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Abstract

We examine how trade integration affects the incentives and policy choices of local governments, using the construction of China's national expressway as a natural experiment. We find that governments of peripheral counties connected to expressway "gave up" by adopting less business-friendly policies. Affected local governments changed both the level and the composition of public spending, and became less involved in inter-jurisdictional spending competition. Private firms in connected peripheral counties received fewer subsidies and faced higher effective tax rates, while state-owned firms were less likely to be privatized. These policy changes contribute significantly to the observed output decline in these regions.

Keywords: local governments, transportation, infrastructure, institution

JEL Classification: H4, H7, O18, R4, R5

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1 Introduction

Trade and the change of market access affect institutional quality (Levchenko, 2013; Nunn and Trefler, 2014). As large-scale transportation infrastructure like intercity expressway enhance domestic trade, they could influence an important institution within a nation's boundary–the incentives and quality of sub-national governments. Most studies on transportation infrastructure focus on how such projects affect economic growth or regional inequality (Chandra and Thompson, 2000; Donaldson and Hornbeck, 2016; Donaldson, 2018; Michaels, 2008), and find that the benefits of trade and economic integration may not be equally distributed (Banerjee, Duflo and Qian, 2020; Baum-Snow et al., 2018; Faber, 2014; Puga and Venables, 1997). Little attention has been paid to how improved domestic trade affects incentives and policy choices of local governments. Can the observed variations in the quality of sub-national governments be a result of policies that aim to boost regional trade integration? If so, how changes in sub-national governments' policy making contribute to their different growth experiences? We address these issues in this study using the construction of the expressway network in China, one of the largest in the world, as a natural experiment.

Quality of government contributes to economic growth and development. In the Chinese context, many argue that giving the "right" incentives to local governments contributed significantly to the phenomenal growth of the country's economy during its early transition period (Bardhan and Mookherjee, 2006; Cull et al., 2017; Jin, Qian and Weingast, 2005; Li and Zhou, 2005; Montinola, Qian and Weingast, 1995; Oi, 1992). Despite decades of economic growth, economic gaps between regions are widening. The quality and performance of local governments also vary widely across regions in China and convergence has not occurred. This heterogeneity arises alongside various policies implemented by the central government to enhance domestic trade and reduce regional inequality.

One important policy that connects richer and poorer parts of the country is to build an extensive transportation network. A total estimated cost of 240 billion US dollars has been spent on expresssway network construction in China during the period 1992-2020. While the expressway boosts cross-region trade and economic integration, we show in this study that it has somewhat surprising implications for the incentives and quality of peripheral governments. Specifically, we find various indicators show that peripheral county governments started to pursue less business-friendly policies, especially towards private firms, after being connected to the expressway network. We further show that this change in local governments' behaviour is a crucial mechanism through which the expressway negatively affects peripheral regions' output growth, as documented in Faber (2014) and Baum-Snow et al. (2018).

To motivate our empirical analyses, we provide a simple theoretical framework in the spirit of Cai and Treisman (2005). We show the mechanism through which intercity transportation leads peripheral governments to pursue less business-friendly policies. Similar to previous work on market access and endogenous institutional quality, our model indicates that local government's pursuit of business-friendly policies is determined by equating the economic return to such policies with their opportunity costs. Our model suggests that local governments facing a larger market are more likely to adopt pro-business policies as the return of such policies are likely to be higher. Consequently, intercity transportation may have created a vicious circle for peripheral regions–a shrinking market leads to a less friendly government which in turn dampens economic activities that are already in decline. Our thought experiment also echoes the view in several studies (Ludema and Wooton, 2000; Baldwin and Krugman, 2004) which analyze how trade integration affects tax competition among regions.

Empirically, we adopt the difference-in-differences (DID) strategy to analyze changes in various policies that local governments could utilize to attract private businesses after they were connected to the expressway during the period 1996-2010, compared with the unconnected peripheral counties. To address the potential endogeneity of the connection status, we adopt the inconsequential units approach that is widely used in the literature on transportation and economic growth (Redding and Turner, 2015). Specifically, we use connected counties that are not targeted main nodes in the expressway network to form the treatment group, and compare them with non-connected counties in the DID estimations. This approach assumes that intercity transportation connects smaller units, such as peripheral counties, only because they happen to lie along the routes between major nodes. Hence, the connection status of a peripheral county does not depend on local economic conditions or other unobserved characteristics. We further conduct Instrumental Variables estimations, exploiting the variation that non-targeted counties on a hypothetical minimum-cost path that link major nodes are more likely to be connected to the expressway. By interacting the indicator for being on the minimum-cost path with province-year specific intensity of expressway construction, we obtain an instrument that is exogenous to local economic conditions and also varying over time. Further robustness checks suggest that there is little spillover effect on non-connected counties, which lends support to our empirical strategy.

We examine several policy variables that reflect the quality of local governments, especially their incentives and attitudes towards private businesses. First, we examine the level and the composition of local governments' budgetary spending, as well as their involvement in spending competition with neighbors. How much a local government spends and how it allocates its resources matter for both the creation of firms and the flow of businesses across regions. On the other hand, governments with larger consumption and hence less expenditures, are more likely to be corrupt (La Porta et al., 1999). Relative to comparable unconnected counties, we find that governments of connected peripheral counties significantly reduced the level of budgetary spending even after controlling revenue, especially on capital outlays which are most likely to be productivity-enhancing. Counties also engaged in spending competition with their neighbors to attract businesses, but they became less keen following the expressway connection. These changes in local governments' spending policies are first evidence that affected peripheral governments "give up" efforts for growth.

Second, we examine whether trade integration changes peripheral governments' incentive provisions for firms, including subsidies and tax. Utilizing the survey on manufacturing firms, we find that private firms in connected peripheral counties experienced a drop in the level of subsidies from the local governments. They also became less likely to receive government subsidies. On the other hand, these firms faced an increase in their effective corporate income tax rates, relative to firms in unconnected counties. Interestingly, state-owned firms (SOEs) in connected peripheral counties did not lose their subsidies. Nor did they have to pay more corporate taxes. These results again suggest that transportation and trade integration may have led peripheral county governments to change from a "helping hand" to a "grabbing hand".

Third, we find that trade integration may also have changed local governments' attitude towards privatizing state-owned enterprises. As peripheral counties lost market following the expressway connection, the benefits of privatizing SOEs became smaller despite potential efficiency gain. Furthermore, our thought experiment predicts that a private firm in a connected peripheral county would tend to relocate to nearby core areas. In contrast, an SOE is generally less mobile. For these reasons, we hypothesize that connected peripheral county governments, especially those facing a smaller initial market size, would be less willing to privatize SOEs. Using the firm-level survey that traces firms' ownership type over time, we find that when a peripheral county was connected to the expressway, the probability of a firm staying as an SOE during our sample period was substantially higher in connected peripheral counties, relative to that of a firm located in non-connected counties. Not only would this slow-down in privatization affect economic growth, it may also imply a deterioration of market environment and institutional quality as SOEs are often linked with protectionism and rent-seeking.

How did these changes in the quality and performance of local governments feedback on the economy? Previous studies document a decline of output in connected peripheral counties (for example, Faber (2014)), but they are silent about the role played by local governments. We conduct a simple back-of-envelop calculation, which suggests that policy changes following the expressway connection can explain at least 24% of the output decline among affected counties. This is not a small effect that has nevertheless been neglected in previous work.

Our study contributes to at least three strands of literature. First, this paper links to a growing literature that institutional quality and trade policy can endogenously respond to the change of market access. Levchenko (2013) examines how trade openness may lead to changes in institutional quality of countries such as property rights and contract enforcement. Stefanadis (2010) shows that institutional quality could worsen for countries with weak political institutions when trade opens. Guimaraes and Sheedy (2020) suggest that countries could specialize in providing better or worse institutions when trade cost is reduced, based on evidence from the transition from sail to steam-powered vessels in the 19th century. Jiao and Wei (2017) examine if China's accession to the WTO changes its trading partners' institutional quality. Our paper differs from previous work in two aspects. While previous studies focus on how international trade affects institutions across countries, we analyze how domestic trade influences sub-national governments. Our analyses provide a new angle to understand factors driving divergence in both wealth and institutional quality across regions within a nation. Unlike previous work that examines how countries protect property rights or enforce contracts, we examine local governments' incentives to attract private businesses reflected by their spending policies, subsidies and taxes, as well as their attitudes towards privatization. Arguably, quality of sub-national governments is more likely to diverge in these aspects while other institutional characteristics, like rule of law, are likely to be more homogeneous within a country.

Second, we relate to research on determinants of the quality of government. Most studies on this topic use cross-country data, and only a few have examined the interesting question why the quality of some sub-national governments are higher than others, even though they share many formal institutions (Charron and Lapuente, 2013). Whether or not to choose national or sub-national governments as the subject, this literature has emphasized the role of history, politics and culture in shaping government quality (La Porta et al., 1999). By emphasizing the effect of market size on the incentives of local governments, our study echos the alternative view that how institutions are formed is determined by balancing benefits and transaction costs (North, 1981). The thrust of the economic theories for the creation of institution is that economic development itself creates a demand for good institution (La Porta et al., 1999). We show the opposite is also true—shrinking opportunities for development would lower the demand for good institution. Using the exogenous shocks due to the expressway connection, we also tackle the challenge of reverse causality from institution to development.

We also provide a new perspective for understanding the effects of transportation infrastructure on regional growth. The new economic geography theories predict that market accessibility from new roads would benefit the core regions at the cost of periphery (Puga and Venables, 1997), while empirical evidence is somewhat mixed. Surprisingly this literature is more or less silent about the links between infrastructure, access to market, and government behavior. Until recently, the role of government quality has seldom been considered when examining the effects of transportation infrastructures (Crescenzi, Di Cataldo and Rodríguez-Pose, 2016). As far as we know, we are the first study to explicitly examine the impact of large-scale transportation infrastructure on the incentives and policy choices of local governments.

The remainder of the paper is structured as follows. Section 2 explains the mechanism. Section 3 provides the policy background. We describe our data in Section 4 and estimation results in Section 5. Section 6 concludes.

2 Mechanism

When there is trade and capital flows between regions, location of firms depends on local production advantages relative to local demand. Intercity transportation like national expressways not only reduces transport cost of goods but also changes the relative production advantages between connected regions. As shown in Faber (2014), firms in hinterlands tend to move to core areas with the access to cheaper transportation. When intercity transportation concentrates rather than diffuses production, the incentives of local governments to attract private capital and promote growth may change.[1] We illustrate this market size effect below.

While we only discuss the main features and predictions of the theory, Appendix A provides a more formal model that is in line with discussions here.[2] We make several assumptions to reach our theoretical predictions. First, we assume that private and public capital are complements in production by employing a Cobb-Douglas production function, which is supported by several empirical studies (Lynde and Richmond, 1992; Cavallo and Daude, 2011). Second, local governments put at least some weight on promoting economic activities in their objective functions. This is a reasonable assumption, as previous studies indicate that economic growth matters for promotion of local politicians in the context studied in this paper (Li and Zhou, 2005). More, we assume that local governments cannot affect interest rate in equilibrium, which allows us to simplify the model without loss of the main features.

Consider two jurisdictions, H and L. H has higher endowment in total factor productivity (TFP) than L due to exogenous factors such as geographical location or natural resources. There is a single manufactured goods. The representative firm in each jurisdiction has access to local technology that produces the manufactured goods with decreasing marginal product of private capital. Governments of both jurisdictions H and L can provide resources that enhance local productivity. It is necessary to emphasize that in our model, such government provision is a rather general concept that covers any pro-business policy measures, and is not limited to growth-enhancing public expenditure.

