



Contents lists available at ScienceDirect

Regional Science and Urban Economics

journal homepage: www.elsevier.com/locate/regec

Interjurisdictional competition for FDI: The case of China's "development zone fever" [☆]

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ARTICLE INFO

Article history:

Received 24 September 2010

Accepted 21 December 2010

Available online 28 December 2010

JEL classification:

C72

H77

R58

Keywords:

Interjurisdictional competition

Development zone

All-pay auction

ABSTRACT

In the attempt to compete for foreign investment, local jurisdictions in China set up a large number of development zones for industrial and commercial uses. Many of these areas never received any investment and sat idle for years as undeveloped sites. In several periods of time, development zones mushroomed at such a rampant pace that the central government had to intervene in order to prevent the rapid reduction of agricultural land. In this paper, we propose a model to account for the "development zone fever" experienced in China. We consider local jurisdictions as participants in an all-pay auction competing for investment projects. An investment always goes to a jurisdiction with the highest-quality infrastructure in its development zone. A jurisdiction has to pay the cost of infrastructure in advance, which is irrecoverable whether it wins the investment or not. In equilibrium, many jurisdictions set up economic development zones and spend on infrastructure, although some of these sites will not receive any investment. Potential effects of several policies are examined. The model suggests that to reduce land use by development zones, the central government could either claim a larger share of the tax revenue generated by foreign investments or raise the tax on the land used for development zones. Other policies, such as putting a budget constraint on infrastructure spending or restricting some jurisdictions from competing, are either ineffective or have some undesirable effects.

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1. Introduction

An economic development zone is a government-designated area for industrial and commercial development.¹ In 1984, China opened its first development zone in Dalian. By January 1985, similar development zones were established in thirteen other coastal cities. The central government granted these zoned areas various favorable policies for the purpose of attracting foreign direct investment (FDI).

The number of development zones and their importance grew rapidly in China. They have played a crucial role in China's success in attracting FDI and boosting international trade. In 2008, the 54 national-level economic development zones (a small group established with the endorsement of the State Council of China and for which accurate statistics are easily available) received US\$ 19.5 billion FDI, 21.1% of the total in the country; their total value of imports and

exports was US\$ 385.5, 15.0% of the total.² Some of these development zones have experienced miraculous economic success.³

Although the earliest development zones were all established by the initiation of the central government, local governments in China quickly recognized this useful development tool.⁴ Before long, many local governments started to set up their own development zones. A typical development zone is located at the edge of an urban area. The local government first draws up a blueprint that delineates the land area for development and lays out the stages of planned development. It then raises funds through various channels such as bank loans or sales of land use right to local developers. Using these funds as well as some tax revenue, the local government builds infrastructure in the

² Statistics on all development zones are difficult to come by. According to one report, in 2006, development zones at different levels accounted for 68% of China's GDP and 87% of its exports (http://www.cbfeature.com/special_coverage/lead/changes_in_development_zones/, accessed July 26, 2009).

³ For example, Kunshan, which was still a poor rural area in Jiangsu province in the 1980s, has now become one of the richest counties in China, largely due to the success of its economic development zones. In 2008, Kunshan manufactured 48 million laptop computers and 15.2 million digital cameras, accounting for 40% and 15%, respectively, of all those sold in the world (http://district.ce.cn/zg/200907/28/t20090728_19644318.shtml, accessed May 20, 2010).

⁴ There are four levels of local governments in China, including, from the lower to the upper level, (1) townships; (2) counties; cities; and districts; (3) prefectures and municipalities; and (4) provinces, autonomous regions, and direct-control municipalities.

[☆] This paper was written when I was a visiting scholar at the Federal Reserve Bank of Boston. I thank my colleague at the Bank, Bo Zhao, for many stimulating discussions on this topic and two anonymous referees for helpful comments. Any errors are my own.

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¹ "Development zone" is a generic name. In practice, a development zone in China may be officially called an economic development zone, economic and technological development zone, new and high technology development zone, industrial park, etc.

development zone, typically including paved roads, utility connections for water, sewer, electricity, gas, cable, and phone services, and some landscaping. Local government officials will actively solicit or campaign for FDI; some of them travel all over the world to court potential investors. In addition to the tax breaks granted by the central government, local governments will often offer additional incentives for FDI located in their development zones, which may include local tax breaks, discounted land rents, and lowered utility prices in the early years of investment.

By one count, there were already 1951 development zones in China by the end of 1992, with the planned area totaling 15.3 thousand square kilometers (Yang, 1997; Zhang and Li, 2007). To put this in perspective, China's total urban built-up area was only 13.4 thousand square kilometers in that year. During this explosive boom of development zones, local governments seized a large amount of land from peasants and the total area of cultivated land decreased sharply.⁵ Naturally, many of the newly designated development zones never saw any investment and most of the zoned areas were never developed, leaving a lot of arable land idle. In response, the central government urged local governments to raise the approval requirements for development zones. The State Council ran a campaign to review existing development zones and canceled many of them.

However, this policy did not solve the problem. By 1996, the number of development zones reached 4120 (Zhang and Li, 2007). As a further response, the State Council decided in April 1997 to temporarily stop authorizing any conversion of arable land for nonagricultural uses. In 1998, this policy was extended for another year. Despite this effort, the expansion of development zones was again out of control in the late 1990s and early 2000s. By 2003, the number of development zones increased to 6866, with a total planned area amounting to 38.6 thousand square kilometers (again even higher than the total urban built-up area in China, which was 28.5 thousand square kilometers in 2003). During these years, even more peasants had their land taken away by local governments with little compensation. Some observers would call this phenomenon the "enclosure movement" in China (He, 2003).⁶

In 2003, the central government again had to step in to curb this wild development. The State Council ordered a complete halt of new development-zone approvals. Local governments were requested to take stock of the development zones in their jurisdictions and rectify the disorder. According to the guidelines issued by the central government, each county in principle could have at most one development zone, which had to be authorized by the central or provincial government. Development zones approved by lower-level governments all were to be closed and the undeveloped land they occupied had to be returned to peasants. Even the development zones that survived this round of reorganization were required to cut back their use of arable land. It took more than three years to complete this round of cleanup. In late 2006, the central government released a directory that listed only 1568 surviving development zones, and together they only had a total planned area of 9949 square kilometers. Compared to those in 2003, the number of development zones and their planned area were reduced by 77.2% and 74.2% respectively (see Fig. 1).

