Manufacturing Underdevelopment: India's Freight Equalization Scheme, and the Long-run Effects of Distortions on the Geography of Production

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Abstract

India's Freight Equalization Scheme (FES) aimed to promote even industrial development by subsidizing long-distance transport of key inputs such as iron and steel. Many observers speculate that FES actually exacerbated inequality by allowing rich manufacturing centers on the coast to cheaply source raw materials from poor eastern regions. We exploit state-by-industry variation in the effects of FES on input costs, in order to show how it affected the geography of production. We find, first, that over the long-run FES contributed to the decline of industry in eastern India, pushing iron and steel using industries toward more prosperous states. This effect sinks in gradually, however, with the time needed to construct new plants serving as a friction to industry relocation. Finally, we test for the stickiness of these effects, by studying the repeal of FES. Contrary to popular opinions of the policy and to agglomeration-based reasons for hypothesizing stickiness, we find that the effects of repealing FES are equal and opposite to those of its implementation. Still, due to changing locations of the processing of basic iron and steel materials, the resource-rich states suffering under FES never fully recover.

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1 Introduction

A common goal of industrial policy is to promote balanced economic development, both across sectors and across regions. India's Second Five Year Plan in 1956 made this goal explicit: "Only by securing a balanced and co-ordinated development of the industrial and the agricultural economy in each region, can the entire country attain higher standards of living". Balanced development might prove difficult to attain, however, if some regions are inherently more productive than others. Even if balanced development is feasible, it might prove undesirable, if concentrating economic activity leads to gains from specialization or agglomeration externalities. Indeed, policies such as special economic zones and subsidies for industrial centers aim at precisely the opposite of India's goal: concentration rather than balance.

This paper provides empirical evidence on the effects of policies aimed altering the geographic distribution of industry. We focus, in particular, on India's Freight Equalization Scheme (FES), which was in force from 1956 to 1991 and subsidized the long-distance transport of certain key manufacturing inputs, such as iron, steel, fertilizers, and cement. While FES aimed to promote "the dispersal of industries all over the country" (Ministry of Commerce and Industry, 1957), evidence on its effects is mixed.

First, was FES effective in altering patterns of geographic development over the long term? A 1977 government report claimed that the size of the freight equalization subsidies amounted to only a small proportion of firms' final output prices, and therefore could not have affected the geography of production (Government of India Planning Commission, 1977). Evidence from Garred et al. (2015) on the implementation of FES is consistent with this claim, showing that in the initial years of FES, it had little effect on the location of industry.

Politicians from eastern India, on the other hand, claim that the FES subsidies were devastating to industry in their home states (Ghosh and Das Gupta, 2009; Krishna, 2017). Even though the subsidies were small, they provided just enough incentive for certain industries to move production away from the resource-rich eastern states and to expand production in prosperous western states such as Maharashtra, Gujarat, and Punjab. These politicians' gripe becomes all the more plausible in light of the Hirschman (1958) notion of backward and forward linkages: Once certain industries move from eastern to western India, it becomes more attractive for their upstream and downstream neighbors to locate there, driving agglomeration and disproportionate economic growth in the west. Over the past half-century, the western (and southern) states benefiting from FES have enjoyed India's highest rates of manufacturing growth, while the resource-rich eastern states have fallen from being manufacturing powerhouses in the 1950s and 1960s to being among India's poorest states today.

We find evidence consistent with these claims: FES achieved exactly the opposite of its purported goal, exacerbating inequality between western India and the resource-rich east. Specifically, we show that FES led industries using the equalized iron and steel to move farther from the bases of raw materials production in eastern India. The empirical strategy relies on a triple-difference, studying how output in a state-industry is affected by the state's distance from the sources of iron and steel, interacted with the intensity of iron and steel use in the industry's production. We also show that input linkages magnify these effects, with eastward relocation occurring not only for the direct users of the equalized materials, but also for their downstream neighbors and for industries with higher Leontief input shares of these materials.

While these results point to long-term effects of FES, they leave open questions about the dynamics following its implementation: How long does it take for the location of industry to reach its steady state under FES, and what happens along the transition path? A burgeoning literature highlights the importance of transitional dynamics in studying the effects of trade liberalizations and other changes in mobility frictions (Dix-Carneiro, 2014; Caliendo, Dvorkin and Parro, 2017). As Dix-Carneiro and Kovak (2017) show, the impact of Brazilian tariff cuts on regional earnings 20 years after liberalization was more than three times the effect 10 years after liberalization. Our results show that the transition under FES was gradual. Even though the policy had little effect over its first 10 to 15 years, it led to steady movements of iron and steel using industries out of eastern India, and significant overall effects by the time FES reached its culmination in 1990. Tracing the transition paths shows that these movements tightly coincide with movements in the locations of factories. Evidence suggests that the time needed to set up new factories is one of the key frictions slowing the transition.

The data from more recent years also enables a deeper analysis of the mechanisms behind the FES effects, and stronger support for the identification strategy. In particular, 1950s manufacturing data come from the Census of Manufactures (CoM), which divides output into just 28 industry categories. Of these, exactly one corresponds to the production of iron and steel, and one other, "engineering" includes a broad set of activities which use iron and steel. India's successor manufacturing survey, the Annual Survey of Industries (ASI), provides a more detailed classification of activity, based essentially on the International Standard Industrial Classifications (ISIC). We thus obtain precise measures of each industry's use of equalized iron and steel in its inputs, and we can map industries to their Leontief shares, reflecting higher-order input-output linkages. We thus obtain greater precision, and ability to show that the movements we observe in FES-affected industries actually result from their usage of iron and steel, and not from other industry characteristics. We employ these techniques in studying both the transition path and repeal of FES.

Indeed, after 35 years of accumulated distortion under FES, a final open question concerns the effects of FES's repeal, which occurred in 1992. On the one hand, repealing FES might restore the natural advantage to eastern India, undoing the policy's effects in a symmetric fashion. But on the other hand, FES might have contributed to agglomeration externalities (Marshall, 1890), and entrenched the productivity advantage of western India. Some commentators argue that this is exactly what happened. Because FES left eastern states with such a deficit in productive infrastructure, these states were unable to recover after the removal of FES (Das Gupta, 2016). A wide literature in economic geography also provides reasons why a given spatial distribution of production might be dynamically stable and therefore difficult to change (Fujita et al., 1999; Baldwin et al., 2011).

We find that the truth is somewhere in between these two possibilities. Stickiness, first of all, is minimal. When FES is repealed, iron and steel using industries move back toward the sources of their materials, and the magnitude of this effect is exactly the opposite of the effect of implementing FES. The sources of these materials changed under FES, however, as the government constructed new integrated steel plants (ISPs) for the processing of basic iron and steel materials. Whereas the ISPs were initially located only in West Bengal and Bihar, the fact that they were more dispersed at the time of FES repeal meant that the gains from this repeal were shared among these Eastern states and a handful of other locations. Thus the historical narrative of aggrievement bears some truth – FES robbed West Bengal and Bihar of their industrial strength, then its repeal provided them little compensation. Yet stickiness due to agglomeration and entrenched advantage was not the mechanism for this.

The remainder of the paper proceeds as follows. Section 2 describes the history and institutional context of FES, clarifying the structure of steel production in India, the terms of the FES policy, and its possible channels of effect given the geography of production in India. The empirical analysis then proceeds in three parts. First, subsection 3.1 considers the effects of FES on the long-run steady state distribution of manufacturing activity. Next, subsection 3.2 characterizes the transition path as the geography of production gradually changes under FES. Finally, subsection 3.3 studies the repeal of FES, testing whether these effects are symmetric with the effects of implementing FES in the first place. Section 4 offers concluding remarks to put the results in context.

2 Background

India enacted the Freight Equalization Scheme (FES) in 1956, with the goal of achieving balanced industrial development. As Figure 1a shows, manufacturing output at the time was heavily concentrated into just a few areas, with West Bengal and the surrounding region being one of the most important centers of production. In 1950, West Bengal and Bihar accounted for 92 percent of all iron and steel production in India and 48 percent of all manufacturing output in engineering-related industries. These areas enjoyed a natural advantage in manufacturing, due to their proximity to raw materials, particularly iron ore, as depicted in Figure 1b. They were also rich in coal and other important mineral resources.

FES served to neutralize this geographic advantage. Starting in 1956, the government fixed uniform prices for the transport of iron and steel. This acted as a subsidy to long-distance shipping, with a user located all the way across the country now being able to obtain iron and steel at the same cost as a user located nearby the sources of materials in West Bengal and Bihar. Along with the equalization of iron and steel to achieve geographic balance in manufacturing, the government also equalized the shipping costs of cement and fertilizers, in order to promote balance in construction and agriculture. Below we find that the cement and fertilizer equalization had little effect on manufacturing activity, and moreover that the data show manufacturing firms making little use of these materials.[1] So we maintain focus on the equalization of iron and steel.[2]

The administration of FES for iron and steel fell under the authority of the Ministry of Steel, as detailed by Raza and Aggarwal (1986), Singh (1989), and Mohanty (2015). To finance FES, the government calculated an ex-factory "retention price", which depended on the expected average distance of shipments for the particular type of iron or steel. A self-financing Equalization Fund collected the difference between this price and the actual shipping cost of short shipments, and paid out the associated credits for longer shipments. The fund was administered initially by the government Tariff Commission, then starting in 1964 by a Joint Plant Committee (JPC) established by the Ministry of Steel specifically for price regulation.

The scope of FES was limited to the output of India's integrated steel plants (ISPs). Figure 3 places these ISPs in the context of a stylized depiction of the supply chain for iron and steel products in India. The most basic natural resource needed for these products is iron ore, which as noted above, is located primarily in a handful of states in eastern India. The next step in the supply chain is transforming iron ore into basic iron and steel "materials" such as pig iron, structural steel, coils, sheets, and plates. This transformation generally happens at the ISPs, which are controlled by the Ministry of Steel and operate at tremendous scale, giving them a virtual monopoly on the production of the basic materials. There are only seven ISPs in India, and the newest of them was constructed in 1971. So the empirical analysis will regard the location of the ISPs as exogenously

[1] The geographic distributions of cement and fertilizers are also less concentrated ex ante, reducing the scope for the equalization of these materials to lead to large geographic shifts in economic activity.