Manufactured goods are tradable subject to some trade cost. That is, for each unit of goods sold to the other jurisdiction, there is a constant trade cost per unit of goods. All else equal, production in H has lower marginal cost due to better productivity endowment. This in turn implies a lower unit price and consequently, jurisdiction H would export to jurisdiction L with a low level of trade cost. However, when the trade cost between the two jurisdictions is high, each jurisdiction sells mostly to its domestic market and trade is limited.

[1] Local governments may also change how they differentiate from each other when engaging in fiscal competition in providing different infrastructure services (Justman, Thisse and Van Ypersele, 2002, 2005).

[2] Appendix B provides more technical details.

The level of production in jurisdiction L needs to be large enough to meet local demand, which requires a significant presence of private capital. In this scenario, the local government of jurisdiction L would have strong incentives to enhance local production, since a large scale of local production would benefit from its pro-business measures. Moreover, the more weight jurisdiction L puts on local production in its utility function, the stronger incentive it would have to provide productivity-enhancing policies.

When inter-city transportation reduces the regional trade cost, a general equilibrium model as illustrated in Appendix A predicts that jurisdiction H would now export more to jurisdiction L, whose production of the manufactured goods would be crowded out. Further, as H produces at a lower unit price due to its productivity advantage, the price in L in equilibrium would decrease with exports from H. Together, these suggest a shrinking market size faced by firms in L . Appendices A and B show that this change in market size would lead to a lower level of government provision in equilibrium. Intuitively, the marginal benefit of government provision declines in L, as a smaller scale of local production is left to benefit from its pro-business measures.

Our model is not limited to certain types of government policies that enhance productivity. Thus, empirically we investigate the impact of the expressway on various growth-related policy instruments, depending on available data. While government spending, such as that on water and electricity, may be the most direct form of productivity-enhancing public goods, there can be other less direct growth-promoting policies. This may include government subsidies that ease firms' financial constraints, which can be important for firms in developing countries. Lowering firms' effective tax rate via discretionary tax incentives is another popular policy instrument to promote firm growth. Moreover, governments can promote local productivity by re-arranging firms' ownership. Allowing private ownership to play a dominant role in previously state-owned enterprises is one example. Finally, the incentives of the local government to promote growth can also be reflected by its engagement in inter-jurisdictional spending competition, which in China often aims to attract private capital. We examine the impact of the expressway on all these government policies below.

3 Chinese expressway: policy backgrounds

The construction process of the Chinese national expressway network has been documented in various studies (Baum-Snow et al., 2017, 2018; Faber, 2014). Starting from 1992, the network aims to connect provincial capitals and major cities, to reduce the economic gap between the eastern and western parts of the country, and to facilitate trades with bordering countries. The construction of Chinese national expressway takes several stages. The first stage was to build the 7-5 network, which consists of 7 horizontal and 5 vertical routes. The construction was completed by 2007, 13 years ahead of its schedule. In 2004, the plan was expanded to construct 7 radical expressways connecting Beijing and major cities, 9 north-south expressways, and 18 east-west expressways (the 7-9-18 network). Again, the new plan was completed ahead of schedule by 2011.

Figure 1 shows the national expressway network. The red lines indicate routes that were completed by 2010. In addition to connecting major cities, the expressway also connects peripheral counties which are not main nodes of the network. Figure 2 shows the percentage of counties connected to the expressway network during the period 1992-2010. With the gradual construction process, more counties were connected to the network over time. By 2010, around 60 percent of 2,408 counties in our sample had been connected to the expressway network.

The construction of the Chinese national expressway network is financed by various sources, which is a natural outcome given the sheer scale of the project. The major share of investment is conducted by profit-making expressway companies controlled by provincial governments through Private-Public-Partnership (Bai and Qian, 2010; Xu, 2011). Most of these companies are listed in stock exchanges and raise fund using various financial instruments, including bank loans, bonds, share issuance, and asset-backed securities. Bank loans are especially important for financing the expressway construction, and are provided by large state-owned banks. Usually, the expressway companies are the borrower and the provincial governments serve as the guarantee. All expressways in China are toll roads, and the estimated connection of toll fees is used to back the loans to the expressway companies.

Faber (2014) shows that the Chinese expressway had a negative impact on the output growth of connected peripheral counties, relative to unconnected ones. While Faber (2014) uses two years' data in 1997 and 2006 alone, we have county-level panel data for the period 1996-2010. Despite the differences in the nature of the data, we find similar results to those in Faber (2014). We examines in Appendix C the effect of expressway connection on peripheral counties' output and population using difference-in-differences specification with our panel data. It shows that relative to unconnected counties, connected counties experienced lower total output growth, relative to unconnected peripheral counties. The decline in total output growth in connected peripheral counties was primarily driven by a lower industrial output growth, while little changed in agricultural output growth. There is also a significant decline in population growth in connected peripheral counties, consistent with the conjecture that labour would accompany capital movement. We find similar patterns when using a shorter panel for the period 1996-2006, which corresponds to the sample period as in Faber (2014). These results, as argued by Faber (2014), suggest that the expressway connection moved productions from peripheral counties to nearby core regions.[3]

[3] An alternative explanation for these results is that production was relocated to non-connected counties from connected ones. However, this explanation is ruled out by Faber (2014) after careful analysis.

4 Data and empirical strategies

We use the China Expressway Database provided by ACASIAN to obtain information on the construction process of the Chinese expressway network. The data is based on a variety of road atlases published by the Chinese government over the years, which indicates the status of expressway construction starting from 1992. The database contains geo-referenced location of 4,161 expressway segments. It also contains the status of each segment from multiple sources of road atlas in 1992, 1993, 1998, 2000, 2002, 2003, 2005, 2007 and 2010. Combined with administrative boundary information, this data allow us to determine if a county is connected to the expressway. Specifically, we define a county as being connected to the expressway in a given year if a completed expressway segment is found within the county boundary as indicated in the road atlas.

To evaluate policy choices of county-level governments, we use both county-level and firm-level data. County-level variables, such as output, population density, and government spending, are obtained from official county-level statistics yearbooks during 1996-2010. We start with 1996 which is the earliest year when most county-level statistics are available. The sample stops in 2010, which is the last year we have information on expressway construction for. Our sample includes 1,937 counties for sample period. Firm-level variables are obtained from the Industrial Enterprise Survey on a comprehensive sample of manufacturing firms during 1998-2007, which is conducted by China's National Statistics Bureau. From the firm-level surveys, we observe firm-level characteristics like size, profitability, exporting status, tax paid, and time-varying ownership types. We also obtain useful information such as whether a firm receives government subsidy and the amount of subsidies. Firms in the survey are matched to counties based on their area codes. Table 1 provides summary statistics for key county-level and firm-level variables.

We use a difference-in-differences approach to evaluate policy changes of local governments. Since different counties were connected to the expressway network in different years, we have a setting of a staggered reform. Similar to the inconsequential units approach that is often employed in evaluation of the impacts of intercity transportation projects (Redding and Turner, 2015), we first exclude cities and counties that are main nodes of the expressway network as in the $National\ Expressway\ Network\ Plan$ (He, Xie and Zhang, 2018). While not serving as network nodes, many counties are still connected to the expressway and others are not. It is sensible to assume that these peripheral counties are connected to the expressway only because they lie close to the routes between main nodes of the network, and to regard their connection status as being randomly assigned. Under this assumption, we then compare changes in policies adopted by connected and unconnected peripheral counties, using the standard DID estimator.

To evaluate how the expressway connection affected local governments' budgetary spending, we use county-level panel data and estimate Equation 1 below:

$$Y_{j,t} = \alpha + \beta Connected_{j,t} + \gamma X_{j,t-1} + \mu_t + \delta_j + \epsilon_{j,t} \tag{1}$$

where $Y_{j,t}$ stands for a set of policy variables in county j in year t, including budgetary spending and its different components; $Connected_{j,t}$ is a dummy variable that equals 1 since county j is connected to the expressway; $X_{j,t-1}$ is a set of county-level control variables measured in year $t-1$; μ_t is the year fixed effects, δ_j is the county-specific fixed effects, and $\epsilon_{j,t}$ is the unobserved error term. The treatment effect of expressway connection is captured by the parameter β.

When capital is mobile, local governments would also engage in spending competition with its neighbours to attract business activities. If the expressway connection weakened local governments' incentives to attract private capital, it should also be reflected by less involvement in inter-jurisdictional spending competition. To test this hypothesis, we estimate a spatial model as Equation 2:

$$EXP_{j,t} = \alpha EXP_{j,t-1} + \rho_1 \overline{EXP}_{j,t} + \rho_2 Connected_{j,t} \times \overline{EXP}_{j,t} + \beta Connected_{j,t} + \gamma X_{j,t-1} + \mu_t + \delta_j + \epsilon_{j,t} \tag{2}$$

where $EXP_{j,t}$ is real government expenditure per capita in county j in year t; $\overline{EXP}_{j,t}$ is the average expenditure of county j's neighboring counties weighted by distance. The parameter of interest is ρ_2, which measures the change in the sensitivity of connected counties' spending towards its neighbors' average spending following the expressway connection, relative to the control group.

As a complement to analyses based on county-level data, we further use firm-level survey data to examine policy changes in connected peripheral counties. For this purpose, we estimate Equation 3 below at firm level:

$$S_{i,j,t} = \alpha + \beta Connected_{j,t} + \gamma X_{j,t-1} + \psi Z_{i,j,t-1} + \mu_t + \theta_i + \omega_{i,j,t} \tag{3}$$

where $S_{i,j,t}$ is a set of firm-level outcome variables, such as subsidies and the effective corporate income tax rate, for firm i located in county j in year t; $X_{j,t-1}$ is a set of county-level control variables and $Z_{i,j,t-1}$ is a set of firm-level control variables, both measured in year $t-1$; θ_i is the firm-specific fixed effects, and $\omega_{i,j,t}$ is the unobserved error term.

While the inconsequential units approach reduces potential endogeneity of the connection status to a large extent, we construct instrumental variables that predict expressway connection and conduct the IV regressions as robustness checks. In line with previous work (Faber, 2014; He, Xie and Zhang, 2018), we construct a hypothetical path that connects all major nodes in the expressway network in a distance-minimizing manner.

Specifically, we construct a hypothetical network using a minimum spanning tree algorithm so that it consists of straight lines between major nodes using minimum number of bilateral connections.[4] A county that lies on this hypothetical path is then more likely to be connected to expressway due to its geographical location.

To obtain time-varying IVs, we interact the indicator for whether a county lies on the hypothetical path with the intensity of the expressway construction process in each province. We measure the intensity of the expressway construction process using the share of counties connected to the expressway in each province in a given year. The chance of a county being connected in a given year increases with the intensity of construction process in the whole province, and that needs not relate to economic conditions of individual counties. Our time-varying instrument is thus specified as $Z_{j,p,t} = MST_j \times S_{p,t}$, where MST_j is an indicator for county j lying on the hypothetical network and $S_{p,t}$ is the share of counties with expressway connections in province p in year t. In the estimation of Equation 2, we also use neighbor's lagged demographic variables including number of students per capita, number of hospital beds per capita and the number of government employees per capita as instruments for the average expenditure by county j's neighboring counties, $\overline{EXP}_{j,t}$.

5 Empirical results

Our thought experiment shows that the expressway connection would make connected peripheral local governments less business-friendly. To test this, we examine the impact of the expressway on several growth-related policy choices of peripheral county governments. In Section 5.1, we investigate changes in local government's budgetary spending, including both its level and composition. We also examine local governments' involvement in inter-jurisdictional spending competition. In Section 5.2, we use firm-level survey data to examine changes in other policies, including government subsidies and effective tax rate. In Section 5.3, we analyze the impact of the expressway on the process of privatizing state-owned enterprises.