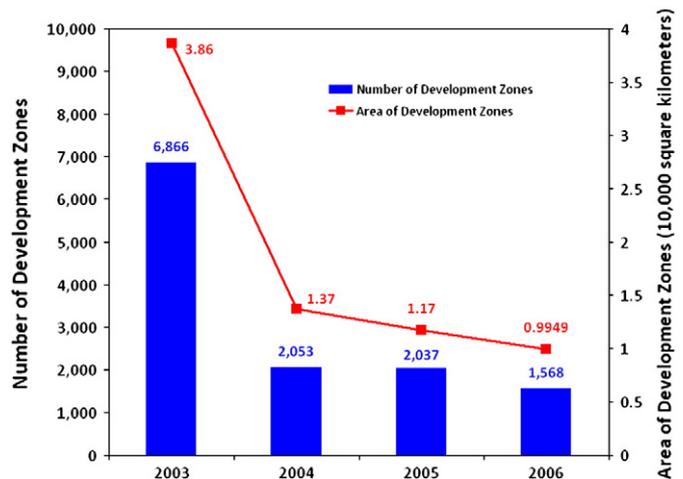


Fig. 1. Closing down undeveloped development zones in China, 2003–2006. (Data source: National Development and Reform Commission of China.)

These developments in China during the past two decades pose a puzzling question: why did local governments decide to open so many development zones even though only some of them would succeed in securing investments. Ex post, there appears to be a great waste of resources, especially arable land. Given the concern that a similar development zone fever may return in the near future, one also wonders how different central government policies would affect the outcome. A better understanding of this phenomenon is crucial for comprehending some important features of land use patterns and the process of urbanization in China.

In this paper, we propose a simple model to account for the strategic competition for FDI among local governments in China. We think of this situation as an all-pay auction in which local governments are bidders. Each jurisdiction decides how much resources are used to open a development zone and build infrastructure in it to attract an indivisible FDI project. The jurisdiction where the infrastructure is of the highest quality will win the competition. A key feature of this game is that all participating bidders incur a sunk cost. That is, even if a jurisdiction fails to obtain the FDI, it still has to pay a cost because its spending on infrastructure cannot be recovered. It is shown that in equilibrium more than one jurisdiction will spend on infrastructure even if only one of them wins the project, which explains why ex post we see a seeming waste of resources. More importantly, this model provides a framework for us to discuss the effects of various policies.

The rest of the paper is organized as follows. Section 2 introduces the institutional background in China, focusing on why it is reasonable to treat local jurisdictions in China as tax revenue maximizers. Section 3 briefly reviews the literature on interjurisdictional competition. Section 4 presents the model and discusses its policy implications. Section 5 concludes with some remarks.

2. Institutional background

It is rather remarkable that China, once a socialist economy with a deep root in centralized planning and control, has fostered fierce competition among its local jurisdictions since the inception of its economic reform. Indeed, this may well be the key to understanding China's rapid economic growth in the past three decades (Oi, 1992; Cheung, 2008).

Prior to 1980, China had a highly centralized fiscal system that was characterized by "unified revenue collection and unified spending" (*tongshou tongzhi*). The central government controlled almost all revenue sources and adopted a unified budget that included receipts and expenditures of the central government, provinces, as well as

⁵ In China, land is owned by the state in urban areas and by local collective economic organizations in rural areas. Most arable land in rural areas is distributed or leased to peasants. Technically, peasants are not owners but only have the use rights of their land for certain years. In practice, peasants often do not even have the basic tenants' rights to keep the land for a pre-specified period; their land can be taken away (with limited compensation) at the local governments' discretion.

⁶ From 2001 to 2003, China's Ministry of Land and Resources and its local branches investigated 364 thousand cases of illegal land uses, many of which involved land appropriation by local governments and developers. Some peasants would confront government officials and riot police in order to keep their farmland. During these years, land-related protests by peasants became a major source of social unrest in China (Keidel, 2006).

sub-provincial governments. Local governments thus did not have their own separate budgets; their expenditures were approved by the central government and financed by funds allocated through the central government. Although this system evolved in detail over time, its most prominent feature before the reform era had always been centralized planning and control.

A key component of China's economic reform was fiscal decentralization. In the early 1980s, China established a "fiscal contract system" with the goals to promote self-sustainable local public finance and provide incentives for local governments to develop their local economies. Under this system, a local government would sign a contract, stipulating the share of its revenue or a lump-sum payment that should be remitted to its upper-level government.⁷ Such a contract typically lasted three to five years before a revision. An important incentive device built into this system was that local governments could keep all (or almost all) extra revenues they generated beyond their contract responsibilities. In the meantime, the central government also decentralized many authorities, granting local governments a greater autonomy in terms of approving investments, allocating resources, and regulating local economies in their own jurisdictions.

This fiscal decentralization, together with other complementary reforms, provided an institutional foundation for a "Chinese-style federalism" (Montinola et al., 1995). It created an environment in which local governments and their officials benefited greatly from local economic prosperity. It thus gave local government officials a significant incentive to pursue economic growth. Oi (1992) would famously characterize this institutional arrangement in China as "local state corporatism." As she pointed out, local governments in China show many features of a large business corporation and their officials behave like managers or entrepreneurs in seeking profit/revenue opportunities for their own jurisdictions. In an account of the intense inter-county competition as the key driver of economic growth in China, Cheung (2008) made a similar point that county government officials are very much like corporate executives.

During a major tax reform in 1994, China replaced the fiscal contract system with a new "tax sharing system." This system defined certain taxes as revenue sources for the central government and other taxes as revenue sources for local governments; it also created a value-added tax that would be shared by the central and local governments. Whereas this tax reform was meant to strengthen the fiscal position of the central government, the incentives for local governments to pursue economic development were essentially preserved.

Local government officials in China benefit from a prosperous local economy in many different ways. First, a growing local economy is a stable revenue source. This makes it much easier for local government officials to do their job such as providing local public education and improving local infrastructure. Second, a stable source of government revenue also rewards government officials financially. Part of the revenue will become perks and fringe benefits for them; part of it will be used to fund their work-related travel and consumption; and of course, part of it may end up in the officials' pockets through corruption, fraud, or other questionable conduct.

Third, and perhaps most importantly, a prosperous local economy helps government officials climb up the hierarchy within the ruling party's cadre system. In China, government officials are not elected through a democratic system; they are promoted by upper level officials in the communist party. At least during the post-reform era, economic performance of their jurisdictions has been an important factor that determines the career paths of local government officials. As shown by Li and Zhou (2005), a better economic performance increases a provincial leader's probability of being promoted and

decreases the probability of his or her career termination.⁸ The same is true at lower government levels. Consider the example of Suzhou, a municipality in Jiangsu province that has been most famous in recent years for several successful development zones within its jurisdiction. During 2000–2009, four consecutive party leaders in Suzhou were all quickly promoted to higher positions (either within or outside the province) to spread the "Suzhou experience."⁹

This institutional arrangement in China has fostered fierce competition among local government officials to develop their local economies. They work hard to attract capital to their regions; they experiment with different policies that are tailored to investors and entrepreneurs; they learn from other localities' successes as well as their failures. It is in this context that we believe it reasonable to model local jurisdictions in China as tax-revenue (or tax-base) maximizers that compete with one another for foreign investments.

