not incited to incur innovation efforts. Treated counties do not benefit from between-industry technological spillovers, which have been identified as the drivers of innovation and development in the long run (see Carlino and Kerr, 2015, for a recent review).

This paper is the first to identify spatial, negative agglomeration externalities in the long run through the observation of linkages between production units.

The adoption of industrial technologies is associated with an intensive use of intermediate inputs and a homogenization of technology along the production chain (Ciccone, 2002). Our observed boom-and-bust is consistent with spillovers operating mostly through these input/output markets, with: (i) production specialization and increasing returns to scale during the early phase of industrialization (Ciccone, 2002); (ii) a negative long-run effect of such specialization (as in Duranton and Puga, 2001; Faggio et al., 2017) due to low incentives to innovate for linked firms and limited technology spillovers across industries (Glaeser et al., 1992; Henderson et al., 1995). There exist other channels through which MRPs may have affected growth in the long run. First, early industrialization might induce a shift in the local supply of entrepreneurs (Chinitz, 1961; Glaeser et al., 2015). We do identify such a downward shift by investigating the selection of emigrants across origin counties. We show that emigrants from treated counties are much more likely to be educated, self-employed, and a high earner at destination.[6] Second, treated counties may experience a form

[6]We use a nationally representative household survey and a module capturing values and aspirations to show that respondents in treated counties are less likely to display individualistic values associated with entrepreneurship. The limited prospects for entrepreneurs, as induced by a local economy dominated by the production chain of the MRP, could explain this change in values, e.g., through a selection effect in which entrepreneurial individuals migrate out of the county.

of Dutch disease (Corden and Neary, 1982), with an inefficient provision of factors across production units and high production costs (Duranton, 2011).[7] We find that: labor costs are low but dispersed across production units; firms competing for the same local resources as MRPs are not smaller or less numerous than similar industries in control counties (in contrast with Falck et al., 2013); and the accumulation of human capital is not negatively distorted (in contrast with Glaeser, 2005; Polèse, 2009; Franck and Galor, 2017). Third, the boom-and-bust is not driven by the boom-and-bust of State-Owned-Enterprises (SOEs) over the period (Brandt et al., 2016): if anything, SOEs in treated counties appear to be productive and innovative, and our findings are mostly driven by private establishments. Fourth, 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., 2017; Wen, 2019) and MRPs may benefit for instance from favoritism and preferential access to capital (Fang et al., 2018; Harrison et al., 2019). We find little support for such 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. Fifth, we control for the life-cycle of establishments (Mueller, 1972) and for industry- and product-fixed-effects to clean our findings from a rise and fall pattern due to the demographics of production units or the boom and bust of certain production sectors.

The research relates to the literature on agglomeration economies and urban growth (see Duranton and Puga, 2014, for a review). Our contribution is close to Greenstone et al. (2010), looking at the effect of Million-Dollar plants in the United States, 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). The distinct aspect of our study is to document the negative impact of such investments in the longer run. In contrast to most studies, we can also precisely characterize treatment spillovers by observing all dimensions of treatment heterogeneity and micro-data at the establishment level.

Our findings contribute to 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), by identifying the agglomeration spillovers operating in the long run. Numerous contributions analyze the effect of

[7] The analysis of the possible mechanisms through which MRPs may affect other establishments relates to a large literature studying the credit market frictions (Hsieh and Klenow, 2009; Song et al., 2011; Hsieh and Song, 2015; Brandt et al., 2016) and labor market frictions (Brandt et al., 2013; Tombe and Zhu, 2019; Mayneris et al., 2018) in China.

more recent spatial policies on the distribution of economic activity in China, for instance, the Special Economic Zones and industrial parks (Wang, 2013; Crescenzi et al., 2012; Alder et al., 2016; Zheng et al., 2017).

Finally, identifying spillovers from local MRP(s) presents an econometric challenge. With treatment heterogeneity, i.e., with MRPs operating different technologies to produce different products and drawing on different factor markets, a simple difference-in-differences procedure 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 and hypothetically attribute the associated MRP(s) to the control county. This empirical strategy could be useful to contributions analyzing the spillovers of FDI on domestic firms (see, for instance, Head et al., 1995; Aitken and Harrison, 1999; Konings, 2001; Smarzynska Javorcik, 2004; Haskel et al., 2007).

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 background and the "156" program

The "156" program is a unique experiment to study agglomeration effects in the long run. The program constitutes a massive push shock in an otherwise agrarian economy (Lardy, 1987; Rawski, 1979); different types of factories were built thereby allowing us to identify treatment heterogeneity. 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.

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) Although Sino-Soviet cooperation was central in the first years of the People's Republic, it was not based on strong pre-existing economic relations. In 1949, after decades of destruction through the Sino-Japanese and Chinese civil wars, Chinese leaders studied the possibility of international economic cooperation to foster the development of heavy industry and transform China's agrarian economy. For geopolitical and ideological reasons,[8] the Chinese government engaged in economic cooperation with the Soviet Union to give China its own independent industrial system (Dong, 1999; Lüthi, 2010). The possibility of economic cooperation became credible after the Sino-Soviet Treaty of Friendship and Alliance of 1950, which included a large loan. In August 1952, Chinese Premier Zhou Enlai visited Moscow to formalize the involvement of the Soviet Union 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 precipitated a Sino-Soviet split that ended all cooperation between the two countries. The split formally unfolded in 1960 with (i) an abrupt termination of industrial collaboration and (ii) 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 already completed and were operational by 1960. The end of the military alliance also affected later industrial investment in China. Before the Sino-Soviet Split, proximity to military U.S.S.R. air bases would guarantee security against possible aerial attacks from the United States or from the Republic of China relocated in Taiwan. After the Sino-Soviet Split, U.S.S.R. air bases would be considered another threat, thereby explaining the peculiar features of later strategic decisions (e.g., the Third Front Movement).

1.2 The "156" program

This section summarizes the key features of the "156" program; a comprehensive description can be found in Appendix A.2. We also provide a more systematic description of later place-based policies in Appendix A.3, and we derive descriptive statistics about the MRPs in Appendix A.4.

[8]The regime's revolutionary agenda, American support for the Nationalist government in Taiwan in the aftermath of the civil war, the Western embargo (Zhang, 2001) and then the Korean War, in which China directly participated by sending troops, reinforced links between China and the Soviet Union. This policy was called "leaning to one side" (*yi bian dao*) by Chairman Mao in a famous speech ("On the People's Democratic Dictatorship") delivered on June 30, 1949.