5.1 Local governments' spending policies

5.1.1 The level and composition of budgetary expenditures

Government spending can significantly affect growth and local governments often engage in spending competition to attract private capital. On the other hand, governments with larger consumption are prone to corruption. We first analyze whether the expressway connection led to changes in the level of total budgetary spending in peripheral counties, controlling for either output or revenue. Specifically, we estimate Equation 1 where the dependent variable is real budgetary spending per capita (in natural logarithm) in county j in

[4] We use Kruskal's algorithm to construct the minimum-distance path. We plot the path in Figure D1.

year t. We control for lagged real output per capita (in natural logarithm), population density, and the share of agricultural output in total output throughout different columns. A set of year dummies is included to control for common business cycle effects. Standard errors are clustered over county. Column 1 of Panel A, Table 2, reports the result using the sample 1996-2010. Relative to unconnected counties, governments of connected peripheral counties significantly lowered their total spending per capita by around 3 percentage points following the expressway connection. The same pattern is found when we use a shorter sample for the period 1996-2006 (Column 2). Note that this decline in local government expenditure and hence, an increase in government consumption, is unlikely due to substitution–the expressway connects counties to other counties and cities in the network and it should not affect spending on local roads that usually connects towns and villages within a county. Moreover, as discussed above, the financing of expressway is mainly from provincial governments and large transportation companies. Thus, its construction should have little impact on county-level governments' budgets.

We obtain similar results in the first columns of Table D1 when we use the ratio of budgetary spending to total output as the dependent variable. To address the concern that fiscal squeeze due to the fall in revenue, rather than changes in incentives, leads to the observed drop in spending, we use the ratio of spending to revenue as the dependent variable in columns 3 and 4 of Table D1. There, we find that the spending-to-revenue ratio dropped significantly among peripheral county governments after the expressway connection. Thus, the decline in spending is unlikely to be caused by the decline in revenue alone.

We next allow for more flexible dynamic effects in our estimation, by replacing $\beta Connected_{j,t}$ in Equation 1 with a set of indicators for number of years relative to expressway connection. Figure 3 plots the point estimates for the coefficient on these indicators. It shows that the parallel pre-trend between the connected and unconnected counties generally holds, as the estimated coefficients on the difference between the two groups before the expressway connection are not significantly different from 0. However, government expenditure declines steadily upon expressway connection.

Some types of government spending, such as local roads, sewers and utilities, may have a larger and more immediate effect on local output and be more powerful in attracting new business activities. Other public goods, such as schools, hospitals, recreational facilities and social services, are likely to have a less immediate impact on local production. Keen and Marchand (1997) suggest that to attract private capital, local governments would over-provide public inputs that are most production-enhancing, while under-provide other types. If the expressway weakened county governments' growth-promoting incentives, we may observe a shift in the composition of budgetary spending.

We test this hypothesis in Columns 3-6 of Table 2, where the dependent variable is the share of different categories of government spending in total budgetary spending. We divide total budgetary spending into four categories: capital outlays that mainly contain spending on local infrastructure[5], education, public administration, and others that mainly contain spending on hospitals and social welfare. As the official classifications of county-level budgetary spending changed dramatically from 2007, we use the sub-sample of 1996-2006 for this exercise. The results reveal a significant change in the composition of local government expenditures upon the expressway connection. The share of capital outlays was reduced by around 0.9 percentage point, compared with unconnected counties. Meanwhile, the share of spending on administration and social welfare increased by 0.3 and 0.8 percentage point, respectively. These changes in spending composition among connected counties are also statistically significant.

In Panel B, we use our instrumental variable to address the potential endogeneity of counties' connection status, as discussed in Section 4. In the first stage regression (Table D2), we find that our instrument is highly significant. The point estimates in Panel B are of the same signs as those in Panel A, and are strongly significant. We obtain a larger impact of the expressway on connected counties' spending level and composition. For example, the share of capital outlays in total spending was lowered by 6 percentage points in connected peripheral counties. If the network planners tend to connect more prosperous regions, the connection status is likely to be positively correlated with unobserved local economic conditions. This would yield upward bias in OLS estimates for total spending or share of capital outlay.[6] The IV estimations results reinforce the OLS results, which lends further support to our theoretical prediction that the expressway connection led to a reduction in the provision of productivity-enhancing public goods.

5.1.2 Inter-jurisdictional spending competitions

Changes in the incentives of local governments can also be reflected in their involvement in inter-jurisdictional fiscal competition. In particular, when a county government's incentives for attracting capital is weakened, we may observe a moderation in its involvement in inter-jurisdictional fiscal competition. We test this hypothesis by analyzing patterns of county-level spending competitions before and after the expressway connection. We focus on spending competition instead of tax competition for two reasons. First, previous studies show that local governments engage in spending competition to attract private capital (Keen and Marchand, 1997; Bucovetsky, 2005; Taylor, 1992). While the majority of the literature on fiscal competition focuses on tax competition, Taylor (1992) suggests that public spending may be a more powerful inducement to business

[5]There is no separate item for infrastructure spending in the official county-level statistics yearbooks.

[6]The same comparison between OLS and IV estimates is found by Faber (2014). Large IV estimates (in absolute magnitude) could also be consistent with the presence of spillover effects from expressway connection. In that case, the unobserved error term in Equation 1 would be composed of the effects for being located close to expressway. Our instrument, constructed from hypothetical path of network, predicts whether a county is connected to the expressway, while on the other hand may also predicts whether a county is located close to the expressway if not actually connected. This implies our instrument could be correlated with the unobserved error term in Equation 1, and may lead to larger IV estimates than the true treatment effect if the spillover effect has the same sign. In the section that follows, we explicitly analyse how counties close to the connected ones are affected through inter-jurisdictional spending competition channel.

than tax incentives. This is likely to be true especially in developing countries, where inadequate public goods provision is often the bottleneck for investment. Second, Chinese local governments do not have the legal rights to change the statutory tax rates. Even though local governments can still provide discretionary tax incentives, like tax rebates and exemptions, the scope of tax competition is likely to be more limited.

Table 3 reports the estimation results based on Equation 2. When calculating the weighted-average spending by county j's neighbors, we use the inverse square distance between two counties within the same province as the weight ($w_{j,k} = \frac{1}{d_{j,k}^2}$). If two counties are in different provinces, the weight is set to be 0. Columns 1 and 2 report the OLS estimation results, based on the full sample (1996-2010) and the shorter sample (1996-2006), respectively. The first observation is that Chinese counties engaged in spending competitions to a large extent before the expressway connection, as indicated by the large positive coefficient on $\overline{EXP}_{j,t}$. When weighted average spending of neighbors increased by 1 RMB, real expenditure per capita of county j would increase by 0.5-0.6 RMB. There is strong evidence that connected peripheral counties became less involved in spending competition with its neighboring counties, compared with unconnected ones. When a county was connected to the expressway, its spending sensitivity to $\overline{EXP}_{j,t}$ dropped by around -0.14, which is statistically significant at 1 percent level.

In Column 3, we report the IV estimation results based on the shorter sample. Specifically, we use $Z_{j,p,t} = MST_j \times S_{p,t}$ to instrument county j's connection status. We further use neighboring counties' demographic characteristics to instrument their spending and $\overline{EXP}_{j,t}$. These include the number of student per capita, the number of hospital bed per capita and the number of government employees per capita, all lagged by one year. There, we again find that connected peripheral counties became less sensitive to neighbors' spending. Columns 4-7 report the spatial estimation results based on Equation 2 for different expenditure categories. While there was a universal decline in the extent of competition engagement across different types of spending by connected counties, such decline was most substantial regarding capital outlays. We report the IV estimation results for each spending category in Table D3, using our baseline IV strategy. There, we find a significant and substantial decline in the extent of competition in terms of capital outlays. In contrast, while the point estimates for other spending categories are all negative, they are not statistically significant.

As a further robustness check, we use an alternative weight matrix to calculate the weighted average spending by neighbors. The results are reported in Table D4. There, the weight matrix has each element $w_{j,k} = 1$ if counties j and k belong to the same province and share a border, and 0 otherwise. Similar patterns are found as those in the baseline model. Overall, these results suggest that the expressway connection reduced county governments' involvement in spending competitions with neighbors, especially in capital outlays.

5.2 Firm-level evidences

We use the Industrial Enterprise Survey from 1998-2007 to further investigate whether expressway connection altered county governments' policy choices. We focus on two policy tools that local governments can use to promote business: subsidies, and firms' effective corporate income tax rate.

5.2.1 Subsidies

In China, government subsidies can be productivity enhancing as they are an important source of financing along with bank loans (Allen, Qian and Qian, 2005; Chen, Lee and Li, 2008). Government subsidies are likely to be especially important for privately-owned Chinese firms, which face greater financing barriers than SOEs. Both central and local governments can provide subsidies, but local governments play an increasingly important role since the 1980s (Lim, Wang and Zeng, 2018). Even though local governments should follow guidance of the central government in determining subsidies, they enjoy much discretion over not only who gets the subsidies but also how many. Subsidies can be either monetary (for example, direct cash payment) or be in various non-monetary forms such as land grants and price subsidies. From the Industrial Enterprise Survey, we only observe the monetary subsidies that are reflected in firms' financial statements. The subsidy variable we obtain from the Survey is generally production-related, and is not specific to innovation or exporting activities.

We first examine whether governments of connected counties became less likely to provide subsidies. In Panel A of Table 4, we estimate a Logit model of Equation 3 where the dependent variable is a dummy that equals 1 if firm i in county j received subsidies in year t, and 0 otherwise. On the right-hand side, we control for firms' profitability, size, exporting status and a set of county-level covariates, all measured in $t-1$.[7] Pooling all firms together, the estimated marginal effect on $Connected_{j,t}$ is negative but statistically insignificant. However, an interesting contrast appears once we differentiate between SOEs and non-SOEs. While there was no change in the probability of receiving subsidies for SOEs (Column 2), the chance of receiving subsidies was significantly lowered for non-SOEs in connected counties (Column 3). We report the IV estimation results in Columns 4-6 and obtain the same patterns. The estimated magnitude of the change is also larger regarding non-SOEs. According to Column 6, the expressway connection reduced the probability of receiving subsidies by 12%.

In Panel B of Table 4, we examine the intensive margin of subsidies based on Equation 3, where the dependent variable is the amount of subsidies firms received (in natural logarithm). In the OLS estimations, the point estimate on $Connected_{j,t}$ regarding SOEs is positive (Column 2) and that regarding non-SOEs is

[7] As we control for firm-level fixed effects in the Logit estimation, firms that never received subsidies and those always receiving subsidies during our sample period are automatically dropped in the estimations.

negative (Column 3), although not statistically significant. We obtain a negative and significant coefficient on $Connected_{j,t}$ using the full sample in the IV estimations (Column 4), which is driven by non-SOEs (Column 6). The estimated effect of the expressway connection on the amount of subsidies provided for non-SOEs is rather large in the IV estimations–a close to 90% reduction on average. Taken together, results in Table 4 suggest that non-SOEs in connected peripheral counties not only faced a lower chance of receiving government subsidies, but also received a smaller amount. In contrast, SOEs were not affected.

5.2.2 Effective tax rate

Another proxy we examine using firm-level survey data is the effective corporate income tax rate. Although county-level governments cannot change the statutory corporate income tax rate in China, they can affect firms' effective tax rate through various channels. For example, local governments can change the degree of tax enforcement. Local governments can also provide ad hoc tax rebates on a case-by-case basis (Wu et al., 2007). If a county government became less business friendly, we may observe strengthened enforcement or reduced tax rebates, both of which should lead to a higher effective tax rate.