[2] Some sources have erroneously stated that coal was subject to FES (Chakravorty and Lall, 2007). This is not quite correct. Coal production is a state enterprise and has been subject to a series of controls ensuring uniform pricing across markets, however the transportation has essentially always been priced based on distance (Raza and Aggarwal, 1986; Indian Railway Conference Association, 2000).

fixed, and study where other, more flexible factories choose to produce given these locations.[3]

The users of the materials produced by ISPs can be grouped into two categories. First, makers of processed iron and steel products directly use the ISP output, in order to produce somewhat more specialized products, such as more refined forms of iron and steel, or pieces of iron and steel shaped in particular ways – say into a car axle or chassis. Finally, there is a set of downstream industries using these specialized products, and for example, assembling a car or another final good. Figure 3 indicates how we use industry codes to group industries according to their downstreamness in a way that is consistent across years, including years in the 1950s and 1960s when the industry codes observed in data are coarse. For recent years with more detailed industry classifications, measures such as Leontief input shares provide a more sophisticated way to characterize the linkages across industries.

As of 1956, India had two ISPs in operation, one being the current Tata Steel plant at Jamshedpur, Bihar, and the other being the IISCO plant, operated by the state-owned Steel Authority of India (SAIL) at Burnpur in West Bengal. Figure 4 plots their locations. The concentration of iron and steel material production at these points makes it clear how FES would have served as a subsidy for downstream iron and steel users to move production away from West Bengal and Bihar. After the implementation of FES, several new steel plants opened and fell under the FES scheme: SAIL Bhilai Steel Plant in Madhya Pradesh (now Chhattisgarh), SAIL Rourkela Steel Plant in Orissa, SAIL Bokaro Steel Plant in Bihar (now Jharkhand), and SAIL Durgapur Steel Plant in West Bengal, and Vizag Steel Plant in Andhra Pradesh. Under FES, the location of these new plants affects average shipping distances and therefore affects the all-India prices of iron and steel products. Since FES keeps prices uniform across regions, however, the new plants do not provide any particular advantage to nearby iron and steel users, and therefore should not affect these users' location choices.

The products covered by FES included most iron and steel materials produced by the ISPs for domestic use. Excluded were tin plates, pipes, electrical steel, and alloy steel, though these products amount to a small fraction of the plants' output. The more important products subject to FES included basic materials such as pig iron and steel sheets. These materials serve as inputs to other firms manufacturing more processed or complex products. But the restriction of FES to the ISPs means that the output of these downstream users, even if it contains iron and steel, is still subject to normal, distance-based shipping charges.

[3]This assumption is plainly innocuous in studying the effect of implementing FES. At the time, there were only two ISPs and these plants had been in existence since 1907 and 1918. Once FES begins, moreover, the location of ISPs is irrelevant, since the cost of obtaining the ISP materials is equalized across locations. For studying the repeal of FES, there is in principle a concern that the locations of more recently constructed ISPs could be co-determined with the industry growth trends we are interested in studying. Subsection 3.3 examines this concern, arguing that it ultimately does not threaten identification.

FES remained in effect until 1991. The repeal was sudden, with the National Development Council meeting to evaluate FES in December 1991 and announcing its removal with effect from January 1992. In place of FES, the government implemented a "freight ceiling" policy, charging freight based on distance for shorter shipments, but capping the price of longer shipments. The ceiling was, however, set very high: 1125km for pig iron, 1375km for flats, 1400km for bars, and 1500km for semi-steel. In practice, the ceiling did not bind for most users, with only the farthest reaches of northern and southern India lying more than this distance from the nearest steel plant. In 2001, the ceiling was also lifted, marking the complete abolition of FES.

Ex-post appraisals of FES have involved vigorous debate over its effects on the geography of production. A 1977 inter-ministerial report calculated the size of the FES subsidies, concluding that they were inconsequential, amounting to a relatively small fraction of firms' final output prices (Government of India Planning Commission, 1977). Other commentators argue, however, that FES was a driving force for industrial production to move away from eastern India. Over the past half-century, the western (and southern) states benefiting from FES have enjoyed India's highest rates of economic growth, while the resource-rich eastern states find themselves among India's poorest states today. Figure 2 shows that the divergence has been especially stark in manufacturing, lending plausibility to the idea that FES and the reversal of the manufacturing advantage contributed to these states' overall reversal of fortune.

3 Empirical analysis

This section estimates the empirical effects of FES, focusing on three main questions. First, what was the long-run effect of FES on the geography of production? Second, what was the transition path from the implementation of FES to this long-run steady state? Finally, what was the effect of removing FES, and was it symmetric with the effect of enacting the policy?

3.1 Long-run effect

The long-run effect is the main point of contention in debates over the geographic consequences of FES. The government report calculating a small total cost of the FES subsidies might set our priors toward expecting a small total effect of FES on industry location. But it is well know in economic geography that even a small divergence in fundamentals across regions can lead economic activity to concentrate in one area rather than the other (Baldwin et al., 2011), and more specifically that even a narrow advantage in the transportation costs affecting one region can lead to large competitive gains for the firms there (Redding and Turner, 2015; Firth, 2017). Some literature also suggests that subsidies to upstream sectors have the largest effects on aggregate productivity (Liu, 2017), leaving open the possibility that even a small subsidy to raw materials like iron and steel could lead to substantial gains spread throughout linked sectors.

To identify the effects of FES, we estimate

$$\Delta \ln Y_{is\tau} = \beta(\text{IronSteelUser}_i \times \ln \text{DistanceSteelPlant}_s) + \delta_i + \delta_s + \epsilon_{is\tau}, \tag{1}$$

where $Y_{is\tau}$ an outcome of interest for industry i in state s over the period τ from 1950-51 to 1990-91. In all specifications, we divide the long-differenced growth rate $\Delta \ln Y_{is\tau}$ by the number of years in τ, so coefficients can be interpreted as effects on average annual growth rates. IronSteelUser_i indicates whether industry i makes use of iron or steel as an input, and $\text{DistanceSteelPlant}_s$ is the distance from the centroid of state s to the nearest ISP in existence as of 1956. The fixed effect δ_i controls for industry-level trends, while δ_s controls for state-level growth trends affecting all industries in the state. In essence, β captures whether iron- and steel-using industries outperform other local industries by a larger margin in the states where FES should give more of a boost to these iron and steel users.

Since FES was lifted at the beginning of 1992, the time period considered provides the longest possible horizon for estimating the effects of FES. Studying this long horizon is important, because the results of Garred et al. (2015), as reproduced in Figure 5, show a minimal effect of FES in the decade following its implementation, but some indication that iron- and steel-using industries are moving away from West Bengal and Bihar by the late 1960s, which is the end of their sample period. The empirical strategy reflected in (1) is similar to that in Garred et al. (2015), but incorporates more data to capture long-run effects.

The data to estimate (1) comes from two main sources. The first source is the Census of Manufactures (CoM), an annual survey of manufacturing firms, conducted from 1946 to 1958. For this analysis, data is available for 1950-51. The data indicates, for each manufacturing industry, the details of production happening in each state. The main state-by-industry variables of interest for this analysis are the number of factories in operation, number of workers, and total value of ex-factory output.

One limitation of the CoM arises from its categorization of industries. This categorization is very coarse compared to modern industry classifications, with all production divided into 28 industry categories, listed in Table 1. Among these, two are especially relevant for the present analysis: the "Iron and Steel" industry which uses equalized material as an input, and the "Engineering" industry which is one step further downstream. Some of the output attributed to the Iron and Steel industry will itself be subject to equalization, but only that coming from the handful of ISPs.

Another limitation concerns state boundaries. The states listed in the CoM reflect state boundaries prior to the major redrawing which occurred in the late 1950s and early 1960s. This redrawing carved new states along ethno-linguistic lines in ways that often entail many-to-many mappings between the old and new states. A handful of states do remain unchanged from 1950 until 1990: West Bengal, Orissa, Bihar, Delhi, and Uttar Pradesh.[4] So in looking at long-run patterns, we consider each of these states as existing continuously, and construct a synthetic state, Other, which is a composite of all remaining states. Below we also conduct separate analyses for more limited sets of years within which more states exist continuously.

The second main data source is the successor to the CoM, known as the Annual Survey of Industries (ASI). From 1959 to 1971, we have annual ASI data, at the level of state-by-industry. The industries correspond to three-digit codes in the International Standard Industrial Classification (ISIC), Rev. 1. The set of available outcome measures varies by year, but always includes, for each state-industry, the number of factories, the number of workers employed, and the total value of ex-factory output. Starting in 1988-89, we have annual establishment-level ASI data. The wide coverage of years and the establishment-level data will facilitate more detailed analysis below, but to estimate (1) we only need 1990-91 data, with industries and states collapsed to match those in the 1950 data.

Estimates of (1) appear in Table 3. The $\hat{\beta}$ are positive and significant, meaning that iron- and steel-using activity shifts toward states which are distant from the sources of iron and steel. Specifically, to interpret the magnitude in Column (1), consider a comparison between two states: Uttar Pradesh, whose centroid is 731km from the nearest of the original ISPs, and Punjab, which is roughly twice as far, 1388km. If all industries in Uttar Pradesh are growing at the same rate, the estimate $\hat{\beta} = 0.5$ says that in Punjab the iron and steel industries are growing at an annual average of 0.5 percentage points faster than the rest of the state's industries. Column (2) shows that this growth is accompanied by growth in the industries downstream from the iron and steel users. These downstream industries in Punjab would, for example, experience a 0.6 percentage point annual growth advantage.[5]

To clarify the trends underlying these results, Column (3) departs from the preferred specification. In particular, it removes the state and industry fixed effects, and adds controls for state distance to

[4] In 2000 some of these states split: Bihar split into Bihar and Jharkhand. Uttar Pradesh split into Uttar Pradesh and Uttarkhand. Madhya Pradesh split into Madhya Pradesh and Chhattisgarh.

[5] While this effect is larger than the effect on industries directly using iron and steel, the two estimates are not statistically distinct.

a plant and industry iron and steel use. The average state-industry grows between 1950 and 1990.[6] Iron and steel industries grow by an average of 4.3 percentage points more than other industries. A state like Punjab grows by 0.478 percentage points more than a state like Uttar Pradesh. Then, as the coefficient of interest shows, FES gives a special advantage to the iron and steel producers located in places like Punjab which receive subsidized shipping under equalization.

Columns (4) through (6) of Table 3 present similar results, but with the distance variable replaced by an indicator which equals zero for the states containing one of the original ISPs (West Bengal and Bihar), and one for other states. These results measure the direct loss to the states which claimed aggrievement under FES. As the results show, these states not only lose their share in the iron and steel industry, but also see downstream producers move away.