An industrial collaboration As part of the First Five-Year Plan (1953–1957), the U.S.S.R. committed 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 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.[9] Second, the collaboration involved the exchange of information, human capital, and technology (as in the Marshall plans, see Giorcelli, 2019). 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). In order to build capabilities, 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 for an agrarian economy (Bo, 1991).[10]

Chinese scholars credit the "156" program with having (i) invested in basic sectors such as the energy and steel industries and laid the foundations for the development of other industries, (ii) boosted production capacity and shifted the technological frontier, and (iii) promoted a more 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 firms and planners put much thought in siting decisions. First, planners selected locations using economic criteria. These suitability 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 smooth the spatial distribution of income.

[9]As a payment, China was to give 140,000 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.

[10]The last 15 projects agreed on in 1954 even benefited from state-of-the-art equipment that few Soviet factories enjoyed (Goncharenko, 2002), allowing China to make the most of Gerschenkron's (1962) "advantage of backwardness" (Tang, 2009).

We will use these criteria to identify a relevant set of suitable counties.

However, 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 the brand-new plants 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 and allied air bases. Major enemy air bases in Japan, South Korea and Taiwan were remnants of the major 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, mostly in the Soviet Union and North Korea, able to intercept them. As explained earlier, the Sino-Soviet split made this location criterion redundant.

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 enjoyed 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.[11] These industrial clusters have diversified their activities, their products ranging from computer screens to carrier-based aircraft.

2 Data and empirical strategy

This section describes data sources, the empirical strategy and provides some descriptive statistics.

[11] 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.

2.1 Data

One requirement for estimating the long-term agglomeration effects of the opening of large plants is to collect local data on economic production, ideally covering 60 years from 1950 to 2015. In this paper, we mobilize the following main data sources: (a) information on the Million-Rouble Plants and their evolution over time, (b) county-level data on population and production (1953–2015), (c) establishment-level data in recent years (1992–2008), linked with patent applications and other product-level information (factor intensities and technological content), and (d) information on entrepreneurship from population census data.

The Million-Rouble Plants In order to define the local treatment induced by the presence of an industrial cluster, we collect information on the geo-coded location of the factories that constitute the "156" program, information on the timing of construction, the initial investment, the original industry, and the evolution of production over time. These pieces of information are extracted primarily from Bo (1991) and Dong and Wu (2004), and 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.[12] 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.[13]

[12] 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://www.chinagazetteer.com/.

[13] 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

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 establishments, as long as their annual sales exceed RMB 5 million, over the period 1992–2008.[14] 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 mark-ups to capture product competition. We first rely on a text analysis based on the description of products in order to associate a unique product code to each establishment and create measures of product concentration (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 mark-ups (see Appendix B.3).

2.2 Empirical strategy

This section describes the two steps of the baseline empirical strategy. We first select counties based on their suitability for hosting a Million-Rouble Plant. We then discuss how we construct a measure of vulnerability to enemy bombings and use it to explain the choice of industry locations among suitable counties.

Propensity score and suitable locations We isolate a group of suitable counties by implementing a propensity-score matching based on the eligibility criteria described in Bo (1991). The first criterion is market access and connectedness to the transportation network. In the baseline matching procedure, we rely on an in-

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.

[14]These data cover and contain a wealth of 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. Unique establishment identifiers can be retrieved thanks to the algorithm designed by Brandt et al. (2014) and extended in Imbert et al. (2020), thereby allowing us to construct a panel of firms spanning the period 1992–2008.

dicator variable that equals 1 if a county belongs to the provincial capital,[15] county population at baseline (measured by the 1953 Census) and county area to capture the former. We construct a measure of proximity to a railroad hub, using the existing railroad network in 1948, to model connectedness. 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.[16]

We regress the treatment, i.e., being in the close neighborhood of one of the MRPs (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"

[15]We consider a county as part of the provincial capital if it belongs to the prefecture in which the provincial capital was located at the time of the First Five-Year Plan.

[16]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. It is also worth noting that siting decisions were certainly informed by little more, and perhaps much less, than our GIS measures. The lack of a well-functioning statistical administration, which explains the delay in devising the First Five-Year Plan (1953–1957), put severe constraints on policy making in the early years of the People's Republic of China. Finally, in the current strategy, few county characteristics are targeted thus leaving many variables available for a balance test. By contrast, more variables could be used to refine the initial matching, thereby leaving few characteristics to compare across treatment and control groups in an "over-identification" check. We will show that our findings are not sensitive to small variations around the baseline matching procedure.

crescent, treated counties are however less likely to be located in Central China.

Vulnerability To isolate exogenous variation in the decision to select counties, we construct measures of vulnerability to airstrikes from U.S. and Taiwanese air bases, accounting for the presence of allied bases acting as a shield.

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). To account for the presence of allied air bases, we penalize travel time for enemy bombers in 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 jet fighters at that time, most notably their range, and produces a continuous measure of the cost for enemy airplanes of traveling through any given point of the Chinese territory. We compute the minimum travel cost from each active U.S.A.F. or Taiwanese base to each county and define the measure of vulnerability V_c as the minimum of penalized distances across all enemy bases.

We illustrate the spatial variation in vulnerability to aerial attacks in Figure 2: Panel (a) shows vulnerability in 1953, i.e., before the Sino-Soviet split, and Panel (b) shows vulnerability after the split, in 1964. Military concerns should favor the Northeast at the expense of Central China in 1953; the set of suitable and protected locations however became much smaller after 1960, and investment during the Third Front had to be targeted toward interior provinces. The paths of surveillance flights between 1963 and 1965 (Panel d) provides a rationale for the decision to shield the MRPs and the later Third Front factories: U.S. reconnaissance aircraft were targeting some of these factories and the "Second Front" was not protected anymore after the Sino-Soviet split. Our empirical strategy uses the pre-split measure as an instrument for factory location decisions, conditioning for the post-split measure, thereby leveraging the ephemeral alliance between China and the U.S.S.R. as the main source of identification.

First stage Figure 3 provides a representation of the relationship between the unconditional and the conditional proximity to U.S. and Taiwanese airbases and factory location choices. Although we find both treated and control counties at most levels of vulnerability, 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.

The relationship between the treatment and vulnerability measure constitutes the first stage of our empirical specification. Table 1 shows that vulnerability to enemy bombings is a crucial factor in the location choice. One additional standard deviation in penalized distance from enemy bases increases the propensity to host a Million-Rouble plant by about 26 percentage points among suitable counties. The average difference in vulnerability 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. 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.

Importantly, while there is a strong relationship between our treatment (i.e., a place-based policy between 1953–1958) and the vulnerability to aerial attacks in 1953, the treatment is not correlated with vulnerability measures as computed 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 hosts a factory. 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 T_c is instrumented by 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 the following 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 the same vulnerability to enemy raids, but 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 by controlling for later spatial policies and large shocks (e.g., Third Front Movement, Cultural Revolution, Special Economic Zones, industrial parks etc.). Second, vulnerability may correlate with unobserved county amenities, which would explain both the decision to locate factories and be correlated with later patterns of economic growth. We control for elevation, ruggedness, indicators of soil quality, and expected crop yield in robustness checks. Third, vulnerability may correlate with the 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.[17] Such a violation of the exclusion restriction would induce a spurious negative correlation between economic growth and the presence of "156"-program industries in the reform period. 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 Million-Rouble Plants 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).[18] 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 100,000,000 yuan, which amounted to 15,000,000 Soviet roubles in 1957 ($120,000,000 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

[17]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.