We measure firm-level effective tax rate using financial statement information from the Survey. We define the effective corporate income tax rate to be the ratio of corporate income tax payable to total pre-tax profits. To have a meaningful measure of the effective tax rate, we exclude loss-making firms and truncate the effective tax rate to be between 0 and 1. We then use the effective corporate income tax rate as the dependent variable in Equation 3. In addition to county-level variables, we control for firms' lagged profitability, size, interest expenses (scaled to total sales), and export status, all of which can influence the effective tax rate.

Table 5 reports the estimation results. Taking all firms together, firms in connected counties experienced 0.8 percentage point increase in their effective tax rate after the expressway connection, relative to those located in unconnected counties. This is roughly 3% increase in the effective tax rate, since the pre-treatment average effective tax rate for the treated firms was 0.27.

Local governments may have different attitudes towards SOEs and non-SOEs when it comes to tax collection. It is also worth noting that while state-owned and private domestic firms faced the same statutory corporate income tax rate during our sample period, foreign firms faced a lower statutory rate. Therefore, in Columns 2-4, we distinguish between different types of firms and re-estimate the impact of the expressway connection on firms' effective tax rate. Interestingly, we find that only domestic private firms experienced the increase in effective tax rate. The results in the OLS estimations largely hold when we instrument the connection status in Columns 5-8. For privately-owned firms, we estimate that the expressway connection led to 2.5 percentage points increase in their effective corporate income tax rate, which is not trivial.

5.3 Privatizing state-owned firms

Finally, we examine whether the expressway connection influenced the privatization process in peripheral counties. During our sample period, China experienced a gradual process of privatization. In our firm-level sample, around 38% of firms were registered as SOEs in 1998 and this ratio declined to less than 5% by 2007.[8] Local governments were major players behind the scene (Cao, Qian and Weingast, 1999; Garnaut et al., 2005). As Liu, Sun and Woo (2006) point out, if privatization leads to more tax revenue, local governments would have stronger incentives to privatize state-owned firms and forego benefits of control over SOEs. In our setting, privatized firms in connected peripheral counties were less able to increase sales, profits and tax revenue, since any productivity spillover between firms in local production was depressed by the expressway connection. That is, the costs of privatization were likely to outweigh its benefits. This leads to our next testable hypothesis that governments of connected counties were less likely to push forward the privatization process of SOEs. Moreover, as the benefits of privatization may depend on the initial size of the local market, our hypothesis is more likely to hold in connected counties with a smaller market size.

To test this hypothesis, we use a sub-sample of firms that entered the Industrial Enterprise Survey as SOEs and trace their ownership changes over time. We first estimate a Logit model on Equation 3 where the dependent variable is a dummy $SOE(i, j, t)$, which equals 1 if firm i in county j is an SOE in year t, and 0 otherwise. Column 1 of Table 6 reports the estimated marginal effect using the full sample of SOEs, which is positive but insignificant. In Column 2, we differentiate between counties with different initial market sizes, based on whether a county's 1997 population is above or below the sample median. Interestingly, we find that connected counties with a smaller initial market size were around 6 percent less likely to privatize SOEs, relative to non-connected counties. In contrast, the expressway had no impact on the privatization process of SOEs in connected counties with a larger initial market size. This pattern is confirmed in Column 3 where we use instrumental variables to address potential endogeneity of the connection status. In Columns 4-5, we proxy initial market size based on whether a county's 1997 output level is above or below the sample median. Similar patterns are found as to those using the 1997 population as the proxy.

In Columns 6-10, we restrict the sample of SOEs to be those entering the Survey the first time in 1998. This reduces the sample size slightly since some SOEs enter the Survey in later years. Based on this sample, around 34 percent of SOEs were privatized by 2007. We repeat the same analyses as in Columns 1-5 using this smaller sample, and we obtain rather similar results. In connected counties with a small initial market size, an SOE was around 6-9 percent more likely to stay as an SOE relative to that in a connected county, based on the Logit estimations (Columns 7 and 9). Again, the expressway connection did not significantly

[8]The Industrial Enterprise Survey includes firms above a certain scale (annual business revenue above 5 million RMB). Therefore, a firm can exit the Survey if it no longer meets this criteria.

change the probability of an SOE being privatized if it was located in a county with a large initial market. The IV estimations results reinforce these conclusions, although the point estimates are larger in magnitude and are associated with larger standard errors.

5.4 Possible spill-over?

In our analyses, we use unconnected peripheral counties as the control group. One concern is that these counties may also be affected by the expressway if there is any spill-over effect. In particular, our theoretical model predicts that the expressway connection would increase the price of goods produced in connected core cities. If the expressway did not change the transportation costs between the unconnected counties and the core cities, it may lead consumers of the unconnected counties to consume more local goods. This in turn would encourage more investment by the government of the unconnected counties, and our benchmark treatment effect would be biased. Nevertheless, if the transportation cost between the unconnected counties and the core cities is high, the trade between the two should be rather limited. Therefore, the change of output price in the core cities may have little impact on the consumption pattern of the individuals in the unconnected counties.

To further examine whether any spill-over effect exists, we conduct the following exercises. In our sample, for each county c that was connected to expressway at some point between 1996-2006, we identify among its geographical neighbors those that were never connected to expressway during the period 1996-2006 (county n). A function $c(n)$ indicates c is a neighbor of county n, that get connected at some point. We then estimate the following equation:

$$y_{n,t} = \beta_1 D_{c(n),t} + \mu_n + \eta_t + \epsilon_{j,t} \tag{4}$$

where $y_{n,t}$ is the outcome variable, including total output, total agriculture output, total industrial output, and population for county n in year t, all measured in logs; $D_{c(n),t}$ is an indicator if n's neighbor c became connected in year t. μ_n and η_t are county and year fixed effects. β_1 captures any spillover effect of expressway connection from county c to n. We use a sample of unconnected counties for this estimation and use variations in the timing of connection in their neighboring counties to identify the spillover effect.

For each n, we further identify its neighbors that never had expressway connection during 1996-2006, and denote them as m. These are second-order neighbors to the connected counties.[9] We then estimate the following equation:

$$y_{m,t} = \beta_2 D_{c(n(m)),t} + \mu_m + \eta_t + \epsilon_{i,t} \tag{5}$$

[9] County m is not a main node or a neighbor to any of the main nodes, and has a unique neighbor n.

where $D_{c(n(m)),t} = 1$ if county c, the second-order neighbor of county m, was connected in year t. The regression sample includes only counties m and we again use variations in the timing of connection across counties c for identification.

Table D5 in the Appendix D presents the estimation results. There, we do not find any significant change in the output or population of unconnected counties that are either the immediate or second-order neighbors to the connected counties. This indicates little spill-over effect.

5.5 The effect of government policy changes on output

Finally, what is the impact of the local governments' policy changes on output? To address this question, we conduct a back-of-envelop calculation in this section. Specifically, we multiply our estimate for the effect of expressway connection on each policy variable with its effect on output obtained from the literature. We then decompose the total effect of expressway connection on output by the following equation:

$$\underbrace{\Delta Y/Y}_{\text{Total effect on output}} = \underbrace{\sum_{v=t,S,G} \sigma_{Y,v}\eta_v}_{\text{Effect of policy changes}} + \underbrace{\Delta Y^{Direct}/Y}_{\text{Implied direct effect}} \tag{6}$$

where $\Delta Y/Y$ is the percentage change in output after a county was connected to the expressway. The policy variables, v, include the effective tax rate (t), government expenditure (G) and the share of SOEs (S). We do not consider the effect of subsidies on output for two reasons. First, the literature focuses on R&D subsidies while our measure of subsidies may include non-R&D types. Second, we cannot find credible estimates from the literature on the relationship between general-purpose subsidies and output, although most studies find subsidies are value-enhancing for firms. η_v is the effect of expressway connection on the policy variable v, and $\sigma_{Y,v}$ is the elasticity of output with respect to each of the policy variable. The contribution on output change from each policy variable v is then $\frac{\sigma_{Y,v}\eta_v}{\Delta Y/Y}$. The implied direct effect, which is the counterfactual output change if government policies did not respond, is the difference between the total output change and that caused by changes in all policy variables.

The expressway connection reduced output of connected peripheral counties by 3.9% ($\Delta Y/Y$), as reported in Appendix C. Based on estimations in previous sections, the expressway connection reduced government expenditure by 2.7% (η_G), increased firms' effective tax rate by 3% (η_t), and increased the share of SOEs by 6% (η_S) for counties with small initial market size. To calculate the elasticity of output with respect to each of the remaining policy variables, we draw parameters from previous related literature. Table D4 provides more details for these parameters. In particular, Guo, Liu and Ma (2016) estimate that the fiscal multiplier of Chinese county governments is 0.6. In our sample, government expenditure is about 10 percent of output, suggesting that the elasticity of output with respect to government expenditure is 0.068 ($\sigma_{Y,G} = \frac{G}{Y}\frac{dY}{dG}$). There is scant evidence on the magnitude of effect of tax rate changes on output in China. In other countries, Romer and Romer (2010) find that the tax multiplier in the US is about -2.5, and Cloyne (2013) find similar estimates for the UK.[10] We assume that these estimates apply to China. The share of corporate tax revenue to output is 0.015 in our sample[11], which implies an elasticity of output to the effective tax rate of -0.038 ($\sigma_{Y,t}$). Furthermore, Liao, Liu and Wang (2014) find that privitization increases output of SOEs by 27%. The share of SOEs is 0.38 in our sample and thus, 1% increase in the share of SOEs should reduce output by 10% ($\sigma_{Y,S}$).

Table 7 summarizes how each policy variable change affects output of the connected peripheral counties. More details are provided in Table D6. Our result suggests that roughly 23.4% of the observed output decline in connected peripheral counties is due to the policy choices of local governments: 4.7% of the output decline is due to changes in government expenditure, 2.9% of the output drop is due to increases in the effective tax rate, and 15.8% is caused by a slower rate of privatization. These results suggest that local governments' policy choices, as a response to the expressway connection, had non-trivial impact on economic growth and regional inequality.

6 Conclusion

We examine how better access to domestic market affects the incentives and policy choices of sub-national governments. We use the construction of expressway in China as a natural experiment and investigate how the network connection affects peripheral county governments' behaviour, especially their attitudes towards private businesses. Theoretically, the reduction in trade and transportation costs induces governments of hinterland to pursue less business-friendly policies, due to a smaller local market size. This prediction is supported by empirical investigations on several observed policy choices by local governments. Our analyses support the view that trade affects institutional quality and in this case, the quality of sub-national governments. In turn, we show that changes in the incentives and quality of local governments matter significantly for regional economic growth.

Our analyses suggest that while transportation infrastructure that connects core cities and hinterland regions can achieve aggregate efficiency gain, it may in fact widen regional economic disparity as peripheral local governments may simply "give up". It remains interesting to analyze whether the increase in accessibility due to transportation infrastructure also influences other government quality, such as rent seeking,

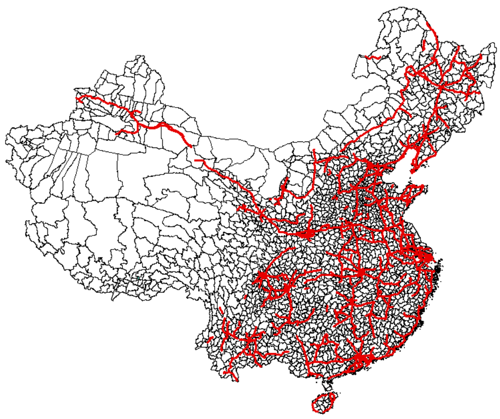
[10] Arnold et al. (2011) estimates the effect of tax revenue on output for OECD countries. The effect of corporate income tax from the study is of similar magnitude.