For robustness, Table 4 presents results with all available states, not only those with unchanged boundaries from 1950 to 1990. These results admit some noise because the observed 1950 to 1990 growth rates for each state owe in part to the states' changing boundaries. Nevertheless, the estimates of interest are essentially unchanged. Table A1 shows that results are also not affected by whether the state-industries are weighted by their 1950 size.

The core identifying assumption behind these results is that in the absence of FES, the growth of industries using iron and steel relative to other industries would not have differed in a way that is associated with distance from the ISPs. As basic support for this assumption, we consider pre-FES trends in state-by-industry output. We know from Garred et al. (2015), as reflected in Figure 5, that the pre-trends were parallel. The share of West Bengal and Bihar in iron and steel using industries followed the same time path as these states' share in other industries, lending plausibility to the claim that these trends would have remained parallel in the absence of FES. The remaining threat to identification, then, would need to come from other state-by-industry differences, arising at the same time as FES or shortly after, which push iron and steel using industries to grow relatively more slowly in West Bengal and Bihar than elsewhere.

One possible confound in this vein is industrial policy enacted around the time of FES. India has tried favor or protect certain industries at various times in its history, including, indeed, with the Industrial Policy Resolution of 1956 (Government of India, 1956). This resolution categorized industries according to their degree of planned state ownership and provided subsidies to particular industries (Mohan, 2002), possibly setting the course for more prosperous growth in some industries than in others. But even this type of industry-level differential growth is not a threat to the

[6] The unreported constant term in this regression is 3.8, suggesting that the average state-industry grows an an annual rate of 3.8 percent between 1950 and 1990. This high rate is partly an artifact of the data (the 1990 ASI is more comprehensive than the 1950 CoM), and partly because of genuine growth over this period. The interest, in any event, is not in this secular growth rate, but in how rates differ by state and industry.

identification strategy, because it is accounted for by the industry effect δ_i. These policies would confound identification only if, for instance, there were cross-state differences in the ability of firms in a particular industry to take advantage of the terms of the policies. But none of the policies' terms nor the historical record about them points to such differences.

As another possible confound, regional development policies or political conditions have at times led to growth advantages for certain regions, especially with the prominence in India of regional parties whose fortunes wax and wane with the political cycles. Ahluwalia (2002) finds some evidence, albeit limited, for effects of government intervention on these divergences in states' growth rates. But the identification strategy circumvents this concern too, since the state effect δ_s partials out differences in regional trends. The strategy's key advantage is that despite the recurrence of state- and industry-specific development policies, FES is rather unique in differentially affecting state-by-industries. Below, with the advantage of richer data from later years, we conduct additional tests to show the movements we attribute to FES are not attributable to other state-by-industry characteristics.

3.2 Transition path

To examine the transition path from the implementation of FES to the long-run steady state under the policy, we conduct an event study:

$$\ln Y_{isy} = \sum_{y=1950}^{2007} \beta_y (\mathbf{1}_{\text{Year}=y} \times \text{IronSteelUser}_i \times \ln \text{DistanceSteelPlant}_s) + \delta_{is} + \delta_{iy} + \delta_{sy} + \epsilon_{isy}. \quad (2)$$

The coefficients of interest are the β_y, which indicate how the year y outcomes Y_{isy} differ as a function of the treatment status of industry i, state s. Some recent work emphasizes transitional dynamics in response to trade liberalization or other changes in frictions (Dix-Carneiro, 2014; Caliendo, Dvorkin and Parro, 2017). Highlighting the importance of these dynamics, Dix-Carneiro and Kovak (2017) show that the impact of Brazilian tariff cuts on regional earnings 20 years after liberalization was more than three times the effect 10 years after liberalization. Estimating (2) helps explain the mechanism by which FES arrived at the effects estimated in subsection 3.1 and what types of gains or losses were realized along the way.

Figure 6 presents the results of the event study. First, Figure 6a shows the effects on output. Several years of data are missing due to limitations in the availability of data from the CoM and ASI. But the remaining years provide enough information to characterize the transition path. In the years following the implementation of FES, represented by the blue line at 1956, there was no great movement of iron and steel industries away from the ISPs. Then, for 1962, there is a positive but insignificant coefficient, indicating some movement in the direction of the ultimate FES effect. A slight upward trend continues until 1970. Projecting this trend forward through the 1970s and 1980s leads to the ultimate effect of FES, which is observed around 1990. The fact that these effects of FES appear gradually points to the key difference between our analysis and Garred et al. (2015), the only other econometric analysis of FES. As of 1970, when their data ends, FES shows some hint of an effect, but it is not statistically or economically significant. Only by looking to the longer term do we see the effect.

Figure 6b helps to explain this speed of transition, by conducting a similar event study for the effects of FES on the number of factories operating in a state-industry. The time pattern is remarkably similar to that for the output event study in Figure 6a. This suggests that the relocation of iron and steel output depends on the closing of factories near the ISPs and the opening of factories in faraway states, not simply the adjustment of output in existing factories. Some institutional details provide further corroboration. As Krishna Moorthy (1984) and Singh (1989) describe, steel plants require extensive planning, taking five to nine years from conception to reaching full operation. Restrictive licensing regulations, as discussed in Krueger (2002), also slowed rates of factory relocation and delayed the time at which we should expect to see effects of FES. If a steel producer decided to move or open a factory around the time of FES in 1956, the new factory would likely become operational only somewhat later, right around the time when we start to see factories move in Figure 6b. These moving and setup costs could then create an additional friction which slows the movement of other input-output linked producers who find it worthwhile to move only once a certain number of other factories have moved.

Another advantage of the transition years is that they afford richer data than what is available in the CoM prior to the implementation of FES. By studying long differences from 1959 until the end of FES in 1990, we can examine the "transition effect" starting from the early years of FES. Such estimates of course miss any impact of FES realized immediately upon its implementation, though as the above event studies show, these impact effects were minimal. Starting in 1959, the ASI reports state-by-industry output at the level of three-digit ISIC, Rev. 1, which maps to the four-digit NIC-87 codes (based on ISIC, Rev. 2) and four-digit NIC-98 codes (based on ISIC, Rev. 3) used in later versions of ASI. To link across years, we concord all data to the NIC-98 codes. We then match these industry codes input-output table measures of each industry's input shares and Leontief input shares (Ministry of Statistics and Programme Implementation, 1994).[7]

This input-output information enables a more structural interpretation of the FES effects. In particular, suppose production is Cobb-Douglas, where a_{ij} is the share of industry j's output used

[7]Results are similar using other measures of input use, such as those from US input-output tables.

in the production of industry i. These shares give rise to the production matrix $\mathbf{A}$. The Leontief inverse matrix is $\mathbf{L} \equiv (\mathbf{I} - \mathbf{A})^{-1}$. An element of this matrix, l_{ij}, indicates the effect of a productivity shock in sector j on output in sector i, accounting for all of the higher-order linkages between j and i (e.g., j is used in the production of some other good, which is in turn used in the production of i). Suppose each state is a closed economy able to obtain iron and steel at an exogenous price. Let j be iron and steel, and $d \ln p_{js}$ the effect of FES on the price, inclusive of transport cost, faced by a producer of i in state s. It follows that

$$d \ln y_{is} = -l_{ij} d \ln p_{js}. \tag{3}$$

We can decompose the price effect into

$$d \ln p_{js} = \kappa(d \ln \bar{\tau}_j - \ln D_s), \tag{4}$$

where κ is the fraction of shipping cost in the price of j, $\bar{\tau}_j$ is the per-kilometer freight rate (which potentially increases with FES due to the distortion of subsidizing long distance shipping), and D_s is the distance from state s to the source of j. The state-specific component of the change in shipping cost is proportional to this distance because under FES all states are charged as if they are the average distance from the source of steel, yielding larger benefits for more distant states. Combining (3) and (4) it follows that

$$d \ln y_{is} = \kappa l_{ij} \ln D_s - \kappa d \ln \bar{\tau}_j. \tag{5}$$

The second term, $\kappa d \ln \bar{\tau}_j$ is absorbed by secular trends, leaving the effect of FES to be the product of the Leontief share l_{ij} and the distance. We therefore estimate a version of (1) with the industry iron or steel use indicator replaced by the Leontief share. Appendix B provides a more general expression for the effects of these distortions, allowing the price of materials to differ for each of an industry's input suppliers, for instance because each industry uses a different set of materials or because these input suppliers are located in other regions whose prices of materials are differentially affected by FES. The implied estimating equation is, however, similar.

Table 5 presents results from estimating this specification. Leontief share and distance interact to increase state-industry growth rates, as we predict under FES. In particular, moving from the 10th percentile of industries' Leontief reliance on iron and steel ($l_{ij} = 0.01$) to the 90th percentile ($l_{ij} = 0.39$) increases the relative growth rate of the industry by 0.9 percentage points annually. The results also show, in Panel B, that factory location is affected, with Leontief shares determining industries' movement away from the steel sources. The final available industry variable which is consistent across years is the number of workers employed, and this increases slightly as a result of FES, implying a positive but insignificant effect on labor productivity. Table 6 presents similar results, but with the raw input shares instead of the Leontief shares. These estimates are noisier but indicate qualitatively the same effects on output and factory location.

Both Table 5 and 6 also use the input-output structure to show the robustness of the results to other input distortions coinciding with the equalization of iron and steel. As described in Section 2, the Indian government also equalized cement and fertilizers around the same time as iron and steel, and implemented price controls on coal which, while not an equalization scheme per se, might also have altered the geography of production. Cement and fertilizers are produced in a more dispersed set of locations, reducing some of the worry that their equalization would confound estimates of the effects for iron and steel. But coal is produced, also as a government enterprise, in the same resource-rich states hosting the ISPs. If the FES for iron and steel was part of a broader set of policies to relocate certain industries between certain states, we might expect to see this working through the controls on coal. Columns (2), (3), and (4) of these tables show, however, that the main results are unaffected by allowing for state-specific effects of using coal, fertilizers, or cement. The driver of the observed patterns is, rather, industries' iron and steel use, just as predicted if the cause is FES.