3. Related literature

The study of interjurisdictional competition has a long tradition (Tiebout, 1956; Oates, 1972) and therefore there is a vast literature on this topic. Tax competition is perhaps the most widely studied topic in this field.¹⁰ In this brief review, we focus on one strand of this literature that examines interjurisdictional competition for mobile firms or investment in physical capital, which is most closely related to this study.

A central theme of the early literature on interjurisdictional competition is that competition for mobile capital may lead to a "race to the bottom," resulting in inefficiently low tax rates and local public expenditures. This idea traces back at least to Oates (1972) and is more rigorously formalized by Wilson (1986) and Zodrow and Mieszkowski (1986). According to this theory, local governments tax mobile capital to provide public goods. By setting a lower tax, one jurisdiction can attract firms from other places to increase its own tax base. However, given a fixed capital stock, this will create a negative "fiscal externality" and reduce the tax base of other jurisdictions. In equilibrium, tax competition transfers resources from the public sector to private sector and leads to an underprovision of public goods.

An alternative view emphasizes that governments, run by self-interested politicians, are not necessarily benevolent planners and may be revenue-maximizing Leviathans (Brennan and Buchanan, 1980). Without any restriction on the power to tax, governments tend to extract an excessive amount of surplus from the private sector, resulting in an over-sized public sector and inefficient resource allocation. In this case, tax competition may help "tame the Leviathan" and thus improve social welfare. Edwards and Keen (1996) and Rauscher (1998) have explored this idea in formal models.

A few other studies also try to explain why interjurisdictional competition for capital investment may not lower social welfare. Black and Hoyt (1989) model a situation in which two cities bid for a large firm. The firm and its workers pay taxes to the city where the firm is located, and the city provides them with public services. If the marginal cost of providing public services to a new firm and its workers is lower than the tax revenue they generate, a city benefits from a new firm locating there. Since the new firm and its workers have to pay the average cost of public services, if the average cost is

⁸ In a widely-cited article, Zhou (2004) argues that this process of selecting and promoting cadres has essentially created a job tournament among local government officials and that it explains many phenomena in China, including local protectionism, interregional trade wars, and redundant construction.

⁹ Journalists have dubbed Suzhou the "cradle for province governors." Some foreign investors even expressed their concerns over the rapid turnover of leaders in Suzhou, which they suspected would interrupt the stability and continuity of the local economic environment. See Yang and Wang (2008) for an informative case study of the Suzhou region in the context of development zone fever.

¹⁰ For some recent reviews of this literature, see, for example, Wilson (1999), Brueckner (2003), Wilson and Wildasin (2004), and Wildasin (2006).

⁷ This remittance could be negative when a local government received a subsidy.

higher than the marginal cost, it makes sense for the city to use a subsidy to attract the firm. More importantly, such a subsidy is not simply a transfer from a local government to the new firm; it enhances social welfare because the bidding leads to the efficient location of the firm.

King et al. (1993) present a two-period model in which local governments bid for a plant. The plant chooses its location in the first period and relocation is costly. Thus the government that won the bid in the first period gains an advantage over the firm in the second period, which allows it to extract a share of the surplus of the firm. Knowing this, the government is willing to offer tax breaks or subsidies in the first period to bid for the plant. King et al. assume that regional governments can invest in infrastructure before the two-period game is played. They show that even if the cost of building infrastructure is identical across regions, in equilibrium, regional governments choose different levels of infrastructure and that this outcome is efficient.

Wilson (2005) analyzes a situation in which each local government provides a public input (e.g., infrastructure) to mobile firms and finances it by taxing wage and capital income. More public input not only raises the productivity of labor and capital but also attracts firms from other regions, both of which result in higher tax revenue. Whereas local residents control the tax rates, government officials choose the level of public input to maximize tax revenue net of the cost of providing this input. The competition among governments, by spending on the public input to lure firms, increases residents' income and makes them better off.

Two studies analyze the welfare effect of interregional competition particularly in the context of attracting FDI. Fumagalli (2003) shows that local subsidies to FDI could be welfare-improving when the location less preferred by the foreign investor benefits more from the investment than the alternative location. However, such subsidies also have a negative effect because they make domestic firms less competitive. Davies (2005) points out that local incentives to FDI not only influence locational choices but also affect the investor's output decisions, because such incentives are usually tied to the investor's use of domestic inputs. He argues that state tax competition does not necessarily reduce national welfare because competition leads the FDI to locate efficiently. Without such competition, federal subsidies are needed to attain the national optimum.

Similar to King et al. (1993), in this paper we also analyze local jurisdictions' investment in infrastructure to attract FDI. We present a simple one-shot game that resembles a sealed-bid all-pay auction, and use it to explain the development zone fever in China and examine the effects of various policies. The analytical techniques are mostly derived from the all-pay auction literature, which was developed to study strategic situations such as rent-seeking, political lobbying, R&D races, and job promotion tournaments.¹¹

4. Model

We analyze interjurisdictional competition for FDI in China as an all-pay auction. We start with a very simple model that is just enough to generate some important insights, and then extend the model to take into account some complications.

4.1. A simple model with complete information

Consider a situation in which two risk-neutral jurisdictions compete for an indivisible FDI project. If located in jurisdiction i , the gross value of the investment for the domestic economy is v_i , which comprises four parts: (1) taxes paid by the foreign-owned enterprise

to central and local governments; (2) the extra income generated by the FDI through creating more jobs for local workers; (3) the extra profit to local businesses that supply intermediate goods or provide business services to the foreign-owned enterprise; and (4) the value of knowledge spillovers from the FDI to local businesses and potential entrepreneurs.¹² To simplify our analysis, we assume that all of the extra income and profit are generated within the jurisdiction hosting the FDI. That is, non-host jurisdictions can only benefit from the FDI through the central government's transfer of tax revenue. Clearly, even for the same FDI project, v_i can be different depending where it is located because the knowledge spillovers tend to be highly location-dependent. Without loss of generality, assume $v_1 \geq v_2 > 0$. Only a portion of the value, λv_i where $0 < \lambda < 1$, accrues to jurisdiction i because the central government will extract some of the value through taxes and use it for the benefit of the entire nation.¹³ Therefore, λ is a policy variable controlled by the central government. Also for simplicity, we assume that λ is the same everywhere so it is not indexed with i .