[11] We calculated the corporate tax charge to output at firm level.

bureaucracy and corruption, if relevant data becomes available. Moreover, if labour is less mobile than capital, our findings indicate welfare losses to those in the connected hinterland. Thus, further research on how to complement inter-regional transportation roll-out with arrangement that takes the incentives of local governments into account could help with policy designs in both efficiency and equity terms.

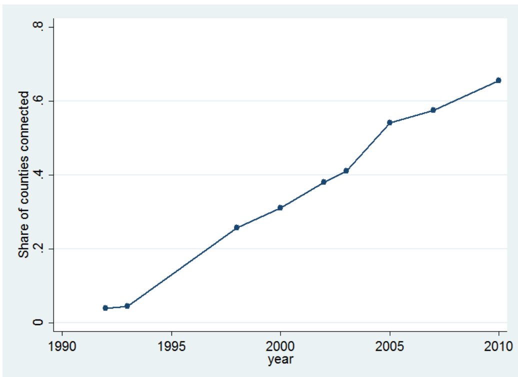
Figures

Figure 1: China's expressway network by 2010



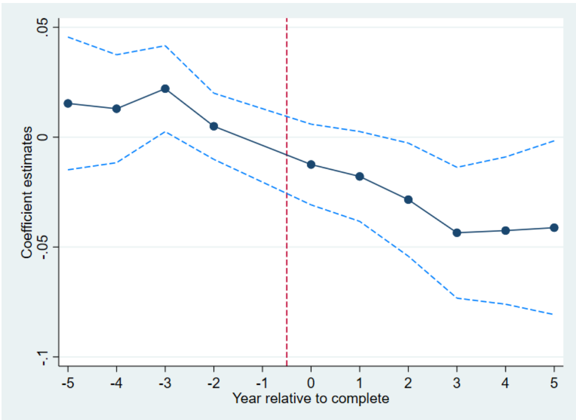
Notes: This graph shows the completed routes of the expressway network in China by 2010, as indicated by the red lines. Data sources: ACASIAN.

Figure 2: Share of counties connected to the expressway over time



Notes: This graph shows the share of counties connected to the national expressway network by year during the period 1992-2010.

Figure 3: Dynamic effect of expressway on (log) real government expenditure per capita



Notes: This graph plots the point estimates and 95% confidence interval for equation 1, by replacing the treatment indicator with a set of dummies before and after the completion of expressway. i.e. $Y_{j,t} = \alpha + \sum_{l=-7,l\neq-1}^{l=5} \beta_l Connected[l]_{j,t} + \gamma X_{j,t-1} + \mu_t + \delta_j + \epsilon_{j,t}$, where $Connected[l]_{j,t}$ is an indicator when the expressway is connected for l years, with years more than 5 are grouped as 5 years, and less than -5 years grouped as -5 years. Sample includes 1996-2006. Controls include lagged real output per capita, population density, share of agricutural output and share of industrial output, year and county level fixed effects

Tables

Table 1: Descriptive statistics

Panel A: County-level variables						
	Connected counties			Non-connected counties		
	Obs.	Mean	S.D.	Obs.	Mean	S.D.
Output (100 million RMB)	7,235	70.076	82.829	21,697	25.323	32.170
Expenditure per capita (RMB per person)	7,235	1119.737	1034.828	21,697	971.085	1290.466
Population (10,000 persons)	7,235	60.439	34.619	21,697	40.799	32.170
Population density (persons per km sq.)	7,235	409.292	284.241	21,697	253.805	977.096
Agricultural output share	7,235	0.244	0.125	21,697	0.341	0.151
Capital outlays (% of total expenditure)	4,194	0.119	0.057	17,079	0.125	0.067
Education expenditure (% of total expenditure)	4,194	0.255	0.063	17,079	0.255	0.069
Administration expenditure (% of total expenditure)	4,194	0.196	0.044	17,079	0.227	0.075
Other expenditure (% of total expenditure)	4,194	0.430	0.078	17,079	0.393	0.088
Panel B: Firm-level variables						
	Connected counties			Non-connected counties		
	Obs.	Mean	S.D.	Obs.	Mean	S.D.
Size	338,537	9.484	1.310	278,413	9.301	1.350
Profitability	338,537	0.098	0.186	278,413	0.078	0.175
Export Dummy	338,537	0.252	0.434	278,413	0.148	0.356
Interests/Sales	338,537	0.017	0.034	278,413	0.025	0.048
Subsidy Dummy	338,537	0.106	0.308	278,413	0.090	0.286
ETR	177,575	0.271	0.158	117,749	0.276	0.163

Notes: This table provides summary statistics for key county-level and firm-level variables. County-level variables are obtained from official statistics yearbooks. Firm-level variables are obtained from the 1998-2007 Industrial Enterprise Survey conducted by China's National Statistics Bureau. $Output$ and $Expenditure\ per\ capita$ are both measured in real terms; $Agricultural\ output\ share$ is the ratio of agricultural output in total output; $Size$ is the natural logarithm of total assets; $Profitability$ is pre-tax profits divided by total assets; $Export\ Dummy$ equals 1 if a firm exports in a certain year, and 0 otherwise; $Interests/Sales$ is the ratio of interest expenses to sales; $Subsidy\ Dummy$ equals 1 if a firm receives subsidies in a certain year, and 0 otherwise; ETR is the effective corporate income tax rate, defined as tax paid as a ratio to pre-tax income.

Table 2: Effects of expressway connection on county-level spending: level and composition

	1996-2010	1996-2006				
	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(EXP)	Ln(EXP)	%Capital outlays	%Education	%Admin	%Others
			Panel A: OLS			
Connected$_{j,t}$	-0.027***	-0.029***	-0.009***	-0.002	0.003**	0.008***
	(0.008)	(0.008)	(0.002)	(0.002)	(0.001)	(0.002)
			Panel B: IV			
Connected$_{j,t}$	-0.181***	-0.123***	-0.060***	-0.021**	0.037***	0.043***
	(0.056)	(0.047)	(0.014)	(0.010)	(0.009)	(0.014)
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs	24,917	17,184	17,223	17,223	17,223	17,223

Notes: This table reports the estimated effects of the expressway connection on the level and composition of counties' budgetary expenditures. Panel A reports the OLS estimation results. The dependent variable in Columns 1 and 2 is the natural logarithm of real budgetary expenditure per capita in county j in year t. In Columns 2-5, the dependent variable is the ratio of different expenditure categories to total budgetary spending. There are four categories of spending: capital outlays, education, administration, and others. Column 1 uses the sample for the period 1996-2010. Columns 2-6 uses the sample for the period 1996-2006 where information on spending by category is available. County-level control variables include real output per capita, population density, and the share of agricultural output in total output, all measured in year $t-1$. Panel B reports the corresponding results from IV estimations. Standard errors are robust and clustered over county.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3: Inter-jurisdictional spending competitions

	1996-2010	1996-2006		1996-2006			
		Total		Capital outlays	Education	Admin	Others
	(1)OLS	(2)OLS	(3)IV	(4)OLS	(5)OLS	(6)OLS	(7)OLS
$\overline{EXP}_{j,t-1}$	0.690***	0.425**	0.396**	0.578***	0.423***	0.748***	0.792***
	(0.0901)	(0.132)	(0.135)	(0.099)	(0.074)	(0.134)	(0.083)
$\overline{EXP}_{j,t}$	0.581***	0.557***	0.662***	0.628***	0.656***	0.351**	0.374***
	(0.0730)	(0.106)	(0.170)	(0.112)	(0.063)	(0.121)	(0.062)
Connected$_{j,t}$	118.6**	70.78**	291.8*	30.88***	3.149	7.542*	13.22
	(43.55)	(25.690)	(115.100)	(9.076)	(1.974)	(3.069)	(9.830)
Connected$_{j,t}$ $\times$ $\overline{EXP}_{j,t}$	-0.134***	-0.146***	-0.391*	-0.339***	-0.0422***	-0.0827**	-0.0677*
	(0.0399)	(0.044)	(0.153)	(0.090)	(0.013)	(0.028)	(0.034)
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	24,884	17,149	17,149	17,217	17,217	17,217	17,198

Notes: This table reports the effects of the expressway connection on inter-jurisdictional spending competitions. The dependent variable is real expenditure of county i in year t. When calculating the weighted average spending of neighbouring counties, the weight matrix use the inverse square distance between two counties within the same province as the weight ($w_{j,k} = \frac{1}{d_{j,k}^2}$), and otherwise 0. Column 1 uses the sample for the period 1996-2010, and columns 2-7 use the sample for the period 1996-2006. County-level control variables include lagged real output per capita, population density, and agricultural output as a ratio to total output. Column 3 uses minimum distance network*share of connected county in the province, and neighbor's demographic variables (lagged number of student per capita, number of hospital bed per capita and the number of government employees per capita) to instrument for Connected$_{j,t}$ and $\overline{EXP}_{j,t}$ and their interaction. Standard errors are robust and clustered over county.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: Provision of subsidies

	Panel A: Extensive margin					
	Logit			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	SOEs	Non-SOEs	All firms	SOEs	Non-SOEs
Connected$_{j,t}$	-0.001	0.005	-0.002*	-0.066	0.084	-0.118**
	(0.001)	(0.004)	(0.001)	(0.049)	(0.085)	(0.057)
No. of obs.	120,438	19,053	98,493	120,438	19,053	98,493
	Panel B: Intensive margin					
	OLS			IV		
	(1)'	(2)'	(3)'	(4)'	(5)'	(6)'
Connected$_{j,t}$	-0.044	0.175	-0.094	-0.552*	0.535	-0.893**
	(0.086)	(0.124)	(0.099)	(0.321)	(0.533)	(0.364)
No. of obs.	153,287	26,928	126,359	148,695	25,816	122,069
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Panel A reports the estimated effects of the expressway connection on the probability of a firm receiving government subsidies. The dependent variable is a dummy that equals 1 if firm i in county j received subsidies in year t, and 0 otherwise. Columns 1-3 report the implied marginal effects from Logit estimations with firm-specific fixed effects. Columns 4-6 report the implied marginal effects from IV estimation of the Logit model. Panel B reports the estimated effects of the expressway connection on the amount of subsidies firms received. Column 1-3 report the OLS estimation results, and columns 4-6 report the IV estimation results. The dependent variable is the natural logarithm of subsidies firm i in county j received in year t. Firm-level control variables include size, profitability, and exporting status. County-level control variables include real output per capita, population density, and the share of agricultural output in total output, all measured in year $t-1$. Standard errors are robust and clustered over county. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5: Firm-specific effective corporate income tax rate

	OLS				IV			
Dependent Variable: ETR$_{i,j,t}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All firms	SOEs	Private	Foreign/HMT	All firms	SOEs	Private	Foreign/HMT
Connected$_{j,t}$	0.008**	0.007	0.008**	0.011	0.022	0.003	0.025*	0.016
	(0.004)	(0.007)	(0.004)	(0.007)	(0.013)	(0.036)	(0.015)	(0.036)
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	261,527	17,560	216,320	27,647	218,496	13,672	179,433	23,479

Notes: This table reports the estimated effects of the expressway connection on firms' effective corporate income tax rate, defined as tax paid as a ratio to pre-tax profit. The dependent variable is firm i's effective corproate income tax rate in year t. We differentiate between three types of firms: SOEs, privately-owned firms, and foreign/Hong Kong, Macau, Taiwan firms. Columns 1-4 report the OLS estimation results, and columns 5-8 report the IV estimation results. Firm-level control includes lagged size, profitability, export status, and interest expenses scaled by sales. County-level control variables include lagged real output per capita, population density, and the share of agricultural output in total output. Standard errors are robust and clustered over county. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6: Privatization of state-owned enterprises