3.3 Stickiness

While FES contributed to iron and steel users' movements from eastern to western India, it is unclear whether repealing FES would fully undo these effects. In particular, industry movements toward western India under FES could have led to agglomeration in western industrial centers. Marshall (1890) posits a variety of possible sources of agglomeration externalities, including labor market pooling, knowledge spillovers, and input-output linkages. Recent empirical work provides direct causal evidence on the strength of more specific agglomerative forces, such as intra-urban transportation links (Ahlfeldt et al., 2015) and firm-to-firm matching (Miyauchi, 2018). Ryan (2012) shows, specifically in India in 2005, that agglomeration levels are similar to those observed in the United States (Ellison and Glaeser, 1997). Once economic activity agglomerates in an area, a change such as the lifting of FES might be insufficient to undo that area's productivity advantage and push production elsewhere.[8]

To test whether the effects of FES persist even in the absence of the policy, we estimate (1) over the time period from 1990, immediately before FES was lifted, until 2013-14, the latest year for

[8]Indeed, a long tradition in economic geography (Baldwin et al., 2011) studies the conditions under which a geographic steady state is stable, and more recent work places these models in a quantitative framework (Allen and Donaldson, 2018).

which data is available. Results of this test appear in Table 7. Columns (1) through (3) show $\hat{\beta}$ which are almost identical in magnitude to those found in subsection 3.1, but now negative instead of positive. In other words, repealing FES leads iron and steel using industries to move back toward the ISPs, just as strongly as FES made them move away. Seemingly FES did not lead to irreversible agglomeration.

Columns (4) through (6) show, nevertheless, that repealing FES did not fully compensate the states of West Bengal and Bihar for their losses under FES. The reasons these states do not fully recover, despite the movements toward ISPs, is that now West Bengal and Bihar are not the only states containing ISPs. Recall from Figure 4 that under FES the government opened new steel plants outside of these states, partly in order to reduce average shipment distances and limit the total cost of the FES subsidy. When iron and steel using activity moves back toward this set of ISPs, it leads to some gains in West Bengal and Bihar, and therefore estimates in columns (4) through (6) which are negative and nontrivial in magnitude. Yet activity is also moving toward some of the new ISPs, outside West Bengal and Bihar, meaning these states need to share some of the gains from FES's repeal.

A new identifying assumption specific to this portion of the analysis is that the location of the new ISPs built under FES was not associated with counterfactual industry growth rates. For example, identification would be confounded if the ISPs were built in areas projected to have high relative growth rates in their iron and steel using industries. One institutional factor allaying this concern is that the new ISPs were built primarily to optimize transport costs under FES, without any indication that FES would be repealed in the future. Also, the newest of the ISPs was built in 1971, at which time it would have been difficult to forecast the industry growth trends starting from the repeal of FES, which was still 20 years to come.

As an additional test against this concern, we estimate a modified version of (1), taking out the state-industry growth rates from the years prior to the FES repeal:

$$\Delta \ln Y_{is,\tau} - \Delta \ln Y_{is,\tau-1} = \beta(\text{IronSteelUser}_i \times \ln \text{DistanceSteelPlant}_s) + \delta_i + \delta_s + \epsilon_{is\tau}. \quad (6)$$

Here, τ is still the period of interest, 1990 to 2013, and $\tau - 1$ is the preceding period containing the pre-trend, 1967 to 1990.[9] In addition to addressing the concern that the new ISP locations might be associated with projected growth rates, this specification allows for the possibility that transition to the steady state was still underway at the time of FES's repeal. In the earlier event study of Figure

[9] This period definition forms pre and post periods of equal length, but we also consider the longest available pre-trend dating back to 1959, and a period dating back only to 1989 in order to capture an instantaneous rate of change.

6 we do not have enough data from the 1980s to reveal the transition path leading up to 1990, and it is possible that this path contains a pre-trend driving the results found in Table 7.[10]

Estimates of (6) appear in Table 8. The results are very similar in magnitude to those in Table 7, though with some loss in precision leading to insignificant estimates in columns (1) and (3). One notable difference is the larger estimate for the effects on downstream industries. A possible explanation is that under FES downstream industries were slower to transition from east to west, so that at the time of the FES repeal these industries were still in the process of moving west, and relative to this benchmark they exhibit an especially large movement west when FES is repealed. The other difference, appearing in columns (3) and (6), is the large negative trend both for iron and steel industries nationwide, and for states distant from ISPs. Possible reasons for this are, first, that the iron and steel industries simply grow slowly relative to the period's strong manufacturing growth in a variety of other sectors (Bollard, Klenow and Sharma, 2013), and second, that distant states' growth rate was slow only relative to the fast benchmark they set while they enjoyed the benefits of FES.

To characterize the transition path associated with the repeal of FES, Figure 7 presents an event study. The effects on output, depicted in Figure 7a, show a steady transition following the repeal of FES, and a leveling off the effect around 2002. This amounts to a somewhat faster transition than that following the implementation of FES, perhaps because economy-wide liberalization in the 1990s reduced the frictions for factories to move and for owners to establish new factories in the locations that were optimal given the new freight regime. An especially relevant reform is de-licensing, studied by Aghion et al. (2008), which removed a set of barriers to firm entry and expansion. Indeed, Figure 7b shows that, once again, the event study for number of firms in a state-industry mirrors that for output, suggesting that factory location is a key margin of adjustment along the transition path.

4 Conclusion

These results demonstrate that even small geographic distortions in input prices can help one region to nose ahead of another and exploit this advantage to steal industrial activity. Over the long term, this can result in substantial effects on the geographic distribution of production. The effects can take time to materialize, however, given frictions such as factory moving and setup costs. The cumulative nature of these advantages might lead one to suspect that they cannot easily be reversed.

[10]The precise event study relevant to identify such a pre-trend would involve an extension of Figure 7 backward in time, which is slightly different from the event study in Figure 2, given the different set of ISPs in existence at the time of repeal versus implementation. Either of these tests would, in any event, require additional data from the 1980s.

We find in the case of FES, though, that repealing the policy led industry to move back toward the sources of iron and steel just as quickly as it left. Indeed, the results on implementation and repeal also complement one another, with the alignment between these results building confidence that, in both cases, the distortions related to FES cause industries to move across space in the manner described.

An important aspect of this story is the role of input-output linkages, with the FES policy distortion affecting not only firms using the equalized materials but also their downstream neighbors. Input-output linkages potentially also play a role determining the rate of transition. For instance, if one set of industries faces frictions and is slow to move across space in response to some price change, then the downstream industries will be delayed in when they find it attractive to move, they will in turn face frictions slowing their move once it starts, and so forth down the supply chain. Avenues for future work could involve exploring these channels through which input-output linkages drive geographic movement and determine its ultimate welfare implications.

References

Aghion, Philippe, Robin Burgess, Stephen J Redding, and Fabrizio Zilibotti. 2008. "The unequal effects of liberalization: Evidence from dismantling the License Raj in India." *American Economic Review*, 98(4): 1397–1412.

Ahlfeldt, Gabriel M, Stephen J Redding, Daniel M Sturm, and Nikolaus Wolf. 2015. "The economics of density: Evidence from the Berlin Wall." *Econometrica*, 83(6): 2127–2189.

Ahluwalia, Montek S. 2002. "State level performance under economic reforms in India." *Economic policy reforms and the Indian economy*, 91–125.

Allen, Treb, and Dave Donaldson. 2018. "Geography and Path Dependence."

Baldwin, Richard, Rikard Forslid, Philippe Martin, Gianmarco Ottaviano, and Frederic Robert-Nicoud. 2011. *Economic geography and public policy.* Princeton University Press.

Bollard, Albert, Peter J Klenow, and Gunjan Sharma. 2013. "India's mysterious manufacturing miracle." *Review of Economic Dynamics*, 16(1): 59–85.

Caliendo, Lorenzo, Maximiliano Dvorkin, and Fernando Parro. 2017. "Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock." *NBER Working Paper*, 77999.

Chakravorty, Sanjoy, and Somik V Lall. 2007. *Made in India: the economic geography and political economy of industrialization.* Oxford University Press, USA.

Das Gupta, Chirashree. 2016. *State and Capital in Independent India: Institutions and Accumulations.* Cambridge University Press.

Dix-Carneiro, Rafael. 2014. "Trade liberalization and labor market dynamics." *Econometrica*, 825–885.

Dix-Carneiro, Rafael, and Brian K Kovak. 2017. "Trade liberalization and regional dynamics." *American Economic Review*, 107(10): 2908–46.

Ellison, Glenn, and Edward L Glaeser. 1997. "Geographic concentration in US manufacturing industries: a dartboard approach." *Journal of political economy*, 105(5): 889–927.

Firth, John. 2017. "I've Been Waiting on the Railroad: The Effects of Congestion on Firm Production."

Fujita, Masahisa, Paul R Krugman, Anthony J Venables, and Massahisa Fujita. 1999. *The spatial economy: cities, regions and international trade.* Vol. 213, Wiley Online Library.

Garred, Jason, David Atkin, Dave Donaldson, and Amit Khandelwal. 2015. "Access to raw materials and local comparative advantage: The effects of India's Freight Equalization Policy."

Ghosh, Prabhat Prasad, and Chirashree Das Gupta. 2009. "Political Implications of Inter-State Disparity." *Economic and Political Weekly*, 185–191.

Government of India. 1956. "Industrial Policy Resolution of 1956."

Government of India Planning Commission. 1977. "Report of Inter-Ministerial Group on Freight Equalisation of Commodities."

Hirschman, Albert O. 1958. *The strategy of economic development.* Yale University Press.

Indian Railway Conference Association. 2000. *Goods rates tables, 1970-2000.*

Krishna Moorthy, K. 1984. *Engineering Change: India's Iron and Steel.* Madras: Technology Books.

Krishna, Rai Atul. 2017. "Freight equalization hit Bihar growth, says Prez." *Hindustan Times.*

Krueger, Anne O. 2002. *Economic policy reforms and the Indian economy.* University of Chicago Press.

Liu, Ernest. 2017. "Industrial Policies in Production Networks."

Marshall, A. 1890. *Principles of economics.* London: MacMillan.

Ministry of Commerce and Industry. 1957. "Annual Administration Report 1956-57."

Ministry of Statistics and Programme Implementation. 1994. *Input output transactions table, 1993-94.*

Miyauchi, Yuhei. 2018. "Matching and Agglomeration: Theory and Evidence from Japanese Firm-to-Firm Trade."

Mohan, Rakesh. 2002. "Small-Scale Industry Policy in India." *Economic policy reforms and the Indian economy*, 213.