To attract this FDI, each jurisdiction may make an irreversible spending of size s_i , which is used to set up a development zone and build infrastructure in the zoned area. The quality (Q) of infrastructure is "produced" using land (L) and physical capital (K), which is governed by a Cobb–Douglas technology $Q = L^\alpha K^{1-\alpha}$, $0 < \alpha < 1$. Given the technology, a jurisdiction always spends αs_i on land in order to minimize the cost of building infrastructure. If land rent is r , $\alpha s_i/r$ is the size of its economic development zone. Assuming α and r are the same for the two competing jurisdictions and by choosing a proper unit for r , we shall proceed by letting $\alpha/r = 1$. Therefore, depending on the context, we may refer to s_i as jurisdiction i 's spending on infrastructure, or the size of its economic development zone, or the quality of its infrastructure built to accommodate the FDI. All these quantities are proportional to one another, so we use the same measure for all of them.

In addition to infrastructure, foreign investors may also care about local taxes, business regulations, and the endowment of human and natural resources in the host jurisdiction, because all these could affect the returns of their investment. For the purpose of this study, we assume that the two jurisdictions are equally competitive along those other dimensions and the quality of their infrastructure alone determines the locational choice of foreign investors. In particular, assume that the FDI will go to the jurisdiction with the higher-quality infrastructure, i.e., a larger s_i . In the case $s_1 = s_2$, the two jurisdictions have equal chances to receive the investment. For the time being, we assume that the size of the FDI (and therefore its value) is independent of the host jurisdiction's spending on infrastructure. In other words, the foreign investors have already decided to invest a fix amount of capital in one of the two jurisdictions; all that can be influenced is the locational decision. We will relax this assumption later by assuming that the size of the FDI is related to the winning jurisdiction's spending on infrastructure.

To facilitate policy discussion below, we introduce a tax on infrastructure spending, which is also controlled by the central government. In particular, if a jurisdiction spends s_i on infrastructure, it has to pay τs_i , where $\tau \geq 1$, with s_i used for building infrastructure and $(\tau - 1)s_i$ paid to the central government.¹⁴

¹² More specifically, knowledge spillovers occur if the FDI project comes with new ideas that stimulate local entrepreneurial activities and make local existing businesses more productive, leading to more income and profit.

¹³ Note that the central government will extract part of v_i as tax revenue and spend it for the welfare of the whole country, including the host jurisdiction i . Therefore, λ should be interpreted as the net effect of this policy on jurisdiction i instead of the nominal tax rate. A second policy variable τ , which we will introduce below, should be interpreted in the same way.

¹⁴ Throughout the rest of the paper, we discuss τ as a tax. But of course it can also be interpreted as a subsidy by assuming $\tau < 1$.

¹¹ See, for example, Hillman and Riley (1989), Baye et al. (1993), Che and Gale (1998), Clark and Riis (1998), Gavius et al. (2002), and Kaplan et al. (2002).

We assume that the gross expenditure on infrastructure in a development zone, once paid, becomes a sunk cost. Therefore, if jurisdiction i wins the competition, its payoff is $\lambda v_i - \tau s_i$; otherwise, its payoff is $-\tau s_i$. Of course, any infrastructure may also be valuable for some alternative uses. Here we normalize the value of its second best use to zero.¹⁵ Note that, whereas the goal of each jurisdiction i is to maximize its expected payoff $(\lambda v_i)Pr[i \text{ wins} | s_1, s_2] - \tau s_i$, social welfare in the domestic economy is maximized only if the winner i gives the highest $v_i - (s_1 + s_2)$.

Suppose the valuations and the rules of this game are common knowledge between the two jurisdictions. This is a two-player game that is often called an all-pay auction with complete information. Our analysis will focus on the equilibrium of this game. Following standard practice in noncooperative game theory, define player i 's (mixed) strategy as a probability distribution over its spending s_i that specifies the probability (or probability density) of choosing each possible s_i . A Nash equilibrium of the game is a pair of strategies, one for each player, that are best responses to each other.

It is easy to see that in equilibrium neither player will choose a specific spending level for sure. In other words, this game has no pure-strategy equilibria.¹⁶ It is well known that this game has a mixed-strategy equilibrium, in which each player continuously randomize over a range of s_i .¹⁷

Proposition 1. Two jurisdictions with values $v_1 \geq v_2$ compete for the FDI through an all-pay auction as described above. (1) In equilibrium, jurisdiction 1 randomly draws s_1 from the distribution

$$F_1(x) \equiv Pr[s_1 \leq x] = \frac{\tau x}{\lambda v_2}, \quad x \in \left[0, \frac{\lambda v_2}{\tau}\right]; \quad (1)$$

jurisdiction 2 randomly draws s_2 from the distribution

$$F_2(x) \equiv Pr[s_2 \leq x] = 1 - \frac{v_2}{v_1} + \frac{\tau x}{\lambda v_1}, \quad x \in \left[0, \frac{\lambda v_2}{\tau}\right]. \quad (2)$$

(2) In equilibrium, expected total spending by the two jurisdictions on economic development zones is no more than $\frac{\lambda v_2}{\tau}$; up to one third of this total is spent by the jurisdiction that will not receive the FDI.

It is straightforward to verify that the pair of strategies indeed constitutes an equilibrium. Given an arbitrary $s_1 \in \left[0, \frac{\lambda v_2}{\tau}\right]$, jurisdiction 1 wins the competition only if jurisdiction 2 chooses an $s_2 \leq s_1$, which happens with probability $F_2(s_1)$. So jurisdiction 1's expected payoff is

$$\pi_1(s_1) = F_2(s_1)(\lambda v_1) - \tau s_1 = \left(1 - \frac{v_2}{v_1} + \frac{\tau s_1}{\lambda v_1}\right)(\lambda v_1) - \tau s_1 = \lambda(v_1 - v_2). \quad (3)$$

¹⁵ That is, if the value of the second best use is positive, we interpret τs_i as the payment for the value beyond the second best use.

¹⁶ It is clear that $s_1 = s_2 = 0$ cannot be an equilibrium because either player has an incentive to raise the spending just a little bit and obtain a higher expected payoff. A pair of strategies with $s_1 \geq s_2 > 0$ cannot be an equilibrium because at least one player is not playing the best response. If $\tau s_1 \geq \lambda v_2$, 2's expected payoff is negative and can do better by choosing $s_2 = 0$. If $\tau s_1 < \lambda v_2$, 2 can do better by raising s_2 just a little bit above s_1 . Similarly, it can be shown that a pair of strategies with $s_2 > s_1 > 0$ cannot be an equilibrium either.