[18]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.

counties as suitable control counties in our baseline specification. As expected from a context of heightened international tensions in Asia following the Korean War, treated counties are located at a much greater distance from U.S.A.F. and Taiwanese bases. The difference in mean penalized distance between treated places and the average Chinese county 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 describes 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 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. We thus include these variables as controls in the baseline specification.

3 The rise-and-fall pattern

This section presents the implications of early industrialization in 1982 and in 2010.

3.1 Baseline results

The influence of the Million-Rouble plants on local trajectories spans two different periods: the rise in the command-economy and the fall during the reform period.[19]

The rise We first describe empirical facts about the local treatment effect of industrial clusters in 1982; the analysis and the choice of outcomes are unfortunately

[19] Note that 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.

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 22% 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 35 percentage points higher (column 2, Panel B). The impact of the MRPs 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; the employment share in industry is 24 percentage points higher. The magnitude of these differences is far beyond the mere output of the average MRP, indicating that counties are richer and more developed—the 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 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 extent of the short-run impact 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.[20] Changes in labor allocation mostly reflect government intervention, which is likely to 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

[20]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.

even further apart from the rest of the economy. As we see next, we find the opposite.

The fall There is 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 significantly 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 similar or even 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 equally 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 in employment in the Million-Rouble plants themselves; the MRPs remain very large and extremely productive.[21] Second, their influence on aggregate productivity is non-negligible: the previous results indicate that other production units must be quite unproductive.[22] Before turning to the mechanisms underlying this stylized fact, 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 1950–1960 may however coincidentally correlate with other geographic determinants of later economic growth. This section provides a comprehensive sensitivity analysis to reduce concerns that the rise and the fall are related to other factors than the allocation of MRPs itself. We summarize these robustness checks below and leave a detailed discussion of the results along with additional Figures and Tables to 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 and over time: (i) the spatial distribution of market access (including exports), access to resources, land supply; and (ii) later spatial policies (e.g., Special Economic Zones, industrial parks).

[21] 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).

[22] 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 first condition the baseline specification on measures capturing an environment that is (un)favorable to economic take-off (e.g., connectedness in 2010, trade routes, natural amenities, elevation, access to ports, distance to the coast, 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 which could reduce the gap between treated and control counties (e.g., Third Front Movement, Special Economic Zones, or industrial parks), for factors underlying these later decisions (e.g., vulnerability to U.S.S.R. strikes), and for other large policy shocks driving the economic evolution of China (e.g., the Cultural Revolution).

We also consider variations in our matching procedure and the use of matching weights. We extend the set of variables used for matching by adding proximity to Ming 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 (log), and county area (log). We further restrict the choice of control counties by considering a one-to-one matching procedure without replacement, and by enlarging the exclusion zone around treated counties. We also provide a sensitivity analysis around the construction of the vulnerability instrument and around the treatment of spatial auto-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. We also provide some insight on the dynamics from 1990 onward showing that there is a gradual decrease in economic activity in treated counties.

3.3 The (dramatic) fall of *other* establishments

Treated counties experience a swift reversion to the mean in aggregate output. The dynamics of the local economy is however strongly driven by the dynamics of MRPs themselves, and these MRPs experience, for instance, an *increase* in patenting activity in the recent period. We now rely on micro-data 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).[23]

In Table 5, we extend Specification (1) at the establishment-level, consider all establishment × year observations between 1992 and 2008, and regress a measure of production on the treatment T_c, instrumented by V_c. We clean for year interacted with 4-digit industry fixed effects and for year interacted with firm type: our results are orthogonal to aggregate industrial trends and to the demise of public establishments. We also 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 (Table 5, column 3). These findings point to a downward shift in labor supply in treated counties compared to control counties.

Total factor productivity is 30% lower in treated counties than in control counties (Table 5, column 4).[24] This finding 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. 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 of Table 5. We find that establishments in treated counties produce fewer patents. The treatment effect is of the order of magnitude of the yearly number of patents produced in the average establishment: very few patents are registered in treated counties.[25] Finally, as shown in column 6 of Table 5, the TFP effect cannot be explained by markups; they are on average higher in treated counties: the probability for a firm to charge a markup above median in a given year and 4-digit industry is 13 percentage points higher in treated counties.

The previous results cannot be attributed to compositional differences induced by the presence of public enterprises, subsidized establishments (Harrison et al., 2019), or young firms. Indeed, (i) controlling for the exact type of an establishment

[23] 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 in Appendix D.3.

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

[25] Controlling for the local industry structure 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.

(ownership structure) does not change the main insight conveyed by Table 5. (ii) 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.[26]

4 Mechanisms behind the fall of treated counties

This section analyzes the possible spillovers exerted by MRP(s) on the local structure of production and on the supply of entrepreneurs. In a first step, we study the treatment effect on the structure of production and product concentration at the county level. This exercise explores various aspects of the tangle of economic relationships across establishments and shows that product concentration along the production chain of MRPs is the marking feature of treated counties. In a second step, we discuss other possible externalities than through the markets for input and output, e.g., a form of Dutch disease affecting production costs or political favoritism. In a third step, we investigate the effect of hosting a MRP on the local supply of entrepreneurs.

4.1 Product concentration and over-specialization

This section proceeds as follows. We first 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 then focus on individual linkages between establishments to better understand the concentration *around the MRP(s)* and the characteristics of linked establishments.

Product concentration at the county level 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:

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

[26] 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.

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).[27]

Figure 4 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 from 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.

[27] 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.6.

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 product 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 a measure of technological closeness based on the intensity of patent citations across different industries. We define a dummy, *Tech. clos.*, as being equal to 1 if technological closeness is higher than the 95%-quantile across all establishments. We finally define 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 revealed factor intensities at the HS6-level). 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 establishments whose needs for this production factor are more pressing.

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.[28] We find that the treatment increases the probability for an

[28] As the estimation procedure relies on multiple draws, we report here the average effect and

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 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

the average standard error over 100 simulations. Correct inference would require 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 $\times$ 4-degree cells.

their counterparts in control counties. The same general patterns can be observed for establishments in the same product market (Panel B).[29]

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.[30] This technological 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? We capture this possible channel in the last section, in which we look at potential entrants and indirectly analyze the decision to set up a production establishment across sectors. Before doing so, we discuss alternative mechanisms through which the MRPs may affect the local business environment.