Mohanty, Gopal. 2015. "Report on Freight Equalization Scheme (FES)."

Raza, Moonis, and Yash Aggarwal. 1986. *Transport geography of India: commodity flows and the regional structure of the Indian economy.* Concept Publishing Company.

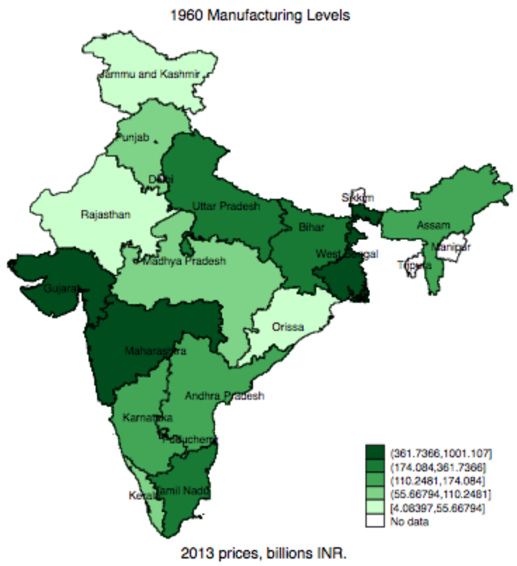
Redding, Stephen J., and Matthew A. Turner. 2015. "Transportation Costs and the Spatial Organization of Economic Activity." *Handbook of Regional and Urban Economics*, 5(20): 1339–1398.

Ryan, Nicholas. 2012. "Causes of Industrial Agglomeration in India."

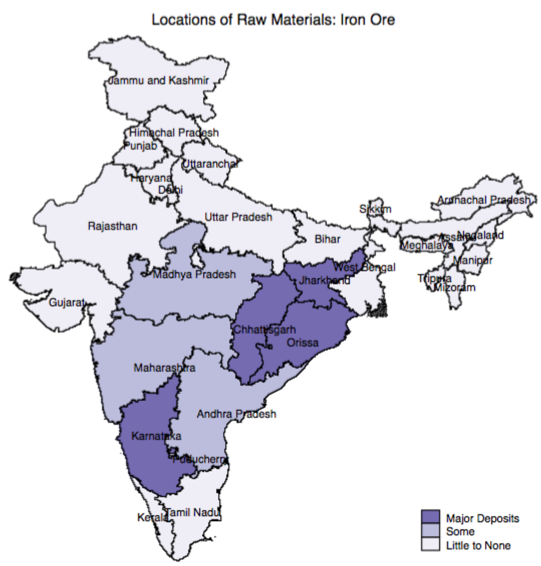
Singh, Ram Badan. 1989. *Economics of public sector steel industry in India.* Commonwealth Publishers.

Figure 1: The economic geography of India at the time of FES implementation

(a) Output at start of FES

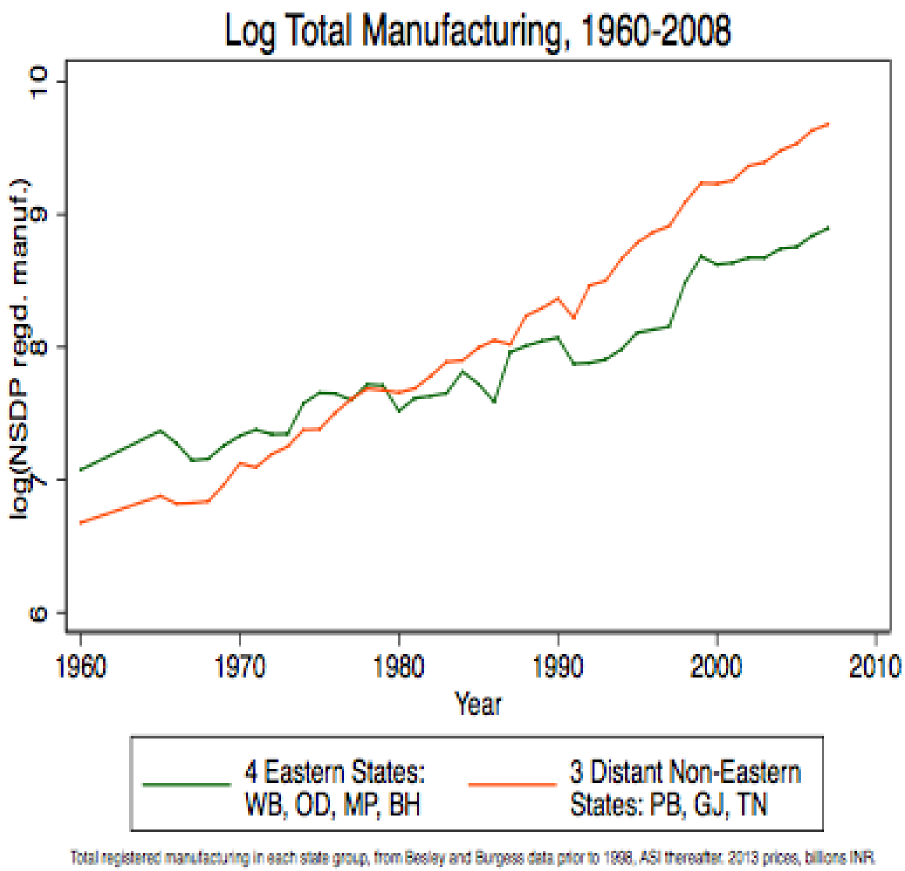


(b) Sources of raw materials



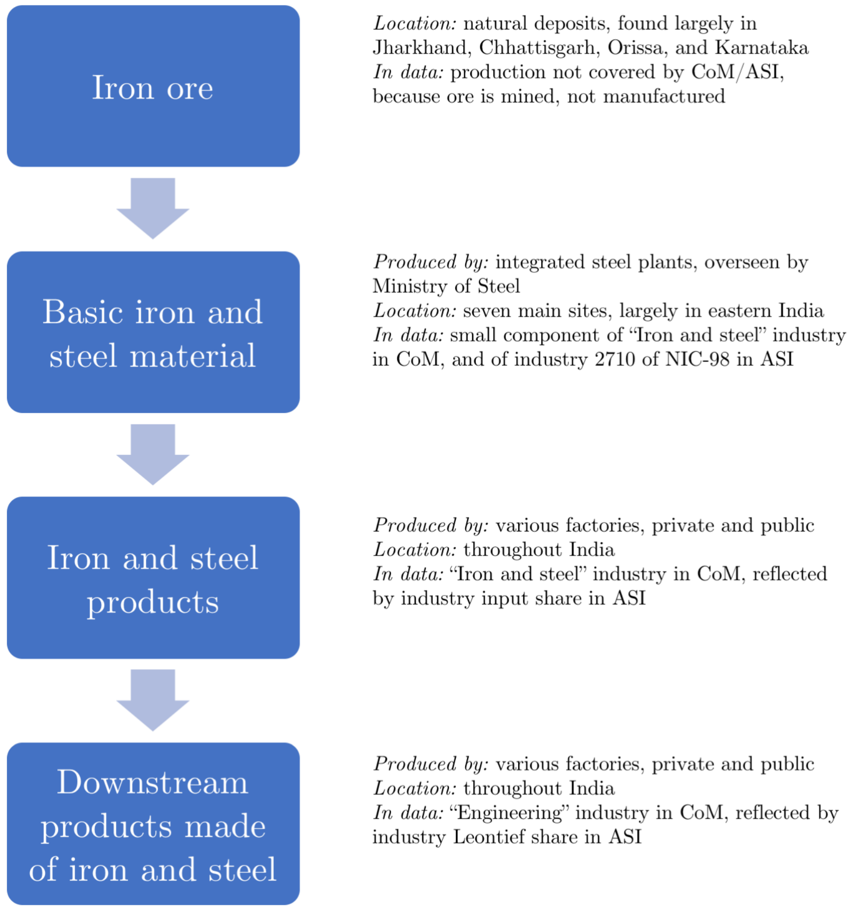
Notes: These maps depict the geography of production in India, and thus the effects which are likely to follow from the Freight Equalization Scheme (FES). As panel (a) shows, industrial activity in 1960, around the time of FES implementation was concentrated in two main centers: one around Bombay, and one around West Bengal. These figures come from ASI data. As panel (b) shows, part of the comparative advantage of West Bengal owed to its proximity of natural resources such as iron ore. By subsidizing long-distance shipments of input materials, FES created and incentive for iron and steel using production to move away from West Bengal and toward other centers like Bombay.

Figure 2: Historical trends in state manufacturing output



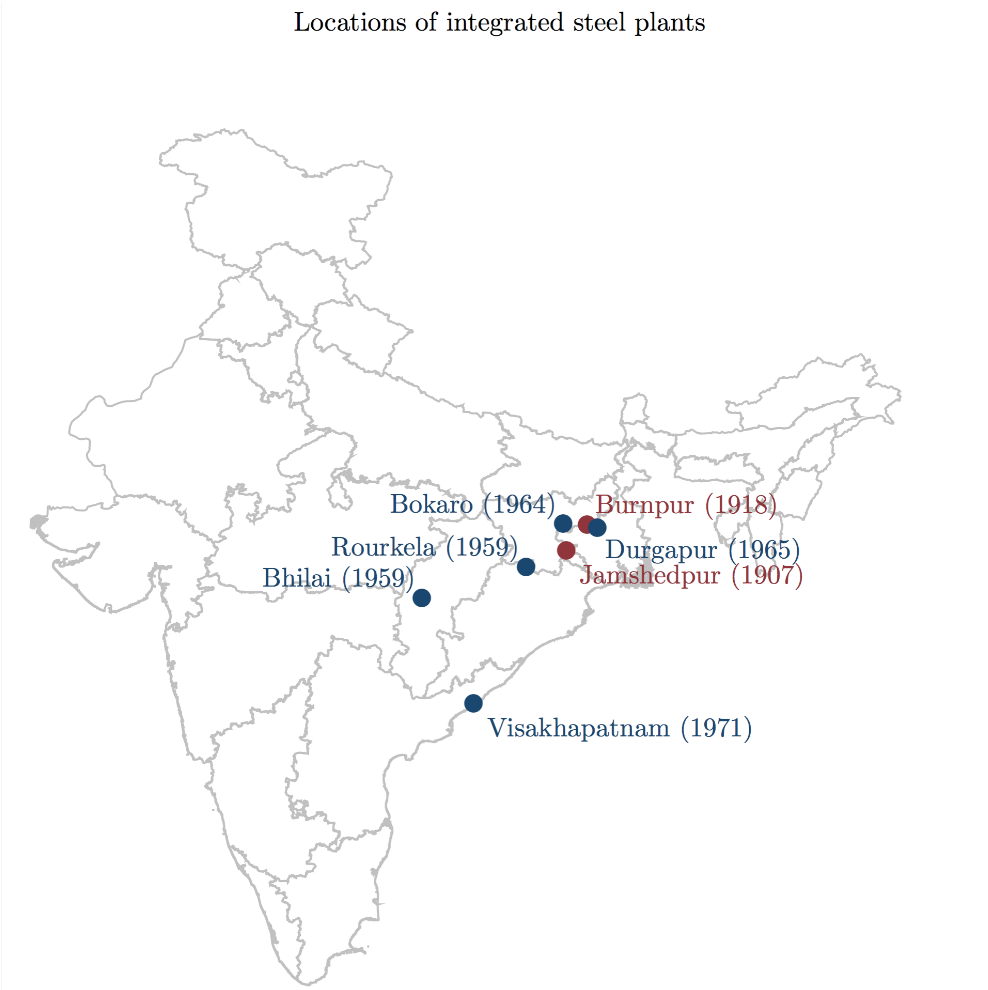
Notes: This figure depicts the broad state-level trends in manufacturing output between 1960 and 2008: growth in resource-rich states such as West Bengal, Orissa, MP, and Bihar has lagged behind growth in distance states such as Punjab, Gujarat, and Tamil Nadu. These latter states stood to benefit most from FES and have indeed enjoyed some of India's most impressive growth rates in recent decades.