¹⁷ See, for example, Hillman and Riley (1989), Baye et al. (1990), and Ellingsen (1991) for games of similar nature but analyzed in completely different contexts.

Given 2's strategy, jurisdiction 1 wins for sure if $s_1 > \frac{\lambda v_2}{\tau}$. However, in that case, 1's payoff is $\lambda v_1 - \tau s_1 < \lambda(v_1 - v_2)$. Therefore, no matter what the distribution of s_1 is, as long as its support is in $\left[0, \frac{\lambda v_2}{\tau}\right]$, jurisdiction 1's expected payoff is always $\lambda(v_1 - v_2)$ and there is no way to improve this payoff. In other words, jurisdiction 1 is playing its best response to jurisdiction 2's strategy.

Now consider jurisdiction 2. For an arbitrary $s_2 \in \left[0, \frac{\lambda v_2}{\tau}\right]$, jurisdiction 2 wins the competition with probability $F_1(s_2)$. So its expected payoff is

$$\pi_2(s_2) = F_1(s_2)(\lambda v_2) - \tau s_2 = \frac{\tau s_2}{\lambda v_2}(\lambda v_2) - \tau s_2 = 0. \quad (4)$$

Given 1's strategy, jurisdiction 2 wins for sure if $s_2 > \frac{\lambda v_2}{\tau}$. However, in that case, 2's payoff is $\lambda v_2 - \tau s_2 < 0$. Therefore, as long as the distribution of s_2 has a support in $\left[0, \frac{\lambda v_2}{\tau}\right]$, jurisdiction 2's expected payoff is always 0 and there is no way to improve this payoff. That is, jurisdiction 2 is also playing its best response to jurisdiction 1's strategy. By definition, this pair of strategies constitutes an equilibrium.

We next calculate the expected total spending on infrastructure in equilibrium. Notice that F_1 represents a uniform distribution over $\left[0, \frac{\lambda v_2}{\tau}\right]$. Thus the expectation of s_1 is $E(s_1) = \frac{\lambda v_2}{2\tau}$. F_2 is also a uniform distribution when $s_2 > 0$. However, $F_2(0) = 1 - \frac{v_2}{v_1}$, so jurisdiction 2 chooses a positive level of spending with probability $\frac{v_2}{v_1} \leq 1$. The expectation of s_2 is therefore $E(s_2) = \left(1 - \frac{v_2}{v_1}\right)0 + \frac{v_2}{v_1} \frac{\lambda v_2}{2\tau} = \frac{\lambda v_2^2}{2\tau v_1}$. Between these two jurisdictions, the expected total spending on economic development zones is

$$E(s_1 + s_2) = \frac{\lambda v_2}{2\tau} + \frac{\lambda v_2^2}{2\tau v_1} = \frac{\lambda v_2}{\tau} \left(\frac{1}{2} + \frac{v_2}{2v_1}\right) \leq \frac{\lambda v_2}{\tau}. \quad (5)$$

This total spending increases with λ and decreases with τ .¹⁸

Eventually, only one of the two jurisdictions will receive the FDI. The other gets nothing; it ends up with an empty development zone and its spending (if positive) appears to be wasted. In equilibrium, with probability $\left(1 - \frac{v_2}{v_1}\right)$ jurisdiction 2 will choose zero spending on its economic development zone and so the smaller spending level is 0. With probability $\frac{v_2}{v_1}$ both jurisdictions will choose spending levels from the same uniform distribution over $\left[0, \frac{\lambda v_2}{\tau}\right]$, which has a density function $f(x) = \frac{\tau}{\lambda v_2}$. In this case, either one's spending may be the smaller one. Therefore, the expectation of the smaller s_i is

$$E(\min\{s_1, s_2\}) = \left(1 - \frac{v_2}{v_1}\right)0 + \frac{v_2}{v_1} \left[2 \int_0^{\frac{\lambda v_2}{\tau}} \frac{\tau}{\lambda v_2} \left(\int_0^t \frac{\tau z}{\lambda v_2} dz\right) dt\right] = \frac{\lambda v_2^2}{3\tau v_1}. \quad (6)$$

¹⁸ One could also think of λ as a combination of government tax policy and a time-variant scaling parameter. For example, let $\lambda = \lambda_0 \lambda_t$, where λ_0 is the local jurisdiction's share of the value and λ_t a parameter indicating that the value is time-dependent. The idea is, even the same FDI may generate a higher value in booming years. This alternative interpretation has the intuitive implication that in booming years (with a larger λ_t) the equilibrium level of spending on infrastructure is higher, which is consistent with what has happened in China.

This is no more than one third of the total spending:

$$E(\min\{s_1, s_2\}) = \frac{1}{3} \left(\frac{\lambda v_2^2}{2\tau v_1} + \frac{\lambda v_2^2}{2\tau v_1} \right) \leq \frac{1}{3} \left(\frac{\lambda v_2}{2\tau} + \frac{\lambda v_2}{2\tau v_1} \right) = \frac{1}{3} E(s_1 + s_2). \tag{7}$$

The situation analyzed here can be thought of as a representative case. When thinking about reality, we would consider a large number of similar but independent situations, each involving two jurisdictions competing for an FDI project. Proposition 1 therefore suggests that many jurisdictions (in different competing jurisdiction pairs), anticipating the gain from FDI, will spend resources setting up economic development zones. Only some of them will eventually receive an investment. Others get nothing despite their spending on infrastructure. We therefore see a development zone fever and many resources appear to be wasted.

From the analysis above, it is clear that the jurisdiction with a lower value will receive the investment with a positive probability. This seems to suggest that the interjurisdictional competition is not economically efficient because the economic gain is not maximized. However, it is unclear what a first-best outcome would be. After all, a mechanism is always needed to allocate the FDI to a particular location, and there is no reason to assume that a mechanism will be costless. Nonetheless, we could check whether an alternative mechanism will do better.

For the purpose of comparison, we consider a hypothetical English auction to allocate the FDI. Assume that no jurisdiction has to pay any sunk cost before they know whether they will receive the investment. All they need to do is to announce an amount of resources they are willing to spend to accommodate the FDI.¹⁹ Again, consider the case in which there are only two jurisdictions competing for the FDI and they know each other's valuation of the investment. If $v_1 > v_2$, jurisdiction 1 will bid $\frac{\lambda v_2}{\tau}$ – just enough to outbid jurisdiction 2 – and win the project. This mechanism is efficient because the jurisdiction with the higher value will always win. It also has the advantage that no resources are wasted in that the losing jurisdiction does not pre-commit anything. Ignoring the profit for foreign investors, the net gain for the domestic economy under this English auction is $v_1 - \frac{\lambda v_2}{\tau}$, with $\lambda v_1 - \tau \left(\frac{\lambda v_2}{\tau} \right)$ retained by jurisdiction 1 and the rest collected by the central government. Notice that the payoff for jurisdiction 1 is still $\lambda(v_1 - v_2)$, the same as in the all-pay auction (see Eq. 3).