4.2 Alternative mechanisms

The previous section presents findings that are consistent with negative spillovers along the production chain, thereby operating through the markets for input and output. This section briefly describes alternative mechanisms suggested by the literature and refers to some evidence supporting or rejecting these interpretations. We provide a summary of the discussion below and leave the more detailed presentation of these tests to Appendix D.3 (production costs and allocation of resources), Appendix D.4 (compositional effects), and Appendix D.5 (entrepreneurial values).

[29] 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.

[30] 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 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 or suppliers.

Dutch disease and misallocation of factors The presence of a large factory may distort the allocation of resources and factors 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). 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; (ii) access to capital and public subsidies do not seem particularly difficult for the average (other) establishment; (iii) 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.5). 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.

Communist spirit and public sector The presence of a large (initially public) factory may affect the involvement of the state in other, linked establishments. The boom and the bust of treated counties could then reflect the boom and the 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, (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.

The influence of the factory may however 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 which could 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 about entrepreneurial values and fairness (Appendix D.5). 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.

Life-cycle of establishments and obsolete sectors Our findings might not be driven by direct negative spillovers, but by the boom and the bust of the MRPs themselves, or the life-cycle of linked (old) 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 than other establishments over 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).

4.3 Entrepreneurial supply

This section documents a shift in entrepreneurial supply. More specifically, we identify a relocation of entrepreneurs through the creation of firms by emigrants originating from treated and control counties.

We rely on the 1% Population Survey of 2005, often referred to as the "2005 Mini-Census," to compare the profiles of emigrants from treated and control counties. Key variables available in the Mini-Census include the level of education, the employment status (with a distinction between self-employed and employers), income, and place of registration at the county level.[31] We use specification (1) and regress the average emigrant characteristic Y_c at the county level on T_c (where c denote the county of hukou registration—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 (normalized by the share of the population with a tertiary degree) is 77% of a standard deviation higher in treated than control counties. Migrants from

[31] 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—see Shi et al. (2018) for a description. They 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.

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 also 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 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.

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, and identifies the externalities supporting this effect using granular data on production units.

The paper relies on a unique experiment (the "156" program), in which large factories were (quasi-)randomly allocated across suitable counties in China, and it follows the evolution of these locations in the long run. While the "156" program was effective in spurring transformation from agriculture to manufacturing and in raising living standards, this head start failed to generate 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 productivity gains observed in 1980–1990 fully vanished between 1990–2015, bringing treated and control counties closer over time. This reversal of fortune occurred even though the Million-Rouble plants created under the program are still productive, innovative, and very dynamic. Treated areas did not merely revert to the path followed by other places in the absence of the "156" program; the (other) production units in control counties are less productive, competitive, and innovative than in treated counties. We find that the structure of production is far too concentrated along the production chain of the 156 Million-Rouble Plants, 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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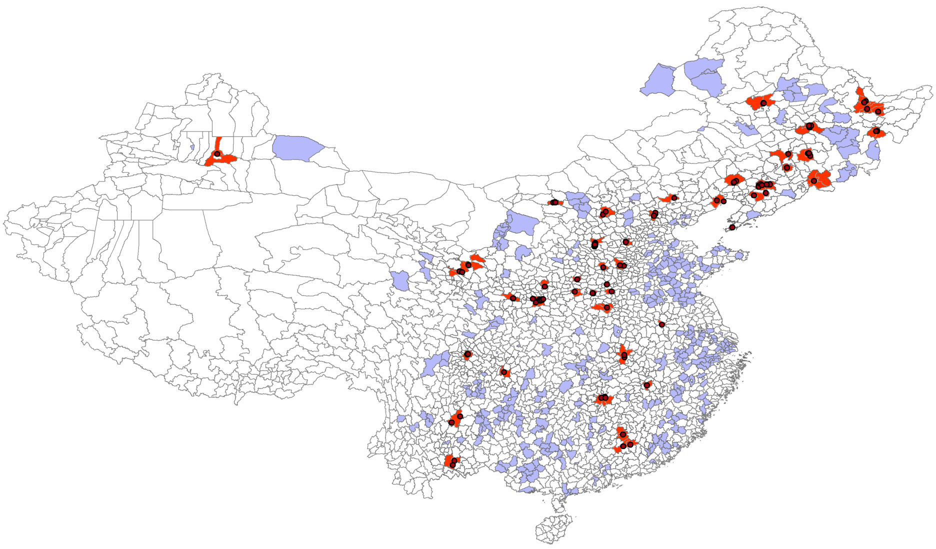
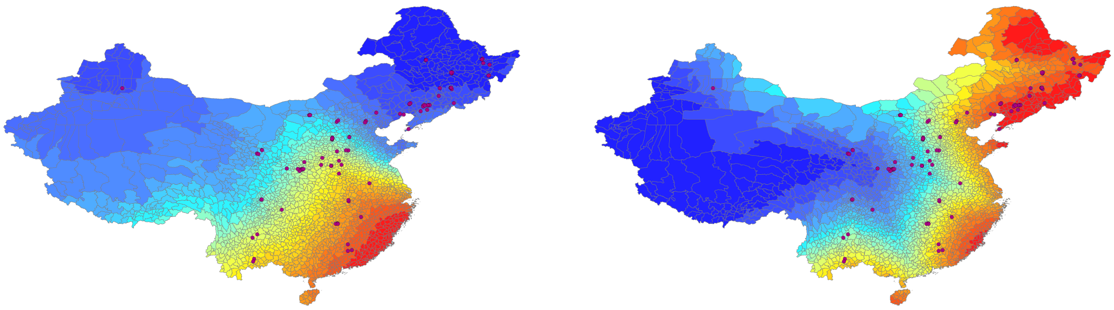
A Figures and tables

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

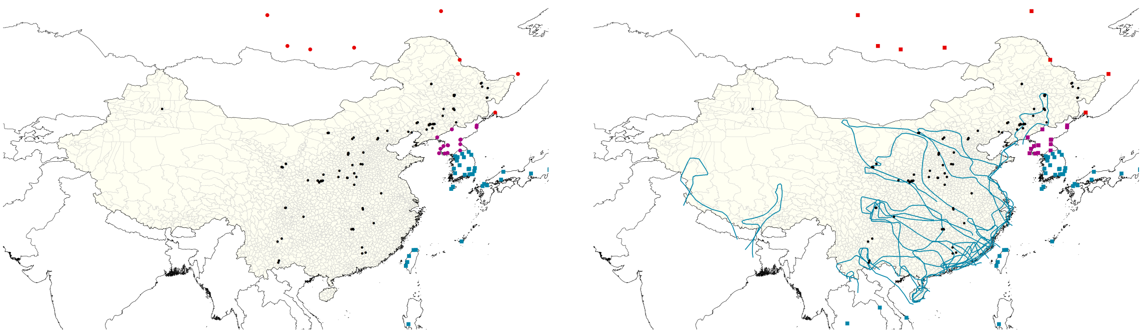


Notes: This map show counties that host at least one "156"-program factory (red) and the control group of counties (blue). The control group is selected through the matching procedure described in Section 2.