Figure 3: Stylized description of supply chain, providing institutional details and link with data



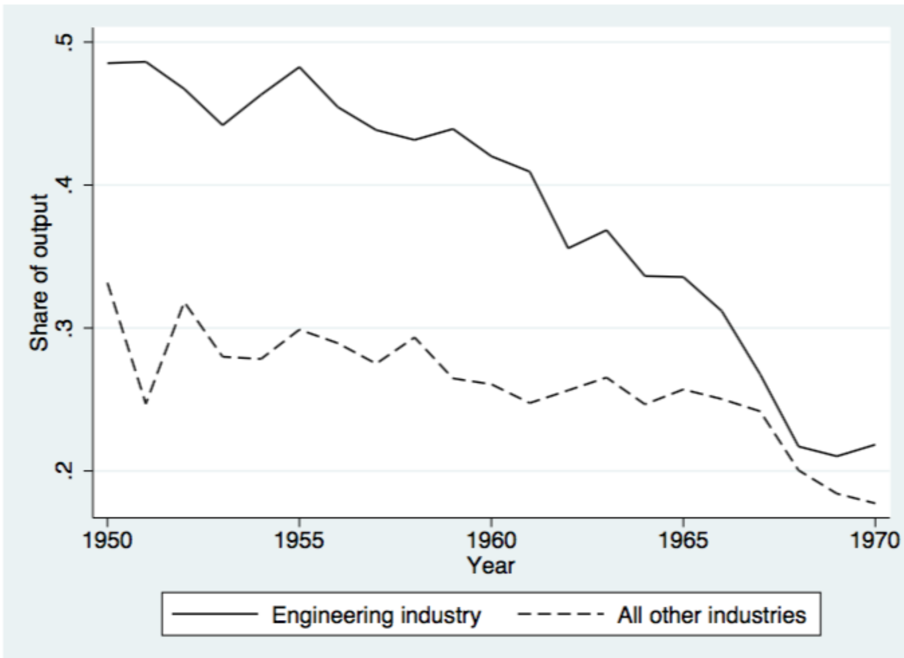
Notes: This figure categorizes activities into steps in the supply chain for products made from iron and steel. It also clarifies the institutional context of production, particularly as this bears on geography. The source locations of iron ore are fixed, and the location of ISPs for processing this ore are essentially fixed given the sites of major plants established by the government. In our framework, users of this basic iron and steel (and those downstream from them) take the location of the government plants as fixed, and choose their own location based on the shipping costs to get materials from those plants. Each piece of this chain which corresponds to manufacturing output finds an empirical counterpart in our data, as indicated.

Figure 4: Map of basic iron and steel production



Notes: This map depicts the locations of India's integrated steel plants (ISPs). Only the output of these plants was subject to FES. At the time of FES implementation, there were only two ISPs, with each operating at a large scale. Five new plants were established in the ensuing years, in part serving to reduce the government's distribution costs under FES.

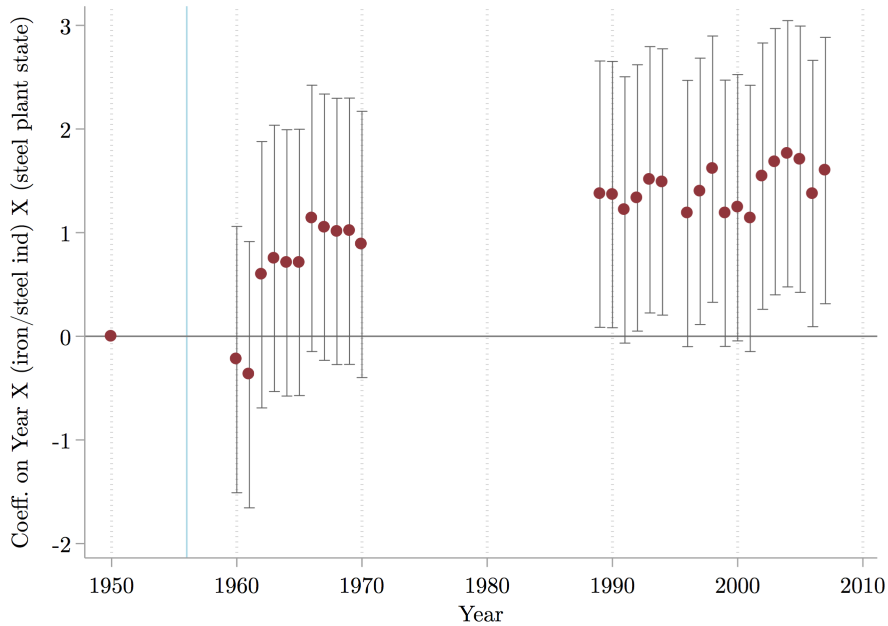
Figure 5: Share of Bihar and West Bengal in iron- and steel-using manufacturing (Engineering) and in other industries



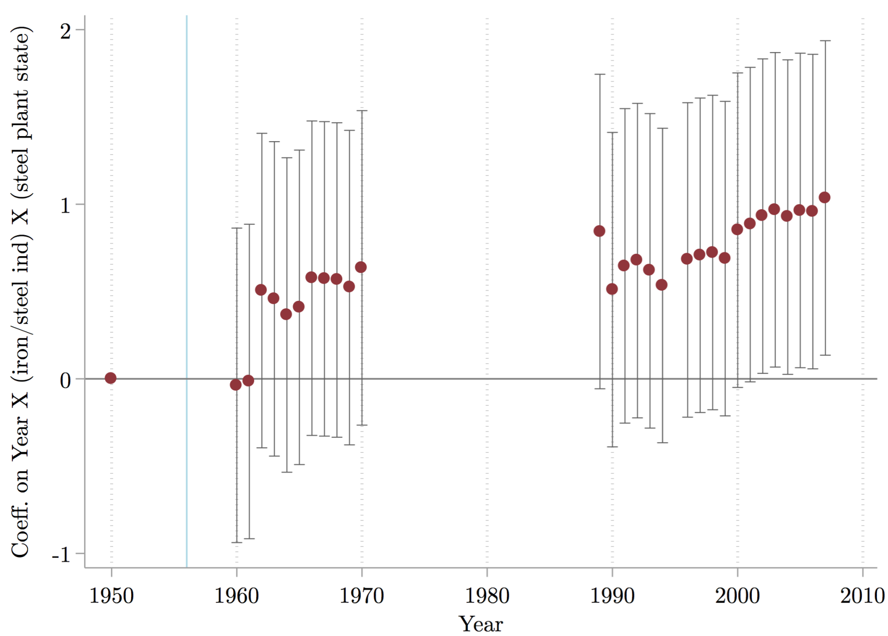
Notes: This figure reproduces Figure 3.2 from Garred et al. (2015). It plots the share of Bihar and West Bengal in Engineering, the main iron- and steel-using manufacturing industry (solid line) versus to their share in industries not using iron or steel (dashed line). The initial years following implementation of FES show little reduction in these states' Engineering share relative to their Other share. Toward the end of the sample period, however, the Engineering share begins to fall to the level of the Other share.

Figure 6: Event study showing transition path of FES effects

(a) ln(Output)



(b) ln(Number of factories)

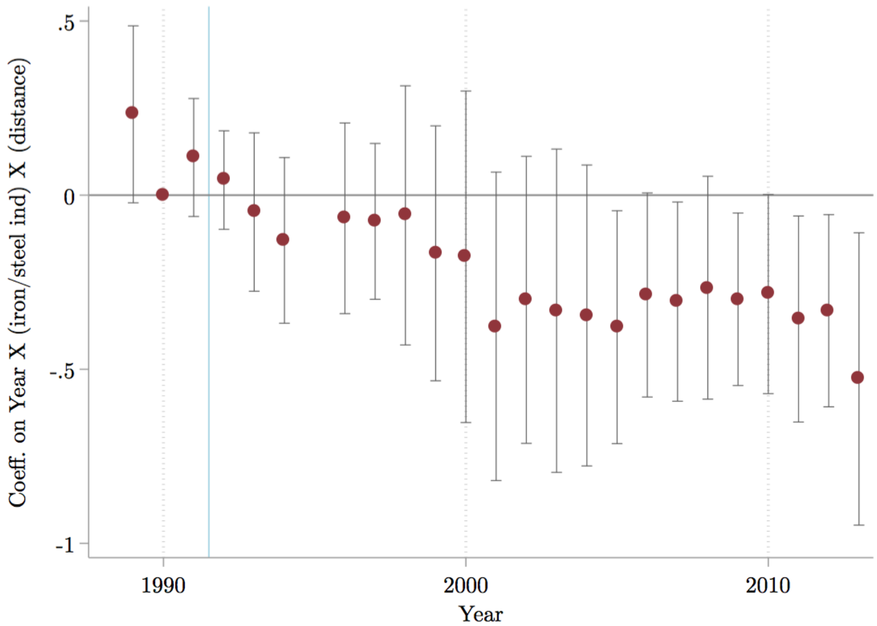


Notes: This figure shows the long-run effects of FES. Plotted coefficients for each year are the β_y from