Is the net gain for the domestic economy larger in this English auction? To see this, we need to calculate the realized value in the all-pay auction because no jurisdiction will always win in that case. So, again, consider the all-pay auction. When jurisdiction 2 chooses $s_2 = 0$ (with probability $1 - \frac{v_2}{v_1}$), jurisdiction 1 will win and the gross value of the FDI for the domestic economy is v_1 . When jurisdiction 2 chooses $s_2 > 0$ (with probability $\frac{v_2}{v_1}$), the two jurisdictions pick their spending levels by independently making two random draws from the same uniform distribution over $\left[0, \frac{\lambda v_2}{\tau} \right]$; they win with equal probabilities and the expected

winner's value is $\frac{v_1 + v_2}{2}$. Therefore, the expected value of the FDI for the domestic economy is

$$\left(1 - \frac{v_2}{v_1} \right) v_1 + \frac{v_2}{v_1} \left(\frac{v_1 + v_2}{2} \right) = (v_1 - v_2) + \left(\frac{v_2}{2} + \frac{v_2^2}{2v_1} \right). \tag{8}$$

Then the expected net gain for the domestic economy is

$$\begin{aligned} G^e &= (v_1 - v_2) + \left(\frac{v_2}{2} + \frac{v_2^2}{2v_1} \right) - E(s_1 + s_2) \\ &= (v_1 - v_2) + \left(1 - \frac{\lambda}{\tau} \right) \left(\frac{v_2}{2} + \frac{v_2^2}{2v_1} \right) \\ &= v_1 - v_2 \left[1 - \left(1 - \frac{\lambda}{\tau} \right) \left(\frac{1}{2} + \frac{v_2}{2v_1} \right) \right] \leq v_1 - \frac{\lambda v_2}{\tau}. \end{aligned} \tag{9}$$

That is, if there is an allocating mechanism like an English auction, the net gain for the domestic economy dominates the gain from the all-pay auction.

Interestingly, in the all-pay auction the total spending $\left(\frac{\lambda v_2}{2\tau} + \frac{\lambda v_2^2}{2\tau v_1} \right)$ is actually less than in the English auction $\left(\frac{\lambda v_2}{\tau} \right)$. This is because each participant in the all-pay auction knows that they must pay the bid no matter what; taking this into account, they tend to bid less aggressively than in an English auction. The real problem with the all-pay auction is that the FDI sometimes goes to the location that will not generate the highest value. Therefore, from the perspective of the domestic economy, the real concern is not that too much is paid for the FDI (or too much land is “wasted” in the form of unused economic development zones); rather, it is the efficiency loss when the FDI ends up in a location with a lower value.

4.2. Policy implications of the simple model

4.2.1. Lowering the ratio $\frac{\lambda}{\tau}$

As indicated above, parameters λ and τ are policy variables controlled by the central government. By Eqs. (5) and (6), a smaller $\frac{\lambda}{\tau}$ leads to a lower total spending on economic development zones by the two competing jurisdictions and less land “wasted” by the losing jurisdiction. Moreover, according to Eq. (9), a smaller $\frac{\lambda}{\tau}$ gives a higher net gain for the domestic economy. This seems to be an ideal policy that helps achieve several desirable goals. In practice, $\frac{\lambda}{\tau}$ can be made lower either by increasing the central government's share of the tax revenues generated by the FDI or increasing the tax on infrastructure spending in development zones.

However, Eqs. (5) and (6) also imply that the winning jurisdiction's spending on infrastructure is $\frac{\lambda}{\tau} \left(\frac{v_2}{2} + \frac{v_2^2}{2v_1} - \frac{v_2^3}{3v_1^2} \right)$, which will decrease as $\frac{\lambda}{\tau}$ becomes smaller. This lower spending on infrastructure may affect the size of the FDI, a possibility that we have assumed away for now but will explore later.

4.2.2. Putting a constraint on infrastructure spending

In the name of preserving arable land, the central government in China repeatedly urged local governments to restrict the size of their development zones. In our model, this is equivalent to setting a maximum level of spending on infrastructure. Here we analyze the effect of this policy. Let s^m be the maximum amount of spending allowed for any jurisdiction. We assume that $s^m < \frac{\lambda v_2}{\tau}$, because otherwise we know from Proposition 1 that this policy is not binding.

¹⁹ Indeed one wonders why jurisdictions in China do not compete for FDI this way, which more closely resembles the competition process in developed countries such as the U.S. The reason perhaps has to do with the fact that both physical and legal-political infrastructures are poor in China. With a legal-political infrastructure inadequate to maintain and enforce contracts, local jurisdictions in China perhaps need to use the construction of physical infrastructure as a commitment device to make their promises credible.

Proposition 2. Two jurisdictions with values $v_1 \geq v_2$ compete for the FDI through an all-pay auction as described above and the maximum amount of spending allowed is $s^m \in \left(0, \frac{\lambda v_2}{\tau}\right)$. (1) If $s^m \in \left(0, \frac{\lambda v_2}{2\tau}\right)$, in equilibrium, the two jurisdictions choose $s_1 = s_2 = s^m$. (2) If $s^m \in \left(\frac{\lambda v_2}{2\tau}, \frac{\lambda v_2}{\tau}\right)$, in equilibrium, jurisdiction 1 randomly draws s_1 from the distribution

$$\tilde{F}_1(x) \equiv \Pr[s_1 \leq x | s^m] = \begin{cases} \frac{\tau x}{\lambda v_2}, & x \in \left[0, 2s^m - \frac{\lambda v_2}{\tau}\right] \\ \frac{2\tau s^m}{\lambda v_2} - 1, & x \in \left(2s^m - \frac{\lambda v_2}{\tau}, s^m\right) \\ 1, & x = s^m \end{cases} \quad (10)$$

and jurisdiction 2 randomly draws s_2 from the distribution

$$\tilde{F}_2(x) \equiv \Pr[s_2 \leq x | s^m] = \begin{cases} 1 - \frac{v_2}{v_1} + \frac{\tau x}{\lambda v_1}, & x \in \left[0, 2s^m - \frac{\lambda v_2}{\tau}\right] \\ 1 - \frac{2v_2}{v_1} + \frac{2\tau s^m}{\lambda v_1}, & x \in \left(2s^m - \frac{\lambda v_2}{\tau}, s^m\right) \\ 1, & x = s^m. \end{cases} \quad (11)$$

(3) Total spending on infrastructure may be higher than without the budget constraint.