Figure 2. Vulnerability map.



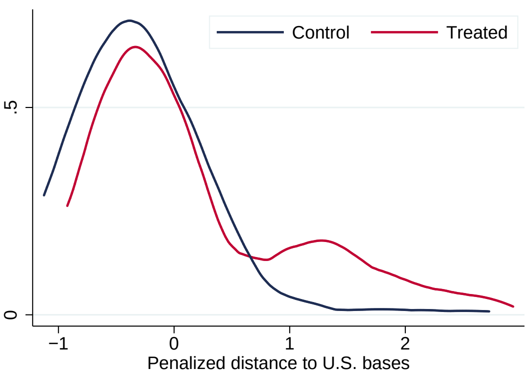
(a) Vunerability (pre-1960 split) (b) Vunerability (post-1960 split)



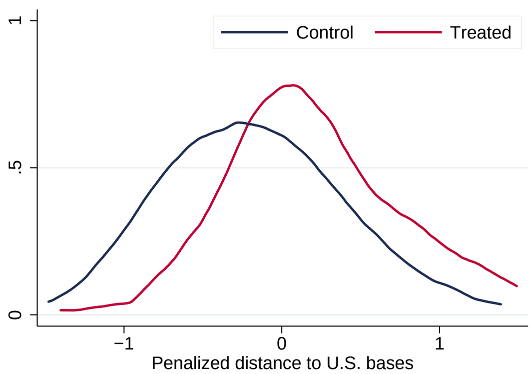
(c) Bases (pre-1960 split) (d) Surveillance flights (post-1960 split)

Notes: This map shows the variation used for identification. Panels (a) and (b), resp., represent the penalized travel time from enemy airfields (red: low travel time, blue: high travel time) before 1960 and after 1960 (1964). The color gradient in Panels (a) and (b) corresponds to deciles of the distribution of penalized travel time. Panel (c) displays 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). Panel (c) 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; 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

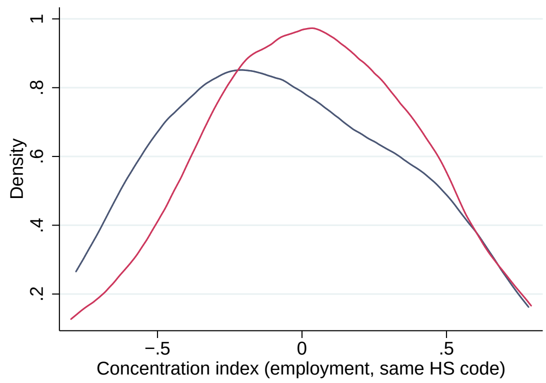


(b) Conditional

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. Product concentration and TFP in treated and control counties.

(a) Concentration (HS) and TFP

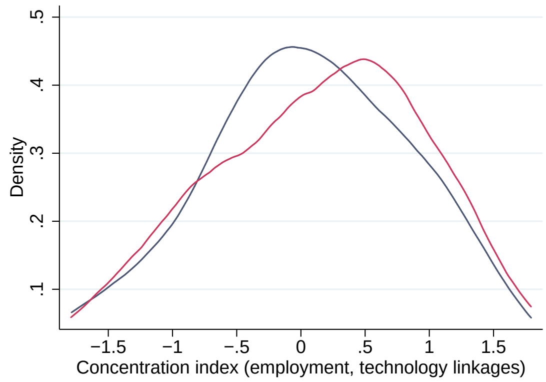


(b) Concentration (HS) in treated/control

(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 from 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	0.143	0.148	0.261
	(0.039)	(0.039)	(0.044)
Observations	430	430	430
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 (Administrative level 3). *Penalized distance* is the normalized distance to the main 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.

Sector	Number	Construction		Investment	
		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. The average planned investment by factory was about 100,000,000 yuan, which amounts to 15,000,000 Soviet roubles in 1957 ($120,000,000 in 2010 U.S. dollars). Note that some projects were not completed in 1960, and thus abandoned. Some planned projects had not yet been awarded a definitive location, which prevents us from using them as a control group.

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)	.139	.130	.291	.097
	(.046)	(.022)	(.070)	(.017)
	[430]	[430]	[430]	[430]
Treatment effect (2010)	.144	.125	-.104	.023
	(.063)	(.019)	(.079)	(.013)
	[430]	[430]	[335]	[430]
Panel B: IV specification				
Treatment effect (1982)	.216	.349	.850	.237
	(.103)	(.060)	(.190)	(.039)
	[430]	[430]	[430]	[430]
	34.52	*34.52*	*34.52*	*34.52*
Treatment effect (2010)	.253	.336	.074	-.129
	(.129)	(.043)	(.218)	(.052)
	[430]	[430]	[335]	[430]
	34.52	*34.52*	*31.22*	*34.52*

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 (average treatment effect).

VARIABLES	Labor (1)	Capital (2)	Wage (3)	TFP (4)	Patents (5)	Markup (6)
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 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.

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.

	University degree	Manager position	Self-employed	Top income
Treatment	.772	.333	1.286	.695
	(.353)	(.230)	(.328)	(.375)
Observations	430	430	430	430
F-stat. (first stage)	34.52	34.52	34.52	34.52

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, normalized by the share of the population (according to the 2000 population census) with characteristic Y. All dependent variables are standardized. *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 (this variable is normalized by the share of employed at origin in 2000, as the 2000 census does not distinguish employment types). *Top income* is the share of emigrants with incomes in the top quintile of the income distribution in their counties of registration. All outcomes correspond to the emigrant's situation at destination.

ONLINE APPENDIX—not for publication

A The "156" program

In this section, we provide additional information about the "156" program. First, we summarize the historical context and geopolitical background. Second, we present the Sino-Soviet cooperation during the First Five-Year Plan, 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 context, Chinese leaders planned to industrialize the economy rapidly, prioritizing heavy industry as the basis of production.[32] 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. 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" (June 30, 1949), 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).

The cooperation between Communist China and the Soviet Union assumed two main aspects: scientific and economic, both embodied in the "156" program. Soviet

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

experts would be dispatched to China to advise Chinese planners. 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 the most crucial for the "156" program. They were responsible for the design and construction of the plants, and they also 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).[33] Blueprints and technical documents for production were shared with Chinese engineers free of charge,[34] 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.[35]

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

[33] 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).

[34] 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).