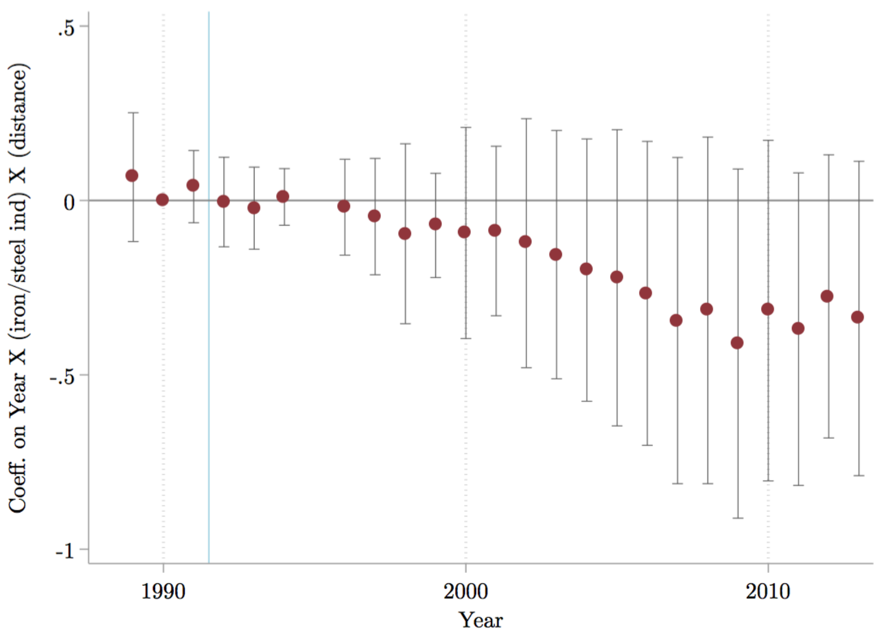
$$\ln Y_{isy} = \sum_{y=1950}^{2007} \beta_y (\mathbf{1}_{\text{Year}=y} \times \text{IronSteelUser}_i \times \ln \text{DistanceSteelPlant}_s) + \delta_{is} + \delta_{iy} + \delta_{sy} + \epsilon_{isy}.$$

Figure 7: Event study on repeal of FES

(a) ln(Output)



(b) ln(Number of factories)



Notes: This figure shows the long-run effects of FES. Plotted coefficients for each year are the β_y from

$$\ln Y_{isy} = \sum_{y=1989}^{2013} \beta_y (\mathbf{1}_{\text{Year}=y} \times \text{IronSteelUser}_i \times \ln \text{DistanceSteelPlant}_s) + \delta_{is} + \delta_{iy} + \delta_{sy} + \epsilon_{isy}.$$

Table 1: List of industries in Indian *Census of Manufactures*

Wheat flour	Plywood and tea-chests
Rice milling	Paper and paper-board
Biscuit making	Matches
Fruit and vegetable processing	Cotton textiles
Sugar	Woolen textiles
Distilleries and breweries	Jute textiles
Starch	Chemicals
Vegetable oils	Aluminum, copper, and brass
Paints and varnishes	Iron and steel
Soap	Bicycles
Tanning	Sewing machines
Cement	Electric lamps
Glass and glassware	Electric fans
Ceramics	General engineering and electrical engineering (including producer gas plant manufacture)

Notes: This table lists the industry categories found in the annual *Census of Manufactures* (1946-58). The final category, Engineering, is broad, encompassing a range of manufacturing activities involving some measure of complexity.

Table 2: Descriptive statistics

	1950 (CoM)		1959 to 1970 (ASI)		1989 to 2013 (ASI)	
	Mean (1)	St. Dev. (2)	Mean (3)	St. Dev. (4)	Mean	St. Dev.
All industries						
Ex-factory value of output	251	911	.145	.334	10519	31899
Number of factories	121	379	26	45	71	176
Workers employed	28556	104814	8550	24381	5495	17517
Annual growth rate	.182	2.857	.014	1.957	.005	2.994
Industries	15		54		104	
State X industry obs.	172		411		1551	
Iron and steel using industries						
Ex-factory value of output	153	202	.147	.268	11125	35369
Number of factories	147	301	25	33	54	88
Workers employed	18008	25474	8682	13774	4359	9768
Annual growth rate	.164	3.065	.005	2.185	-.013	3.131
Industries	2		11		34	
State X industry obs.	19		110		520	

Notes: This table presents descriptive statistics on the state-by-industry data compiles from Indian firm surveys. The data is divided by distinct firm survey: Census of Manufactures (CoM), old ASI, and modern ASI. Each figure reported reflects a state-by-industry level average for each year, with years then averaged within each dataset. Output is reported in millions of INR, at 2011 constant prices. Because industry definitions can change over time, the size of a state-by-industry unit can vary across datasets.

Table 3: Effects of FES on long-run industrial growth, for states with unchanged boundaries

	Dependent variable: $\Delta \ln$(Revenue)					
	(1)	(2)	(3)	(4)	(5)	(6)
(Ind. uses iron/steel) $\times$ ln(State dist. to ISP)	0.452*** (0.128)	0.471*** (0.134)	0.481** (0.191)			
(Downstream iron/steel) $\times$ ln(State dist. to ISP)		0.605*** (0.195)				
(Ind. uses iron/steel) $\times$(State contains ISP)				3.001*** (0.857)	3.127*** (0.894)	3.164** (1.268)
(Downstream iron/steel) $\times$(State contains ISP)					4.055*** (1.313)	
Ind. uses iron/steel			4.312*** (0.973)			4.319*** (0.970)
ln(State dist. to ISP)			0.478*** (0.154)			
State contains ISP						3.197*** (1.011)
Observations	80	80	80	80	80	80
Adjusted R^2	0.815	0.830	0.426	0.815	0.830	0.431
State, Industry FE	✓	✓		✓	✓	

Notes: This table presents results of the main specification (1) for studying the effects of FES. Observations are at the state-by-industry level, weighted by pre-FES output. The dependent variable is change in logged ex-factory value of output between 1950 and 1990, divided by the number of years. The interacted variables of interest include, first, an indicator of whether the industry is a direction user of iron or steel as an input, and an indicator of whether the industry is downstream from an iron or steel user. Precise definitions of these industry categories are in the text and in Figure 3. Next, the state-level variables are logged distance from the state's centroid to the nearest integrated steel plant (ISP), and an indicator of whether the state itself contains an ISP (true for West Bengal and Bihar). The sample is limited to states in continual existence from 1950 to 1990. Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Effects of FES on long-run industrial growth, for all states

	Dependent variable: $\Delta \ln$(Revenue)					
	(1)	(2)	(3)	(4)	(5)	(6)
(Ind. uses iron/steel) $\times$ ln(State dist. to ISP)	0.507**	0.527***	0.747***			
	(0.196)	(0.199)	(0.227)			
(Downstream iron/steel) $\times$ ln(State dist. to ISP)		0.252*				
		(0.151)				
(Ind. uses iron/steel) $\times$(State contains ISP)				3.524***	3.661***	5.110***
				(1.333)	(1.357)	(1.634)
(Downstream iron/steel) $\times$(State contains ISP)					1.779*	
					(1.057)	
Ind. uses iron/steel			4.308***			4.319***
			(0.960)			(0.958)
ln(State dist. to ISP)			0.338*			
			(0.198)			
State contains ISP						2.378*
						(1.383)
Observations	152	152	152	152	152	152
Adjusted R^2	0.778	0.783	0.217	0.778	0.783	0.218
State, Industry FE	✓	✓		✓	✓	

Notes: This table presents results of the main specification (1), with the sample including all available states. In the case of changing boundaries a 1950 state is match to the 1990 state overlapping with it most. All other details are as in Table 3 above. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Effects of FES on long-run location of downstream industries

	(1)	(2)	(3)	(4)
Panel A. Effect on $\Delta \ln(\textit{Revenue})$				
(Leontief share: iron/steel)	2.324**	2.345**	2.443**	2.395**
× ln(State dist. to ISP)	(1.148)	(1.152)	(1.166)	(1.173)
Observations	1048	1048	1048	1048
Adjusted R^2	0.623	0.975	0.974	0.975
Panel B. Effect on $\Delta \ln(\textit{Number of firms})$				
(Leontief share: iron/steel)	1.078*	1.102*	1.104*	1.204*
× ln(State dist. to ISP)	(0.609)	(0.613)	(0.620)	(0.628)
Observations	1063	1063	1063	1063
Adjusted R^2	0.729	0.906	0.901	0.902
Panel C. Effect on $\Delta \ln(\textit{Labor productivity})$				
(Leontief share: iron/steel)	0.605	0.615	0.674	0.590
× ln(State dist. to ISP)	(0.534)	(0.546)	(0.542)	(0.546)
Observations	1048	1048	1048	1048
Adjusted R^2	0.360	0.990	0.990	0.990
Control for State × (Coal use)		✓		
Control for State × (Fertilizer use)			✓	
Control for State × (Cement use)				✓

Notes: This table presents a version of (1) where the indicator of industry iron and steel use is replaced by the industry's Leontief input share of iron and steel use. Underlying this specification is equation (3) and the derivation in Appendix B. All regressions include state and industry fixed effects, and all other details are as above. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Effects of FES on long-run location of iron-using industries

	(1)	(2)	(3)	(4)
Panel A. Effect on $\Delta \ln(\textit{Revenue})$				
(Input share: iron/steel)	3.445*	3.773**	3.709**	3.671*
× ln(State dist. to ISP)	(1.841)	(1.851)	(1.873)	(1.882)
Observations	1063	1063	1063	1063
Adjusted R^2	0.631	0.975	0.975	0.975
Panel B. Effect on $\Delta \ln(\textit{Number of firms})$				
(Input share: iron/steel)	1.554	1.747*	1.610	1.771*
× ln(State dist. to ISP)	(0.962)	(0.961)	(0.982)	(0.996)
Observations	1078	1078	1078	1078
Adjusted R^2	0.730	0.908	0.903	0.903
Panel C. Effect on $\Delta \ln(\textit{Labor productivity})$				
(Input share: iron/steel)	1.182	1.229	1.315	1.192
× ln(State dist. to ISP)	(0.858)	(0.871)	(0.872)	(0.879)
Observations	1063	1063	1063	1063
Adjusted R^2	0.366	0.990	0.990	0.990
Control for State × (Coal use)		✓		
Control for State × (Fertilizer use)			✓	
Control for State × (Cement use)				✓