	Entering Survey first time in any years					Entering Survey first time in 1998				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dep. Var: $\text{SOE}_{i,j,t}$	Logit	Logit	IV	Logit	IV	Logit	Logit	IV	Logit	IV
$\text{Connected}_{j,t}$	0.007	-0.008	-0.137	-0.003	-0.105	0.018	-0.004	-0.132*	0.005	-0.095
	(0.008)	(0.010)	(0.084)	(0.010)	(0.087)	(0.012)	(0.013)	(0.074)	(0.013)	(0.078)
$\text{Small}_j^{Pop} \times \text{Connected}_{j,t}$		0.062***	0.495***				0.087***	0.559***		
		(0.019)	(0.155)				(0.024)	(0.144)		
$\text{Small}_j^{Output} \times \text{Connected}_{j,t}$				0.047**	0.451***				0.058**	0.464***
				(0.020)	(0.161)				(0.025)	(0.152)
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	16,067	15,797	15,797	16,053	16,053	12,739	12,562	12,562	12,733	12,733

Notes: This table reports the estimated effects of the expressway connection on the probability of a state-owned firm being privatized during our sample period. In columns 1-5, we use a sample of firms that enter the Enterprise Survey as SOEs. In columns 6-10, we restrict the sample to be firms that were SOEs in 1998. The dependent variable is a dummy that equals 1 if firm i in year t is an SOE, and 0 otherwise. For Logit estimations, we report the estimated marginal effects. $Small_j^{Pop}$ is a dummy that equals 1 in county j's 1997 population is below the sample median. $Small_j^{Output}$ is a dummy that equals 1 if county j's 1997 output is below the sample median. All control variables are measured in year $t-1$. Firm-level control includes size, profitability, export status, and interest expenses scaled by sales. County-level control variables include lagged real output per capita, population density, and the share of agricultural output in total output. Standard errors are robust and clustered over county. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7: The effect of policy choices on total output

	(1)	(2)	(3)	(4)
Channel	Expressway effect on policy variable (% change)	Elasticity of output	Expressway effect on output (%)	Contribution to total (%)
Expenditure	-2.7	0.068	-0.18	4.7
ETR	3	-0.039	-0.11	2.9
Subsidy	N/A	N/A	N/A	N/A
Share of SOEs	6	-0.103	-0.62	15.8
Implied market effect			-2.99	76.6
Total			-3.9	100

Note: The table summarizes the effect of each policy variable on output and its contribution to total output change. Column (1) reports estimates of the effect of the expressway connection on the policy variable of each row in percentage terms of the baseline level. Column (2) reports the elasticity of output with respect to each policy variable, which we draw from existing literature. Column (3) reports the implied effect of each policy variable on output. It is the product of Columns (1) and (2). Column (4) reports the contribution of each policy variable change to total output change following the expressway connection. It is obtained by dividing Column (3) with the the total output effect of the expressway connection from Table C1.

Appendix A Theoretical Model

In this section, we present a simple theoretical framework to illustrate the impact of inter-city transportation on local governments' provision of productivity-enhancing resources. While we only discuss the main features and predictions of the theoretical model for a succinct presentation, Appendix B provides technical details.

There are two jurisdictions, H and L. H has higher endowment in total factor productivity (TFP) than L due to exogenous factors such as geographical location. There is a single manufactured goods and a numeraire goods (money). The representative firm in each jurisdiction has access to local technology that produces manufactured goods with decreasing marginal product of capital. We assume that no labor is needed for production. Manufactured goods are tradable subject to some trade cost. That is, for each unit of goods sold to the other jurisdiction, there is a constant trade cost per unit of goods. All else equal, production in H has lower marginal cost due to better productivity endowment.

A.1 Consumer, technology and the representative firm

The representative consumer has a quasi-linear utility function in both the manufactured goods and the numeraire goods. For each jurisdictioin $i = H$ or L, the consumer maximizes his utility $U_i = v(x_i)+y_i$, subject to the budget constraint $p_i x_i + y_i = z_i$ where p_i is the price of manufactured goods in jurisdiction i, y_i is the numeraire, and z_i is exogenous income. We consider the case with a linear demand function $v(x) = (a-\frac{x}{2})x$ where a is a constant. The first-order condition of the utility maximization problem suggests that consumer i's demand for the manufactured goods is $x_i^* = (a - p_i)$. Assuming each jurisdiction has s_i share of citizens over a mass of 1, the total demand for the manufactured goods by citizens from jurisdiction i is thus $x_i^d = (a - p_i)s_i$.

The representative firm in jurisdiction i has access to production technology specified as:

$$F_i = A_i K_i^\alpha = \bar{A}_i I_i^\beta K_i^\alpha$$

where F_i is total output; A_i is total factor productivity (TFP) with two elements, the productivity endowment $\bar{A}_i$ and government provisions of productivity-enhancing resources I_i; K_i is private capital for production. In the production function, $\alpha, \beta < 1$ and $\alpha + \beta < 1$. This production function satisfies the assumption that I and K are complements, as the cross-partial derivative of output with respect to the two inputs is positive, i.e., $\frac{\partial F}{\partial K \partial I} > 0$. Jurisdictions differ by $\bar{A}_i$, with $\bar{A_H} > \bar{A_L}$. Firms are price takers and maximize profit π_i:

$$\pi_i = (1-t)p_i x_{ii} + [(1-t)p_j - \tau]x_{ij} - C_i(x_i)$$

where x_{ii} is the amount of goods produced in jurisdiction i and consumed in i, and x_{ij} is goods produced in jurisdiction i and consumed in j. $x_i = x_{ii} + x_{ij}$ is the total amount of goods produced in jurisdiction i. p_i and p_j are prices of the goods x in county i and j, respectively. τ is the trade cost per unit of goods. t is the tax rate on output and is assumed to be equal in both jurisdictions. $(1-t)p_i x_{ii}$ is the after-tax revenue received for each unit of goods produced and sold locally, and $(1-t)p_j - \tau$ is that received for each unit of goods exported. $C_i(x_i)$ is the cost to produce x_i:

$$C_i(x_i) = \min_K rK_i \quad s.t. \quad F = \bar{A}_i I_i^\beta K_i^\alpha \geq x_i$$

Given the cost of capital r, the marginal cost function can be expressed as:

$$C_i'(x_i) = r/F_i'(K_i) = \begin{cases} (1-t)p_i = (1-t)p_j - \tau & \text{if } p_i = p_j - \frac{\tau}{1-t} \\ (1-t)p_i & \text{if } p_i > p_j - \frac{\tau}{1-t} \\ (1-t)p_j - \tau & \text{if } p_i < p_j - \frac{\tau}{1-t} \end{cases}$$

There are two scenarios: a) $x_{ij} = 0$, all goods are sold and consumed domestically and there is no trade; and b) only one jurisdiction exports to the other, $x_{ij} > 0$ and $x_{ji} = 0$. We focus on case b) since all-else equal, jurisdiction H has lower domestic price due to the lower marginal cost and would export. Denote the net of tax prices as $p_i^n = (1-t)p_i$. For jurisdiction H, domestic net of tax price p_H^n equals foreign net of tax price minus trade cost $p_L^n - \tau$. It supplies to both markets and hence, $p_H^n = p_L^n - \tau = C'(x_H)$ in equilibrium. Jurisdiction L supplies only domestically because domestic price p_L^n is higher than the foreign price p_H^n, and $p_L^n = C'(x_L)$.

A.2 The government

Governments of both jurisdictions H and L can provide resources that enhance local productivity. Both governments care about the level of local production (for example, if promotion or re-election of politicians is related to local production), but also enjoy consumption c_i. Specifically, it maximizes a utility function U_i^g specified as:

$$U_i^g = u(p_i F_i) + \lambda c_i$$

where λ captures the local government's preference for consumption, with $u(.) > 0, u'(.) > 0$, and subject to the budget constraint:

$$I_i + c_i = t p_i F_i$$

That is, each government finances provisions of productivity-enhancing resources (I_i) and own consumption (c_i) with tax revenue from local output. We assume that there is no lending and borrowing for simplicity. For the government, the optimal level of productivity-enhancing resource provision is determined by:

$$\frac{\partial p_i F_i}{\partial I_i} + \frac{\partial p_i F_i}{\partial K_i}\frac{\partial K_i}{\partial I_i} = \gamma$$

where $\gamma = \frac{\lambda}{u'(p_i F_i)+\lambda t}$. This first-order condition indicates that government provision of productivity-enhancing resources has two effects on local production: first, it has a direct impact on production by raising productivity; and second, it has an indirect impact on production via changing the amount of private capital in the jurisdiction. At optimum, the marginal benefit of I should equal to its opportunity cost γ, which is increasing in the weight government put on consumption (λ).

A.3 Goods market equilibrium and the impact of intercity transportation

The productivity advantage of jurisdiction H implies unit cost advantage, all else equal. This in turn implies that jurisdiction H would tend to export to jurisdiction L. However, when the trade cost between the two jurisdictions is high, each jurisdiction sells mostly to the domestic market and trade is limited. The level of production in jurisdiction L needs to be large enough to meet local demand[12], which requires a significant presence of private capital. When inter-city transportation reduces the regional trade cost and if we assume a linear marginal cost curve, it can be shown that the direct effect of a lower trade cost is to increase production and the price of the manufactured goods in jurisdiction H, and to reduce both in jurisdiction L. Formally, we have Proposition 1:

Proposition 1 *When intercity transportation reduces the trade cost,* $\frac{dp_L}{d\tau} > 0$, $\frac{\partial p_H}{\partial \tau} < 0$, $\frac{\partial x_L}{\partial \tau} > 0$, *and* $\frac{\partial x_H}{\partial \tau} < 0$, *given a linear marginal cost function.*

Proof: The formal proof is provided in Appendix B1.

[12] We assume exogenous household income in both jurisdictions.

Furthermore, it can be shown that given the level of I in the other jurisdiction, the optimal level of productivity-enhancing government resources in jurisdiction i is expressed as:

$$I_i(\tau, r, I_j) = \frac{\beta + \alpha\epsilon_k + \epsilon_{p_i}}{\gamma} p_i x_i$$

where $\epsilon_k = \frac{I}{K}\frac{\partial K}{\partial I}$ and $\epsilon_{p_i} = \frac{I}{p_i}\frac{\partial p_i}{\partial I}$. Solving the reaction function $I_i(\tau, r, I_j)$ leads to Proposition 2:

Proposition 2 *When intercity transportation reduces trade cost, jurisdiction L would reduce provision of productivity-enhancing resources, as $\frac{dI_L}{d\tau} > 0$.*

Proof: The formal proof is provided in Appendix B2.

The intuition for Proposition 2 is as follows. Under the assumption that private capital (K) and government provisions (I) are complements, local government of jurisdiction L would have strong incentives to provide I that enhances local productivity when the trade cost is high and there remains a large market in jurisdiction L . When inter-city transportation reduces the regional trade cost, jurisdiction H will export more to jurisdiction L. L would produce at a lower level and consequently requires less private capital. In fact, private capital will flow from L to H until the marginal products of capital in the two jurisdictions become equal. With the outflow of private capital, the government of jurisdiction L now has less incentive to provide productivity-enhancing resources since the marginal benefit of doing so declines.