[35] The U.S.S.R. provided between 50% and 70% of the total value of the equipments necessary to build the plants (Dong, 1999). The remainder could be produced locally and was thus not covered by Soviet cooperation (Chinese Academy of Social Sciences and State Archives Administration, 1998).

A.2 The "156" program

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.[36] 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 that China lacked the skills and wherewithal to develop. Military-related industries made up a fifth of the plants, reflecting geopolitical concerns in the 1950s.

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 130,000,000 yuan or 19,500,000 Soviet roubles in 1957, which is the equivalent of $156,000,000 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 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

[36] 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].

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,[37] although he also advised the Chinese to build *new* plants, in

[37] "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).[38] 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[39] 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.[40] 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.

[38] 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.

[39] 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.

[40] 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 should be restricted to strategic military industries, remain exceptional and not be carried out on a large scale.[41] "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 D4, 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 province from Fan and Zou (2019). Table D4, 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.[42]

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,

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

[42] 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 first follow Walder (2014) and code missing values as 0 even if the narrative does refer to casualties but without stating a figure. Alternatively, we replace missing values by (i) the provincial average, (ii) the maximum in the province and (iii) the minimum in the province. Appendix Table D4, Panel F, uses the casualty data to condition for Cultural Revolution violence, distinguishing between "deaths" and "victims." 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 D4). About a third of the "156" plants evolved into large, diversified industrial groups (*jituan*). One such *jituan* is 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

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 D4 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. 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.[43]

Table A1. Share of the "156" factories 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.[44] 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.[45] 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

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

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

[45]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 (1)	Compens. (2)	VA per worker (3)	MPL (4)	MPK (5)	TFP (6)	Public (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×year.

B Data description

In this section, we describe the construction of measures of factor productivity at the establishment level, identified using industry-specific CES production functions and an exogenous labor supply shifter (Imbert et al., 2020), patents linked to establishments (He et al., 2018), and markups De Loecker and Warzynski (2012).

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

Data description [update]

Product codes [update]

Measures of concentration [update]

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—at the sector level—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:[46]

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

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:

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

B.3 Registered patents and mark-ups

Patent applications The measures of patenting used in Section 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

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

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

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 certain 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,

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

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) the parameter A enters as a multiplicative term, (ii) 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.

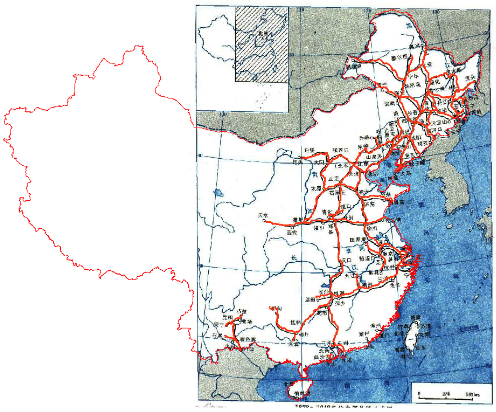
This procedure allows us to estimate the output elasticity to variable input i, which we transform into a markup by combining it with an estimate $\hat{\alpha}$ for the expenditure share α. This last correction replaces the output by the predicted output thereby cleaning for measurement error in the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

C Complements to the empirical strategy

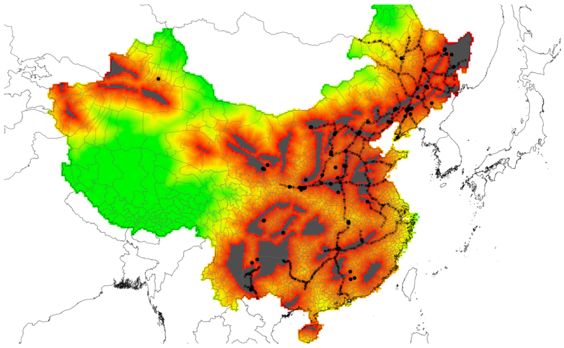
C.1 Matching procedure and complements to the baseline strategy

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$^{\text{th}}$ 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

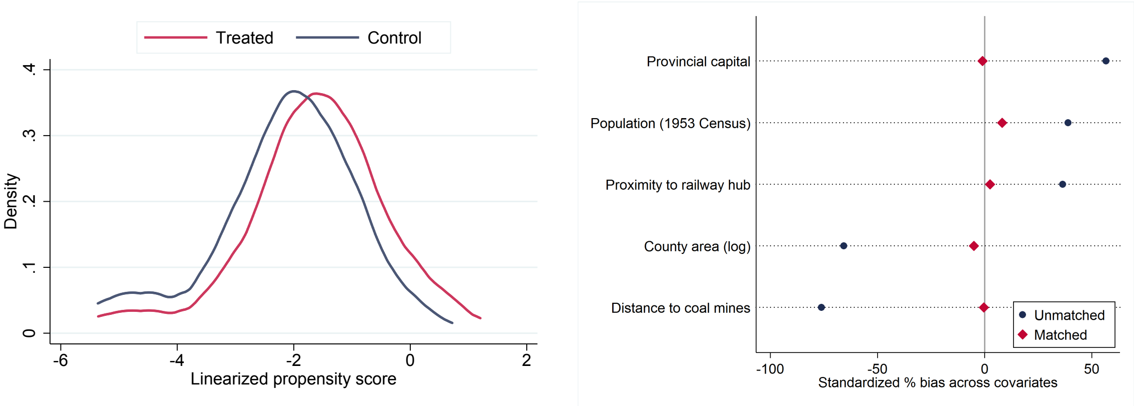
Figure C1.

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.

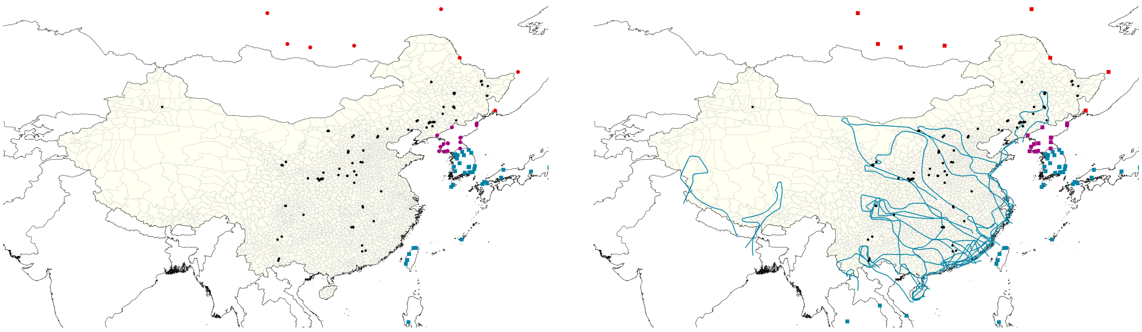
C.2 Vulnerability to air strikes

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 airflights, 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.