Notes: This table modifies the test of Table 5 by using the direct iron and steel input use share, instead of the Leontief share. All regressions include state and industry fixed effects, and all other details are as above. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Effects of repealing FES

	Dependent variable: $\Delta \ln(\text{Revenue})$					
	(1)	(2)	(3)	(4)	(5)	(6)
(Ind. uses iron/steel)	−0.502*	−0.518*	−0.518*			
× ln(State dist. to ISP)	(0.263)	(0.269)	(0.274)			
(Downstream iron/steel)		−0.051				
× ln(State dist. to ISP)		(0.178)				
(Ind. uses iron/steel)				−3.085	−2.781	−3.300
×(State contains ISP)				(2.251)	(2.305)	(2.165)
(Downstream iron/steel)					0.927	
×(State contains ISP)					(1.588)	
Ind. uses iron/steel			1.838			2.036
			(1.117)			(1.739)
ln(State dist. to ISP)			0.342***			
			(0.097)			
State contains ISP						3.270***
						(0.890)
Observations	1355	1355	1355	1355	1355	1355
Adjusted R^2	0.347	0.347	0.009	0.347	0.347	0.011
State, Industry FE	✓	✓		✓	✓	

Notes: This table studies the effect of repealing FES, by estimating (1) over the period 1990 to 2013. All other details are as in Table 3. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Effects of repealing FES, controlling for pre-trend from 1967 to 1990

	Dependent variable: $\Delta \ln$(Revenue)					
	(1)	(2)	(3)	(4)	(5)	(6)
(Ind. uses iron/steel) $\times$ ln(State dist. to ISP)	−0.497 (0.412)	−0.832** (0.423)	−0.519 (0.414)			
(Downstream iron/steel) $\times$ ln(State dist. to ISP)		−0.912*** (0.323)				
(Ind. uses iron/steel) $\times$(State contains ISP)				−0.789 (3.739)	−1.735 (3.812)	−0.992 (3.648)
(Downstream iron/steel) $\times$(State contains ISP)					−2.663 (2.886)	
Ind. uses iron/steel			−12.121*** (2.029)			−13.873*** (3.221)
ln(State dist. to ISP)			−0.346* (0.193)			
State contains ISP						−3.803** (1.659)
Observations	1118	1118	1119	1118	1118	1119
Adjusted R^2	0.447	0.452	0.013	0.447	0.447	0.015
State, Industry FE	✓	✓		✓	✓	

Notes: This table presents estimates of (6). All details are as in Table 7, except that the 1967 to 1990 pre-trend is taken out of the growth outcome variable. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A Additional tables

Table A1: Effects of FES on long-run industrial growth

	Dependent variable: $\Delta \ln$(Revenue)					
	(1)	(2)	(3)	(4)	(5)	(6)
(Ind. uses iron/steel) $\times$ ln(State dist. to ISP)	0.588**	0.600**	0.483***			
	(0.246)	(0.251)	(0.166)			
(Downstream iron/steel) $\times$ ln(State dist. to ISP)		0.157				
		(0.195)				
(Ind. uses iron/steel) $\times$(State contains ISP)				4.639**	4.712**	4.017***
				(1.809)	(1.845)	(1.228)
(Downstream iron/steel) $\times$(State contains ISP)					0.996	
					(1.343)	
Ind. uses iron/steel			2.260**			1.696**
			(0.898)			(0.697)
ln(State dist. to ISP)			0.675***			
			(0.111)			
State contains ISP						4.506***
						(0.764)
Observations	152	152	152	152	152	152
Adjusted R^2	0.354	0.349	0.202	0.356	0.351	0.193
State, Industry FE	✓	✓		✓	✓	

Notes: This table presents estimates of (1) as in Table 3, except that here state-industries are not weighted by 1950 size of state-industry. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A2: Effects of repealing FES, controlling for pre-trend from 1989 to 1990

	Dependent variable: $\Delta \ln$(Revenue)					
	(1)	(2)	(3)	(4)	(5)	(6)
(Ind. uses iron/steel) $\times$ ln(State dist. to ISP)	−0.702	−0.990*	−0.816*			
	(0.510)	(0.524)	(0.492)			
(Downstream iron/steel) $\times$ ln(State dist. to ISP)		−0.711**				
		(0.303)				
(Ind. uses iron/steel) $\times$(State contains ISP)				−1.554	−2.157	−2.420
				(4.174)	(4.224)	(3.938)
(Downstream iron/steel) $\times$(State contains ISP)					−1.634	
					(2.676)	
Ind. uses iron/steel			−10.856***			−12.946***
			(1.934)			(3.224)
ln(State dist. to ISP)			−0.404**			
			(0.183)			
State contains ISP						−4.338***
						(1.534)
Observations	1098	1098	1098	1098	1098	1098
Adjusted R^2	0.444	0.447	0.019	0.443	0.443	0.022
State, Industry FE	✓	✓		✓	✓	

Notes: This table presents estimates of (6) as in Table 7, except that here it takes out the instantaneous pre-trend from 1989 to 1990, instead of the long-run pre-trend going back to 1967. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B Conceptual framework: effects of changes in materials prices

Deriving Estimating Equations Consider a Cobb-Douglas model with input-output linkages. Production function takes the form

$$y_i = z_i l_i^{\alpha_i} \xi_i^{\gamma_i} \Pi_j x_{ij}^{a_{ij}}$$

where ξ_i is raw input (iron or steel) and x_j is the from industry j used for industry i. Suppose i indices for industries and there is a representative consumer with Cobb-Douglas preferences

$$U = \Pi_i y_i^{\beta_i}$$

We have

$$a_{ij} = \frac{p_j x_{ij}}{p_i y_i}$$

$$\alpha_i = \frac{w l_i}{p_i y_i}$$

$$\gamma_i = \frac{p_i^{\xi} \xi_i}{p_i y_i}$$

$$\frac{p_i c_i}{\beta_i} = \frac{p_j c_j}{\beta_j}.$$

$$p_i c_i = \beta_i w l.$$

Total differentiating, the equations above, we have

$$d \ln y_i + d \ln p_i = d \ln p_j + d \ln x_{ij} = d \ln l_i = d \ln p_i^{\xi} + d \ln \xi_i$$

$$d \ln p_i + d \ln c_i = d \ln p_j + d \ln c_j = 0.$$

To derive an estimating equation, total differentiating the production function:

$$d \ln y_i = d \ln z_i + \alpha_i d \ln l_i + \gamma_i d \ln \xi_i + \sum_j a_{ij} d \ln x_{ij}.$$

We now substitute the equations above and get

$$\begin{aligned} d \ln y_i &= d \ln z_i + \alpha_i d \ln l_i + \gamma_i d \ln \xi_i + \sum_j a_{ij} d \ln x_{ij} \\ &= d \ln z_i + \alpha_i \left(d \ln y_i + d \ln p_i \right) \end{aligned}$$

$$
\begin{aligned}
&+\gamma_i\left(d\ln y_i + d\ln p_i - d\ln p_i^{\xi}\right) + \sum_j a_{ij}\left(d\ln y_i + d\ln p_i - d\ln p_j\right)\\
= \;& d\ln z_i + \alpha_i\left(d\ln y_i - d\ln c_i\right)\\
&+\gamma_i\left(d\ln y_i - d\ln c_i - d\ln p_i^{\xi}\right) + \sum_j a_{ij}\left(d\ln y_i - d\ln c_i + d\ln c_j\right).
\end{aligned}
$$

Using the fact that $\alpha_i + \gamma_i + \sum a_{ij} = 1$, we have

$$
d\ln c_i = d\ln z_i - \gamma_i d\ln p_i^{\xi} + \sum a_{ij} d\ln c_j.
$$

In vector form,

$$
d\ln \mathbf{c} = d\ln \mathbf{z} - \gamma d\ln \mathbf{p}^{\xi} + \mathbf{A} d\ln \mathbf{c}.
$$

where capital bold-font letters indicate matrices and non-capital bold-font letters indicate vectors. We therefore have

$$
d\ln \mathbf{c} = (\mathbf{I} - \mathbf{A})^{-1}\left[d\ln \mathbf{z} - \gamma d\ln \mathbf{p}^{\xi}\right].
$$

Given Cobb-Douglas, we also have $d\ln \mathbf{c} = d\ln \mathbf{y}$ hence

$$
d\ln \mathbf{y} \;=\; (\mathbf{I} - \mathbf{A})^{-1}\left[d\ln \mathbf{z} - \gamma d\ln \mathbf{p}^{\xi}\right].
$$

We therefore have

$$
\begin{aligned}
d\ln y_i &= -\sum L_{ij}\left(dz_j + \gamma_j d\ln p_j^{\xi}\right)\\
&= \underbrace{-(dz_i + \gamma_i d\ln p_i^{\xi})}_{\text{own effect}} - \underbrace{\sum \left(L_{ij} - \mathbf{1}_{j=i}\right)\left(dz_j + \gamma_j d\ln p_j^{\xi}\right)}_{\text{network effect}}.
\end{aligned}
$$

We have derived the equation above assuming each i is an industry. Here, we can view dz_i as an industry fixed effect and $d\ln y_i$ is the change in output in industry i, while $d\ln p_i^{\xi}$ is the change in cost of the raw input ξ in industry i. Mapping to data, we have multiple observations for any given industry i as we have regional variation, hence the correct estimating equation should be

$$
d\ln y_{ir} = \delta_i + \delta_r - \gamma_i d\ln p_{ir}^{\xi} - \sum \left(L_{ij} - \mathbf{1}_{j=i}\right)\left(\delta_j + \delta_r + \gamma_j d\ln p_j^{\xi}\right) /
$$

One can run the regression in a reduced form way to lump own- and network-effect together:

$$
d\ln y_{ir} = -\sum_j L_{ij}\left(\delta_j + \delta_r + \gamma_j d\ln p_j^{\xi}\right).
$$

Losing some efficiency, we can relax the restrictions that the fixed effects have to be consistent across equations, and instead run

$$d \ln y_{ir} = \delta_j + \delta_r - \sum_j L_{ij} \gamma_j d \ln p_j^{\xi}.$$