Proposition 2 abstracts from the general equilibrium effect of the intercity transportation on the cost of capital. This is a reasonable assumption if the cost of capital is exogenous and the supply of capital is elastic. It also highlights the best response functions for each of the two regions rather than the joint Nash equilibrium outcome. With these caveats in mind, our model suggests that when intercity transportation reduces trade costs between regions, the region with lower productivity endowment are likely to cut government expenditures, especially those directly enhancing local productivity.

Appendix B Technical Notes for the Theoretical Model

B1: Proof of Proposition 1

In this appendix, we provide proof for Proposition 1. We re-label jurisdiction H and L in the main text as jurisdiction 1 and 2, respectively, for notational convenience. To obtain close-form solutions for illustrative purposes, we assume that the marginal cost function is linear. This can be achieved by assuming $\alpha = \frac{1}{2}$. Under this assumption, $C_1'(x_2) = \frac{r}{\alpha}A_1^{-2}x_2 = c_1x_2$ and $C_2'(x_2) = \frac{r}{\alpha}A_2^{-2}x_2 = c_2x_2$, where $c_i = \frac{r}{\alpha}A_i^{-2}$.

Setting the marginal cost equal to the output price, and supply equal to demand, we reach the following equations:

$$
\begin{aligned}
C_2'(x_2) = c_2 x_2 &= p_2^n \\
C_1'(x_{11} + x_{12}) = c_1(x_{11} + x_{12}) = p_1^n &= p_2^n - \tau \\
x_{12} + x_2 &= (a - p_2)s_2 \\
x_{11} &= (a - p_1)s_1
\end{aligned} \tag{A1}
$$

Since $\bar{A}_1 > \bar{A}_2$, if the investment of jurisdiction H is not so low that it reverses the productivity advantage, we have $c_1 < c_2$. Solving the system of Equation (A1) gives:

$$p_1 = \frac{c_1 c_2 (a - \frac{\tau}{1-t} s_2) - c_1 \tau}{\Delta}$$

$$p_2 = \frac{c_1 c_2 (a + s_1 \frac{\tau}{1-t}) + c_2 \tau}{\Delta}$$

$$x_1 = \frac{c_2 (a^n - \tau s_2) - \tau^n}{\Delta}$$

$$x_2 = \frac{c_1 (a^n + s_1 \tau) + \tau^n}{\Delta}$$

where $\Delta = c_1 c_2 + c_1(1-t) + c_2(1-t)$, $a^n = (1-t)a$ and $\tau^n = (1-t)\tau$. Holding cost of capital and government investment constant, we obtain the following comparative statistics:

$$\frac{\partial p_1}{\partial \tau} < 0, \frac{\partial p_2}{\partial \tau} > 0, \frac{\partial x_1}{\partial \tau} < 0, \frac{\partial x_2}{\partial \tau} > 0$$

That is, with a linear marginal cost curve, the *direct* effect of a lower trade cost is to increase production and product price in the high-productivity jurisdiction, and to reduce production and product price in the low-productivity jurisdiction.

B2: Proof of Proposition 2

We provide proof for Proposition 2 in this Appendix. Re-arrange the first-order condition for the government as:

$$\frac{\partial p_i}{\partial I_i}F_i + p_i(\frac{\partial F_i}{\partial I_i} + \frac{\partial F_i}{\partial K_i}\frac{\partial K_i}{\partial I_i}) = \gamma$$

Denote $\epsilon_{k_i} = \frac{I_i}{K_i}\frac{\partial K_i}{\partial I_i}$ and $\epsilon_{p_i} = \frac{I_i}{p_i}\frac{\partial p_i}{\partial I_i}$. We have:

$$p_i F_i \epsilon_{p_i} + p_i F_i \beta + p_i F_i(\alpha\epsilon_{k_i}) = I_i\gamma$$

Solving for I_i, we obtain:

$$I_i = (\frac{\beta + \alpha\epsilon_{k_i} + \epsilon_{p_i}}{\gamma})p_i x_i$$

Therefore, we obtain the direct effect of trade cost on I_1 as:

$$\frac{\partial I_1}{\partial \tau} = \underbrace{\frac{\beta + \alpha\epsilon_k + \epsilon_p}{\gamma}(1 - \epsilon_{\gamma,px})\frac{\partial p_1 x_1}{\partial \tau}}_{\text{Market size effect} < 0} + \underbrace{\frac{1}{\gamma}(\alpha\frac{\partial \epsilon_k}{\partial r} + \frac{\partial \epsilon_{p_i}}{\partial r})p_1 x_1\frac{\partial r}{\partial \tau}}_{\text{Cost of capital effect}}$$

where $\frac{\beta+\alpha\epsilon_k+\epsilon_p}{\gamma}$ is positive for any interior solution of I_i in the government investment choice problem. $\epsilon_{\gamma,px} = \frac{\partial ln\gamma}{\partial lnp_i x_i} = p_i x_i\frac{-u''(p_i x_i)}{u'(p_i x_i)+\lambda t}$, and is related to the curvature of the curvature of the government's utility function with respect to output. We assume that the utility function satisfies the property akin to that of constant relative risk aversion, where $-\frac{pxu''(px)}{u'(px)} \leq 1$ (which include $U^g(px) = ln(px)$ or $U^g(px) = px$). This implies $1 - \epsilon_{\gamma,px} > 0$. The first term is thus negative as $\frac{dp_1 x_1}{d\tau} < 0$, since $\frac{dp_1}{d\tau} < 0$ and $\frac{dx_1}{d\tau} < 0$. Under partial equilibrium where interest rate is kept constant, $\frac{dr}{d\tau} = 0$, the cost of capital effect is 0 and $\frac{\partial I_1}{\partial \tau} < 0$. Note that the market size effect is decreasing in γ, which is the shadow cost of government provision of productivity-enhancing resources. If the government puts more weight on self-consumption, λ is larger and $\frac{\partial I_1}{\partial \tau}$ is smaller.

Similarly, we obtain the direct effect of trade cost on I_2 as:

$$\frac{\partial I_2}{\partial \tau} = \underbrace{\frac{\beta + \alpha\epsilon_{k_2} + \epsilon_{p_2}}{\gamma}(1 - \epsilon_{\gamma,px})\frac{\partial p_2 x_2}{\partial \tau}}_{\text{Market size effect} > 0} + \underbrace{\frac{1}{\gamma}(\alpha\frac{\partial \epsilon_{k_2}}{\partial r} + \frac{\partial \epsilon_{p_2}}{\partial r})p_2 x_2\frac{\partial r}{\partial \tau}}_{\text{Cost of capital effect}}$$

Assuming the cost of capital effect is 0, we have $\frac{\partial I_2}{\partial \tau} > 0$, since $\frac{dp_1}{d\tau} > 0$ and $\frac{dx_1}{d\tau} > 0$ from A1.

So far we have focused on the direct effect of τ on I_i. To calculate the total effect, note that $\epsilon_{p_i} = \epsilon_{p_i}(I_1, I_2)$, $p_i = p_i(I_1, I_2, \tau)$ and $x_i = x_i(I_1, I_2, \tau)$ and thus, $p_i x_i = p_i x_i(I_1, I_2, \tau)$. Re-express I_i as:

$$I_i = \frac{\beta + \frac{\alpha}{1-\alpha}(\beta - \epsilon_r) + \frac{1}{1-\alpha}\epsilon_{p_i}}{\gamma} p_i x_i$$

Taking the total derivative of I_i with respect to τ, we obtain:

$$\frac{dI_i}{d\tau} = (\frac{\beta + \alpha\epsilon_{k_i} + \epsilon_p}{\gamma})(\frac{\partial p_i x_i}{\partial \tau} + \frac{\partial p_i x_i}{\partial I_i}\frac{dI_i}{d\tau}) + \frac{p_i x_i}{(1-\alpha)\gamma}\frac{\partial \epsilon_{p_i}}{\partial I_i}\frac{dI_i}{d\tau} - \frac{\beta + \alpha\epsilon_k + \epsilon_p}{\gamma^2} p_i x_i \frac{\partial \gamma}{\partial p_1 x_1}(\frac{\partial p_i x_i}{\partial \tau} + \frac{\partial p_i x_i}{\partial I_i}\frac{dI_i}{d\tau})$$

$$= \frac{1 - \epsilon_{\gamma,px}}{1 - \frac{I_i}{p_i x_i}\frac{\partial p_i x_i}{\partial I_i}(1 - \epsilon_{\gamma,px}) - \frac{p_i x_i}{(1-\alpha)\gamma}\frac{\partial \epsilon_{p_i}}{\partial I_i}}(\frac{\beta + \alpha\epsilon_{k_i} + \epsilon_{p_i}}{\gamma})(\frac{\partial p_i x_i}{\partial \tau})$$

where $\epsilon_{p_i x_i} = \frac{I_i}{p_i x_i}\frac{\partial p_i x_i}{\partial I_i} = \frac{c_i c_j + c_i(1-t) - c_j(1-t)}{\Delta}(-\epsilon_{c_i}) < -\epsilon_{c_i} \approx \frac{\beta}{\alpha}$.

When $\beta < \alpha$, $\epsilon_{p_i x_i} < 1$. Moreover, $\frac{\partial \epsilon_{p_1}}{\partial I_i} = \frac{\partial \epsilon_{p_1}}{\partial c_i}\frac{\partial c_i}{\partial I_i} = -\epsilon_{p_i}\frac{[c_2 + (1-t)]}{\Delta}\frac{\partial c_i}{\partial I_i} < 0$, as $\epsilon_{p_i} < 0$ and $\frac{\partial c_i}{\partial I_i} < 0$. Since $\epsilon_{\gamma,px} < 1$, this implies $\frac{1 - \epsilon_{\gamma,px}}{1 - \frac{I_i}{p_i x_i}\frac{\partial p_i x_i}{\partial I_i}(1 - \epsilon_{\gamma,px}) - \frac{p_i x_i}{(1-\alpha)\gamma}\frac{\partial \epsilon_{p_i}}{\partial I_i}} > 0$ and therefore, the sign of $\frac{dI_i}{d\tau}$ is the same as the sign of $\frac{\partial I_i}{\partial \tau}$. The second order condition of the government utility maximisation is satisfied if $\frac{\frac{\partial^2 px}{\partial I^2}}{\frac{\partial px}{\partial I}} < \frac{-u''(p_i x_i)}{u'(p_i x_i) + \lambda t}$. Since $\frac{\frac{\partial^2 px}{\partial I^2}}{\frac{\partial px}{\partial I}} = -2(1 - \frac{\Delta - 2c_2(1-t)}{\Delta - c_2(1-t)}\frac{\Delta - c_2(1-t)}{\Delta})I < 0$, the condition is satisfied for any (weakly) concave function u.

Appendix C Effect of expressway on output and population

To evaluate how the expressway connection affected county level output and population, we use a difference-in-differences empirical strategy. We use our county-level panel data and estimate Equation A2 below:

$$Y_{j,t} = \alpha + \beta Connected_{j,t} + \gamma X_{j,t-1} + \mu_t + \delta_j + \epsilon_{j,t} \quad \text{(A2)}$$

where $Y_{j,t}$ stands for a set of economic outcome variables in county j in year t, including county level output and population; $Connected_{j,t}$ is a dummy variable that equals 1 since county j is connected to the expressway; $X_{j,t-1}$ is a set of county-level control variables measured in year t-1; μ_t is the time fixed effects, δ_j is the county-specific fixed effects, and $\epsilon_{j,t}$ is the unobserved error term. The treatment effect is captured by the parameter β.