First let us verify the equilibrium strategies for the case $s^m \in \left(0, \frac{\lambda v_2}{2\tau}\right)$. If $s_1 = s^m$, jurisdiction 2's best response is to choose $s_2 = s^m$. With a 50% chance to win the FDI, its expected payoff is $\frac{\lambda v_2}{2} - \tau s^m > 0$. There is no way jurisdiction 2 can improve its payoff by choosing any other spending level lower than s^m . Similarly, jurisdiction 1's best response to $s_2 = s^m$ is to choose $s_1 = s^m$. Therefore, each choosing s^m is an equilibrium and the total spending in equilibrium is $2s^m$.

We have shown in Eq. (5) that without the budget constraint, the total spending is $\frac{\lambda v_2}{2\tau} + \frac{\lambda v_2^2}{2\tau v_1}$, strictly smaller than $\frac{\lambda v_2}{\tau}$ when $v_1 > v_2$. It follows that $\frac{\lambda v_2}{4\tau} + \frac{\lambda v_2^2}{4\tau v_1} < \frac{\lambda v_2}{2\tau}$. If the spending cap happens to be $s^m \in \left(\frac{\lambda v_2}{4\tau} + \frac{\lambda v_2^2}{4\tau v_1}, \frac{\lambda v_2}{2\tau}\right)$, then $2s^m > \frac{\lambda v_2}{2\tau} + \frac{\lambda v_2^2}{2\tau v_1}$; that is, the total spending with the constraint, $2s^m$, is strictly higher than the total without the constraint.

Moreover, the stringent budget constraint also affects each jurisdiction's probability of winning the FDI. Recall from Proposition 1 that without the budget constraint, jurisdiction 1's spending s_1 has a density $\frac{\tau}{\lambda v_2}$ and it wins the FDI if jurisdiction 2 bids a smaller s_2 (which occurs with probability $F_2(s_1) = 1 - \frac{v_2}{v_1} + \frac{\tau s_1}{\lambda v_1}$). Therefore, without the budget constraint, the probability that jurisdiction 1 wins the FDI is

$$\int_0^{\frac{\lambda v_2}{\tau}} \frac{\tau}{\lambda v_2} \left(1 - \frac{v_2}{v_1} + \frac{\tau t}{\lambda v_1}\right) dt = 1 - \frac{v_2}{2v_1}, \quad (12)$$

which is greater than 50% when $v_1 > v_2$. In contrast, with a spending cap $s^m \in \left(0, \frac{\lambda v_2}{2\tau}\right)$, jurisdiction 1 (with the higher value) will now win the FDI with a 50% probability, lower than the case without the budget constraint. Therefore, the winner's value (i.e., the realized value of the FDI) is expected to be smaller than before. Given the lower value and higher level of spending, setting a spending cap $s^m \in \left(\frac{\lambda v_2}{4\tau} + \frac{\lambda v_2^2}{4\tau v_1}, \frac{\lambda v_2}{2\tau}\right)$ is clearly a bad policy.

Now consider the case $s^m \in \left(\frac{\lambda v_2}{2\tau}, \frac{\lambda v_2}{\tau}\right)$.²⁰ The two distribution functions, defined in Eqs. (10) and (11), imply that each jurisdiction will either pick a spending level from $\left[0, 2s^m - \frac{\lambda v_2}{\tau}\right]$ or choose s^m . Given jurisdiction 2's strategy specified above, 1's expected payoff is

$$\begin{aligned} \pi_1(s_1 | s^m) &= \tilde{F}_2(s_1)(\lambda v_1) - \tau s_1 \\ &= \begin{cases} \left(1 - \frac{v_2}{v_1} + \frac{\tau s_1}{\lambda v_1}\right)(\lambda v_1) - \tau s_1 = \lambda(v_1 - v_2), & \forall s_1 \in \left[0, 2s^m - \frac{\lambda v_2}{\tau}\right]; \\ \left\{ \left(1 - \frac{2v_2}{v_1} + \frac{2\tau s^m}{\lambda v_1}\right) + \frac{1}{2} \left[1 - \left(1 - \frac{2v_2}{v_1} + \frac{2\tau s^m}{\lambda v_1}\right)\right] \right\} (\lambda v_1) \\ - \tau s^m = \lambda(v_1 - v_2), & s_1 = s^m. \end{cases} \end{aligned} \quad (13)$$

Thus any distribution of s_1 over $\left[0, 2s^m - \frac{\lambda v_2}{\tau}\right] \cup \{s^m\}$ will give jurisdiction 1 the same expected payoff $\lambda(v_1 - v_2)$. It is straightforward to check that jurisdiction 1 cannot do better than this by choosing other spending levels.

Similarly, given jurisdiction 1's strategy specified above, 2's expected payoff is

$$\begin{aligned} \pi_2(s_2 | s^m) &= \tilde{F}_1(s_2)(\lambda v_2) - \tau s_2 \\ &= \begin{cases} \frac{\tau s_2}{\lambda v_2} (\lambda v_2) - \tau s_2 = 0, & \forall s_2 \in \left[0, 2s^m - \frac{\lambda v_2}{\tau}\right]; \\ \left\{ \left(\frac{2\tau s^m}{\lambda v_2} - 1\right) + \frac{1}{2} \left[1 - \left(\frac{2\tau s^m}{\lambda v_2} - 1\right)\right] \right\} (\lambda v_2) - \tau s^m = 0, & s_2 = s^m. \end{cases} \end{aligned} \quad (14)$$

Thus any distribution of s_2 over $\left[0, 2s^m - \frac{\lambda v_2}{\tau}\right] \cup \{s^m\}$ will give jurisdiction 2 the same expected payoff 0 and jurisdiction 2 cannot do better than this by choosing other spending levels. By definition, we have an equilibrium of this new game.