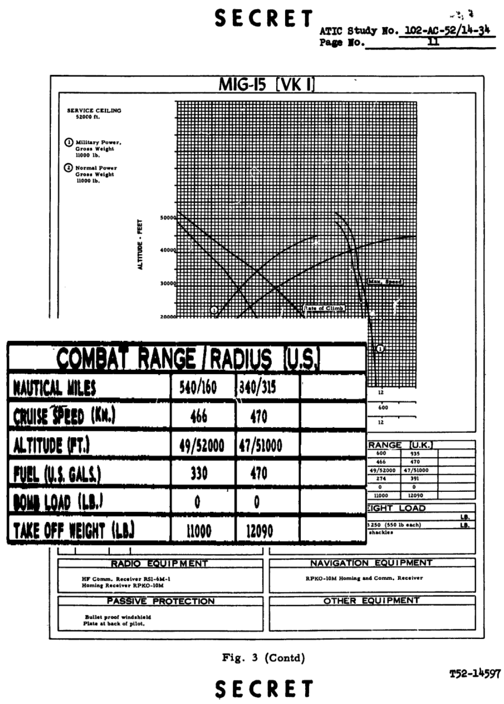
American bombers in the 1950s, like the B-52s, could technically reach any point in China without refueling. However, bombers could be neutralized by interceptors, stationed in allied airbases. Declassified CIA documents such as the one reproduced in Appendix Figure C4 provide us with information on 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

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



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

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 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.[47] 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:

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

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.

[47]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.

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 independent 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 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.

D.1 Identification and exclusion restriction [update]

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

Treatment	(1)	(2)
Penalized distance (1964)	0.131	
	(0.137)	
Penalized distance (1972)		-0.076
		(0.081)
Observations	430	430
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).

First stage [update]

Matching [update] We start by analyzing variation along the baseline specification (Appendix Table D3). In Panel A, 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 B to E, we revert to the IV specification on the sample of counties selected through a matching procedure. In Panel B, we add proximity to Ming stations, distance to military airfields and access to the main trading ports to the matching process. In Panel C, 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 D, we use

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

Treatment	Third-Front (1)	City park (2)
Penalized distance	0.057	0.013
	(0.031)	(0.064)
Observations	430	430
Propensity bins	Yes	Yes
Extended controls	Yes	Yes

Notes: Standard errors are clustered at level of 4-degree $\times$ 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.

a one-to-one matching procedure without replacement between treated and control counties. Finally, Panel E 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.

In the baseline specification, observations are weighted by matching weights accounting for the extent to which the distribution of propensity scores coincides between treated and control counties. Panel F of Appendix Table D3 provides the main estimates without any weights; they are similar to the baseline estimates.

Exclusion restriction [update] Table with current connectedness, trade, amenities and MRP type, Table with abandoned projects.

We then provide a sensitivity analysis designed to support the exclusion restriction hypothesis (Appendix Table D4). 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 provide a robustness check in Panel A of Appendix Table D4 by excluding treated counties with either a closed or displaced MRP.

The rise and fall of treated counties may reflect a very abrupt take-off in control counties, for instance related to general patterns of development in Southeast

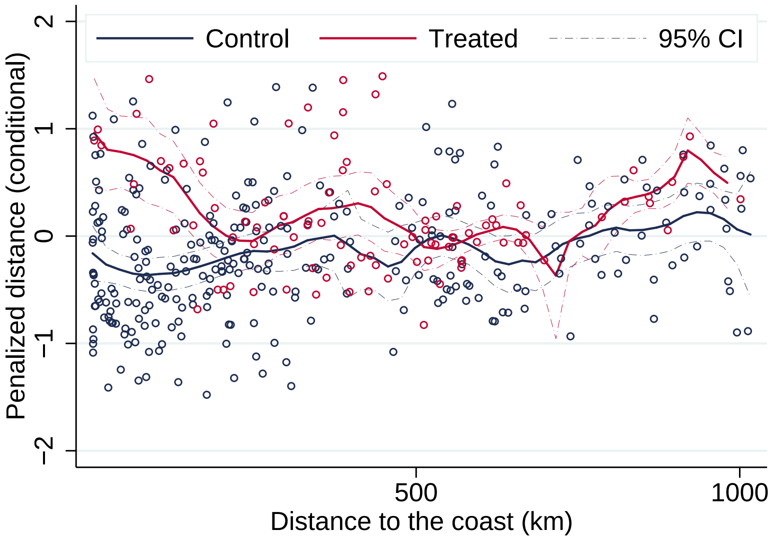
Table D3. Sensitivity to the empirical specification (matching and weights).

VARIABLES	Population (1982)	GDP p.c. (1982)	Population (2010)	GDP p.c. (2010)
Panel A: Local identification				
Treatment effect	.142	.427	.242	-.016
	(.046)	(.085)	(.065)	(.093)
	[2,321]	[2,321]	[2,321]	[2,029]
Panel B: Matching with extended variables				
Treatment effect	.067	.793	.183	-.282
	(.107)	(.202)	(.084)	(.193)
	[407]	[407]	[407]	[312]
Panel C: Matching with fewer variables				
Treatment effect	.137	.753	.113	.066
	(.113)	(.229)	(.107)	(.373)
	[426]	[426]	[426]	[327]
Panel D: One-to-one matching				
Treatment effect	.223	.764	.288	.002
	(.098)	(.205)	(.134)	(.186)
	[222]	[222]	[222]	[158]
Panel E: Matching with larger exclusion zone				
Treatment effect	.114	.641	.197	-.305
	(.083)	(.267)	(.143)	(.196)
	[236]	[236]	[236]	[173]
Panel F: No weights				
Treatment effect	.249	.906	.230	-.013
	(.106)	(.185)	(.135)	(.272)
	[430]	[430]	[430]	[335]

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.

China. We thus exclude a large buffer of (mostly control) counties within a 500-km buffer around the Pearl river delta (Panel B), and we exclude all counties below the 28-degree latitude (Panel C). These robustness checks show that our findings

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.

are not driven by the 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. We further investigate the role of geographic characteristics in Panels D to G. We add to Specification (1) the following variables: distance to the coast (Panel D, to capture a comparative advantage in an exporting economy), elevation, ruggedness, indicators of soil quality—lacustrine plains, sand hills, tidal marshes,—and expected yield—rice, maize, wheat—(Panel E). The geographic conditions do not explain the main empirical fact.

The relative fall of treated counties may be due to the implementation of the Third Front Movement (Fan and Zou, 2019) or other place-based policies in control counties (Special Economic Zones or industrial park policies, as in Wang, 2013; Crescenzi et al., 2012; Alder et al., 2016; Zheng et al., 2017), or severe disruption due to pre-transition policy shocks in treatment counties, e.g., during the Cultural Revolution. We control for such policies and events in Panel F. Beyond these emblematic spatial 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. Neither alternative policies nor alternative measures of vulnerability affect our estimates.