Faber (2014) shows that the Chinese expressway had a negative impact on the output growth of connected peripheral counties, relative to unconnected ones. While Faber (2014) uses two years' data in 1997 and 2006 alone, we use county-level panel data for the period 1996-2010. Despite the differences in the nature of the data, we find similar results to those in Faber (2014). Table C1 examines the effect of expressway connection on peripheral counties' output and population using difference-in-differences specification with our panel data. It shows that relative to unconnected counties, connected counties experienced lower total output growth, relative to unconnected peripheral counties (Column 1). The decline in total output growth in connected peripheral counties was primarily driven by a lower industrial output growth (Column 2), while little changed in agricultural output growth (Column 3). There is also a significant decline in population growth in connected peripheral counties (Column 4), consistent with the conjecture that labour would accompany capital movement. We find similar patterns when using a shorter panel for the period 1996-2006 (Columns 5-8), which corresponds to the sample period as in Faber (2014). These results, as argued by Faber (2014), suggest that the expressway connection moved productions from peripheral counties to nearby core regions.[13]

[13] An alternative explanation for these results is that production was relocated to non-connected counties from connected ones. However, this explanation is ruled out by Faber (2014) after careful analysis.

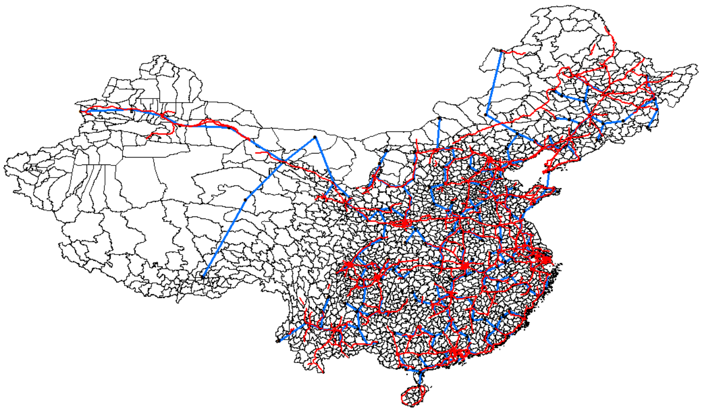
Table C1: Impact of the expressway connection on peripheral counties' output and population

	1996-2010				1996-2006			
	Ln(Output)	Ln(Ind output)	Ln(Ag output)	Ln(Pop)	Ln(Output)	Ln(Ind output)	Ln(Ag output)	Ln(Pop)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connected$_{j,t}$	-0.039***	-0.080***	-0.008	-0.009***	-0.036***	-0.072***	-0.013*	-0.006**
	(0.010)	(0.017)	(0.008)	(0.003)	(0.008)	(0.014)	(0.007)	(0.003)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs	27,901	28,403	28,464	28,810	20,168	20,659	20,720	21,065

Notes: This table reports the estimated treatment effect of the expressway connection on peripheral counties' output and population. The dependent variables in the first three columns are the natural logarithms of total output, total agricultural output, and total industrial output, all measured in real terms for county j in year t. The dependent variable is the natural logarithm of total population in column (4). Column (5)-(8) present estimates for sample from 1996-2006. Standard errors are robust and clustered over county. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix D Additional Figures and Tables

Figure D1: Minimum-cost path connecting major nodes of expressway



Notes: This graph shows the minimum cost path that connect the major nodes of expressway. The blue line represents the minimum cost path, the red line represents the completed expressway in 2010. The minimum cost path is calculated using Kruskal's algorithm. Data source on major nodes: National Expressway Network Plan (He, Xie and Zhang, 2018).

Table D1: Effects of expressway connection on county-level spending as a ratio to output or revenue

	Expenditure/Output		Expenditure/Revenue	
	(1)	(2)	(3)	(4)
	1996-2010	1996-2006	1996-2010	1996-2006
	Panel A: OLS			
Connected$_{j,t}$	-0.024***	-0.010***	-0.474***	-0.490***
	(0.003)	(0.001)	(0.109)	(0.0815)
	Panel B: IV			
Connected$_{j,t}$	-0.171***	-0.079***	-4.597***	-3.883***
	(0.024)	(0.013)	(0.820)	(0.583)
County-level controls	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
No. of obs	24,933	17,204	24,879	17,145

Notes: This table reports the estimated effects of the expressway connection on the ratio of counties' budgetary expenditures to output or revenue. The dependent variable in Columns 1 and 2 is the expenditure to output ratio in county j in year t. The dependent variable in Columns 3 and 4 is the expenditure to revenue ratio in county j in year t (winsorized at top 1%). Columns 1 and 3 use the sample for the period 1996-2010. Columns 2 and 4 use the sample for the period 1996-2006. County-level control variables include real output per capita, population density, and the share of agricultural output in total output, all measured in year $t-1$. Panel B reports corresponding IV estimation results. Standard errors are robust and clustered over county.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D2: IV estimation of expenditure: First stage

	Connected$_{j,t}$		
	1996-2010	1996-2006	
	(1)	(2)	(3)
MST_j*Province share$_{jt}$	0.738***	0.899***	0.893***
	(0.0724)	(0.0835)	(0.0828)
F-stat	61.79	52.28	55.09
County-level controls	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
No. of obs	24917	17184	17223

Notes: The table present the first stage regression estimates for the IV estimation in Panel (b) of Table 2. Column (1)-(2) report the first stage estimate for column (1)-(2) in Panel (b) of Table 2 respectively. Column (3) report the first stage estimate for column (3)-(6) in the same Panel. Connected$_{j,t}$ is an indicator for county j connected to expressway in year t. MST_j is an indicator for county j located on the minimum cost-path. Province share$_{jt}$ is the share of counties in the same province of county j have expressway connected in year t. Other excluded instruments include lagged real output per capita, population density, and agricultural output as a ratio to total output. Standard errors are robust and clustered at county level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D3: Inter-jurisdictional competitions by type of government expenditures-IV estimations

	(1) Capital Outlays	(2) Education	(3) Admin	(4) Others
$EXP_{j,t-1}$	0.572***	0.416***	0.717***	0.827***
	(5.44)	(5.44)	(5.13)	(7.56)
$\overline{EXP}_{j,t}$	0.662***	0.684***	0.435**	0.286
	(4.82)	(7.72)	(2.99)	(1.73)
Connected$_{j,t}$	97.05***	22.11	50.38	49.59
	(3.56)	(1.14)	(1.37)	(0.53)
Connected$_{j,t} \times \overline{EXP}_{j,t}$	-0.595***	-0.134	-0.236	-0.157
	(-3.32)	(-1.49)	(-1.26)	(-0.89)
County-level controls	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
No. of Obs.	17,217	17,217	17,217	17,198

Notes: This table reports the IV estimation results for the effect of expressway connection on inter-jurisdictional competition by spending category. The sample covers 1996-2006. The instrumental variable is the indicator of whether county j lies on the minimum distance network (MST_j), multiplied by the share of connected counties in province p in year t ($MST_{p,t}$). When calculating the weighted average spending of neighbouring counties, the weight matrix use the inverse square distance between two counties within the same province as the weight ($w_{j,k} = \frac{1}{d^2_{j,k}}$), and otherwise 0. The weights are normalized so they sum to one for county j. County-level controls include lagged real output per capita, population density, and agricultural output as a ratio to total output. Standard errors are robust and clustered at county level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D4: Inter-jurisdictional spending competitions using alternative weight matrix

	Total		Capital outlays	Education	Admin	Others
	(1)OLS	(2)IV	(3)OLS	(4)OLS	(5)OLS	(6)OLS
$EXP_{j,t-1}$	0.426**	0.378**	0.633***	0.466***	0.734***	0.797***
	(0.129)	(0.141)	(0.121)	(0.077)	(0.127)	(0.081)
$\overline{EXP}_{j,t}$	0.417***	0.551**	0.374***	0.512***	0.314***	0.335***
	(0.078)	(0.168)	(0.098)	(0.053)	(0.091)	(0.049)
Connected$_{j,t}$	47.77*	160.3	17.95**	0.873	6.923*	14.18
	(19.610)	(172.600)	(6.407)	(2.109)	(2.965)	(8.377)
Connected$_{j,t} \times \overline{EXP}_{j,t}$	-0.123***	-0.307	-0.243***	-0.0331*	-0.0826**	-0.0761**
	(0.036)	(0.220)	(0.070)	(0.013)	(0.027)	(0.028)
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs	17,149	17,149	17,217	17,217	17,217	17,198

Notes: This table reports the estimated effects of the expressway connection on spending competitions using an alternative weight matrix. The weight matrix for calculating $\overline{EXP}_{j,t}$ has each element $w_{j,k}$=1 if counties j and k are in the same province and share a border. The weights are normalized so they sum to one for county j. The sample covers 1996-2006. County-level controls include lagged real output per capita, population density, and agricultural output as a ratio to total output. Standard errors are robust and clustered at county level.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D5: Was there any spill-over effect?

	Immediate neighbors				2nd order neighbors			
	Ln(Output)	Ln(Ind output)	Ln(Ag output)	Ln(Pop)	Ln(Output)	Ln(Ind output)	Ln(Ag output)	Ln(Pop)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connected$_{j,t}$	-0.002	0.001	0.015	0.001	-0.003	0.010	-0.012	0.001
	(0.019)	(0.021)	(0.038)	(0.005)	(0.021)	(0.019)	(0.046)	(0.005)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs	1,609	1,677	1,676	1,691	1,639	1,703	1,703	1,718

Notes: This table reports the estimated treatment effect of the expressway connection on peripheral counties' output and population. The dependent variables in the first three columns are the natural logarithms of total output, total agricultural output, and total industrial output, all measured in real terms for county j in year t. The dependent variable is the natural logarithm of total population in column (4). Column (5)-(8) present estimates for sample from 1996-2006. Standard errors are robust and clustered over county. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D6: Contribution from each channel - parameters

Parameter	Notation	Estimate	Source
Effect of expressway connection on output (% change)	$\Delta Y/Y$	-0.039	Table B1 col. (1)
Expenditure			
Effect of expressway connection on government expenditure (% change)	$\eta_{e,d}$	-0.027	Table 2 col. (1)
Expenditure share of output		0.114	Average Expenditure/output at county level from sample
Fiscal multiplier		0.600	Guo, Liu and Ma (2016) /Zhang (2020)
Elasticity of output with respect to government expenditure	$\sigma_{y,e}$	0.068	Fiscal multiplier*Expenditure share of output
Effective tax rate			
Effect of expressway connection on ETR (level)		0.008	Table 5 col. (1)
Baseline ETR		0.271	Table 1
Effect of expressway connection on ETR (% change)	$\eta_{\tau,d}$	0.030	Effect of expressway/Baseline ETR
Tax multiplier		-2.500	Romer and Romer (2010)/Arnold et al. (2011)
Corporate tax base as share of output		0.057	Average profit-output ratio at firm level from sample
Corporate tax revenue as share of output		0.015	Coprporate tax base as share of output*ETR
Elasticity of output with respect to ETR	$\sigma_{y,\tau}$	-0.039	Tax multiplier*share of tax base over output
Subsidy			
Effect of expressway connection on subsidy amount		-0.044	Table 4
Subsidy as share of output		0.003	Firm data
Subsidy elasticity of output		N/A	N/A
Privitisation			
Expressway connection effect on probability of remaining as SOE (during the sample period)	Δk	0.060	Table 6
Effect of expressway connection on share of SOE (% change)	$\eta_{s,d}$	0.060	Effect of expressway on probability of remaining as SOE
Output difference (firm level) between SOE and non-SOE (percentage term)		-0.270	Liao, Liu and Wang (2014)
Share of SOE (among all firms)	S	0.380	Share of SOE among all firms in firm sample
Elasticity of output with respect to share of SOE	$\sigma_{y,s}$	-0.103	Percentage difference of output at firm level*share of SOE

Note: The table list the parameters used for the calculating the contribution to output change through each channel.

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