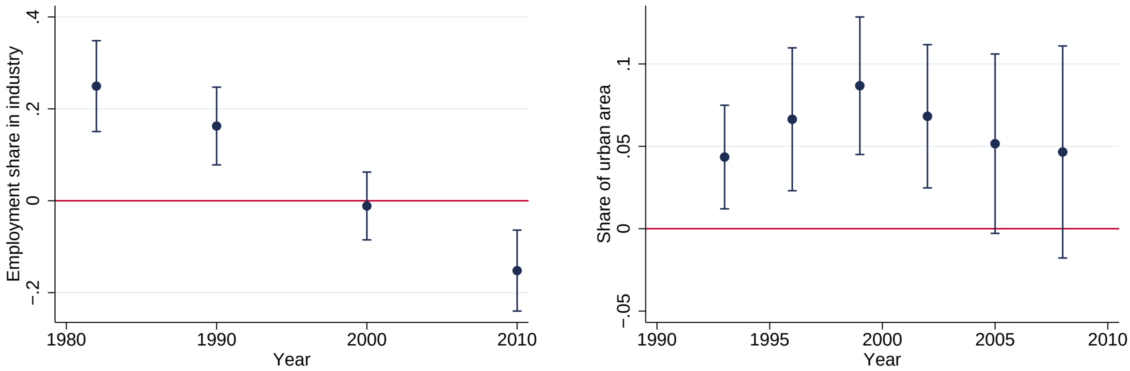
Table D4. Sensitivity to the empirical specification (exclusion restriction).

VARIABLES	Population (1982)	GDP p.c. (1982)	Population (2010)	GDP p.c. (2010)
Panel A: Excluding closed and displaced factories				
Treatment effect	.178	.747	.142	-.244
	(.106)	(.192)	(.124)	(.213)
	[417]	[417]	[417]	[332]
Panel B: Excluding a buffer around the Pearl river delta				
Treatment effect	.358	1.26	.644	.081
	(.194)	(.360)	(.271)	(.196)
	[391]	[391]	[391]	[302]
Panel C: Excluding the South of China				
Treatment effect	.137	.753	.113	-.120
	(.113)	(.229)	(.107)	(.308)
	[316]	[316]	[316]	[236]
Panel D: Controls for distance to the coast				
Treatment effect	.191	.770	.195	.232
	(.135)	(.259)	(.177)	(.270)
	[430]	[430]	[430]	[335]
Panel E: Controls for unfavorable environment (elevation etc.)				
Treatment effect	.247	.591	.202	-.265
	(.140)	(.198)	(.162)	(.165)
	[353]	[353]	[353]	[282]
Panel F: Controls for other policies (Third Front, SEZs etc.)				
Treatment effect	.127	.908	.152	.154
	(.100)	(.220)	(.123)	(.214)
	[430]	[430]	[430]	[335]
Panel G: Controls for vulnerability to U.S.S.R. strikes (1972)				
Treatment effect	.598	.890	.685	-1.22
	(.211)	(.317)	(.253)	(.404)
	[430]	[430]	[430]	[335]

Notes: Each cell is the outcome of a separate regression. Standard errors are clustered at level of 4-degree $\times$ 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.

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]

Additional outcomes We consider alternative outcome measures in Appendix Table D5. In Panel A, 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 B, 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).

Panel C of Appendix Table D5 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 night-time luminosity between 1993 and 2012 ("Average Visible, Stable Lights, & Cloud Free Coverages") as a complement for census-based measures. Our findings 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).

Finally, we analyze the role of government expenditures and revenues in Panel D of Appendix Table D5. 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. This 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.3 Detailed treatment effects on the structure of production

Structure of production We report in Table D6 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 D6, 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 D6 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., 2017;

Table D5. 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.

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 $\times$ 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

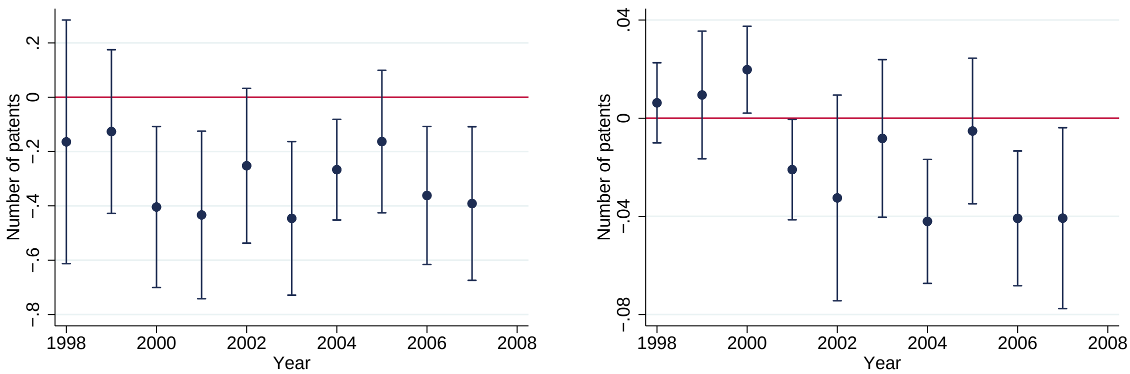
Table D6. Structure of firm production (average treatment effect).

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.

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.

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).

Entry, exit and dispersion Factor cost and factor productivity appear to be low in treated counties, but dispersed. In Panel A of Appendix Table D7, we calculate 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 D7, column 1). In columns 2, 3 and 4 of Appendix Table D7, 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 D7, we show that there is a higher concentration of production in large establishments of treated counties. In Panel C of Appendix Table D7, 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).

Table D7. 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.

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 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 $\times$ 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 D8).

Table D8. 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 $\times$ 4-degree cells. The unit of observation is a firm $\times$ year. We exclude the MRPs from the sample. All specifications include the baseline controls (Table 4), 4-digit industry $\times$ year fixed effects and firm type $\times$ 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 $\times$ 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 D9). Establishments in the same product market as MRPs are however much older and much more likey to be publicly-owned (Panel B, Appendix Table D9).

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.

Table D9. 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.

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 D10).

Using these strategies, we provide below a comprehensive analysis of compositional effects, i.e., 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.

D.5 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.[48] CFPS contains modules on aspirations and world outlook, in particular on effort and individualism, along with socioeconomic data.

[48]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.

Table D10. 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

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.[49] We investigate this possible effect using the China Family Panel Survey (CFPS) and its module on values and aspirations. Table D11 presents the estimates of specification (1), at the individual level and controlling for respondent and household characteristics.[50]

[49] 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.

[50] 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

In Panel A of Table D11, 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 D11. 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.

D.6 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)

12–15.

Table D11. 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 × 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.

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.