In equilibrium, with probability $\left(\frac{2\tau s^m}{\lambda v_2} - 1\right)$ jurisdiction 1 will choose its spending level s_1 from the uniform distribution over $\left[0, 2s^m - \frac{\lambda v_2}{\tau}\right]$ with an expectation $s^m - \frac{\lambda v_2}{2\tau}$. Otherwise, it will choose s^m . Therefore, its overall expected spending is

$$E(s_1 | s^m) = \left(s^m - \frac{\lambda v_2}{2\tau}\right) \left(\frac{2\tau s^m}{\lambda v_2} - 1\right) + s^m \left[1 - \left(\frac{2\tau s^m}{\lambda v_2} - 1\right)\right] = \frac{\lambda v_2}{2\tau}. \quad (15)$$

Jurisdiction 2 spends nothing with probability $1 - \frac{v_2}{v_1}$; if it chooses a positive s_2 , it either spends s^m with probability $1 - \left(1 - \frac{2v_2}{v_1} + \frac{2\tau s^m}{\lambda v_1}\right) = \frac{2v_2}{v_1} - \frac{2\tau s^m}{\lambda v_1}$ or picks a random level of spending from the uniform distribution over $\left[0, 2s^m - \frac{\lambda v_2}{\tau}\right]$ the rest of the time. Its expected level of spending is therefore

$$\begin{aligned} E(s_2 | s^m) &= 0 \left(1 - \frac{v_2}{v_1}\right) + s^m \left(\frac{2v_2}{v_1} - \frac{2\tau s^m}{\lambda v_1}\right) \\ &\quad + \left(s^m - \frac{\lambda v_2}{2\tau}\right) \left[\left(1 - \frac{2v_2}{v_1} + \frac{2\tau s^m}{\lambda v_1}\right) - \left(1 - \frac{v_2}{v_1}\right)\right] = \frac{\lambda v_2^2}{2\tau v_1}. \end{aligned} \quad (16)$$

²⁰ See Che and Gale (1998) for a parallel analysis in a similar game-theoretic situation (with $\lambda = \tau = 1$) in the context of political lobbying. Che and Gale (1998) also discuss special cases such as $s^m = \lambda v_2 / (2\tau)$. Because those special cases are zero-probability events, we ignore them here to conserve some space.

The expected total spending between the two jurisdictions is

$$E(s_1 + s_2 | s^m) = \frac{\lambda v_2}{2\tau} + \frac{\lambda v_2^2}{2\tau v_1}, \quad (17)$$

exactly the same as without the budget constraint (see Eq. 5).

We now check whether this budget constraint $s^m \in \left(\frac{\lambda v_2}{2\tau}, \frac{\lambda v_2}{\tau}\right)$ affects a jurisdiction's probability of winning the FDI. We need to consider two cases: (1) when $s_1 \in \left(0, 2s^m - \frac{\lambda v_2}{\tau}\right]$, jurisdiction 1 wins the FDI if jurisdiction 2 bids a smaller s_2 (which occurs with probability $\tilde{F}_2(s_1) = 1 - \frac{v_2}{v_1} + \frac{\tau s_1}{\lambda v_1}$); and (2) when jurisdiction 1 chooses $s_1 = s^m$ (with probability $1 - \left(\frac{2\tau s^m}{\lambda v_2} - 1\right) = 2 - \frac{2\tau s^m}{\lambda v_2}$), it wins the FDI for sure if jurisdiction 2 bids a smaller s_2 (which occurs with probability $1 - \frac{v_2}{v_1} + \frac{2\tau s^m}{\lambda v_1}$) or wins the FDI with a 50% chance if jurisdiction 2 also bids s^m (with probability $\frac{2v_2}{v_1} - \frac{2\tau s^m}{\lambda v_1}$). Therefore, with a spending cap $s^m \in \left(\frac{\lambda v_2}{2\tau}, \frac{\lambda v_2}{\tau}\right)$, the probability that jurisdiction 1 wins is

$$\int_0^{2s^m - \frac{\lambda v_2}{\tau}} \frac{\tau}{\lambda v_2} \left(1 - \frac{v_2}{v_1} + \frac{\tau t}{\lambda v_1}\right) dt + \left(2 - \frac{2\tau s^m}{\lambda v_2}\right) \left[\left(1 - \frac{v_2}{v_1} + \frac{2\tau s^m}{\lambda v_1}\right) + \frac{1}{2} \left(\frac{2v_2}{v_1} - \frac{2\tau s^m}{\lambda v_1}\right)\right] = 1 - \frac{v_2}{2v_1}. \quad (18)$$

This is again exactly the same as without the budget constraint (see Eq. 12).

That is, putting a budget constraint $s^m \in \left(\frac{\lambda v_2}{2\tau}, \frac{\lambda v_2}{\tau}\right)$ affects neither the expected total spending on infrastructure nor the probability with which a jurisdiction wins the FDI. From the perspective of the domestic economy, this policy is inconsequential.

What we have just demonstrated is rather instructive. Although a bidding constraint will reduce infrastructure spending by jurisdictions with high values, it could also induce some jurisdictions with low values to jump to the constraint and spend more because the constraint gives them a higher chance to win than before. If the constraint is barely binding, i.e., $s^m \in \left(\frac{\lambda v_2}{2\tau}, \frac{\lambda v_2}{\tau}\right)$, these two effects will cancel each other, causing no changes in total spending.

Combining the two cases ($s^m \in \left(\frac{\lambda v_2}{4\tau} + \frac{\lambda v_2^2}{4\tau v_1}, \frac{\lambda v_2}{2\tau}\right)$ or $s^m \in \left(\frac{\lambda v_2}{2\tau}, \frac{\lambda v_2}{\tau}\right)$) discussed above, we see that unless the budget constraint is very stringent, this policy has either a negative effect or no effect. This of course does not necessarily imply that the central government should impose a very stringent constraint on infrastructure spending. A stringent constraint helps only if the spending on infrastructure, no matter how small, will not affect the size of the FDI. This fixed amount of FDI is our assumption at this moment, but it is unlikely to hold as s^m approaches zero and we will relax this assumption later.

4.2.3. Reducing the number of competing jurisdictions

As discussed in the Introduction section, the central government in China has attempted several times to control the number of development zones. Here we analyze whether this goal can be achieved through restricting the number of competing jurisdictions and what the effects of such a policy will be. For this purpose, we need to extend the simple model to cases with more than two players.

Suppose the game is exactly the same except that there are now $n > 2$ competing jurisdictions. Let their values be $v_1 \geq v_2 \geq v_3 \geq \dots \geq v_n$. An equilibrium of this game is defined as a list of strategies, one for each player, in which each strategy is the player's best response to the combination of other players' strategies.

It turns out that the equilibrium of this new game involves the first two jurisdictions (with the two highest values) playing the same strategies as prescribed in Proposition 1 and other jurisdictions not participating in the bid.²¹ Assume the first two players are using the strategies specified in Eqs. (1) and (2). Now consider the third jurisdiction. If it chooses $s_3 = 0$ and stays out of the bidding war, its expected payoff is 0. If it chooses any $s_3 > 0$, it has to choose one such that $s_3 \leq \frac{\lambda v_3}{\tau} \leq \frac{\lambda v_2}{\tau}$ because otherwise its expected payoff is clearly below 0. Given $0 < s_3 \leq \frac{\lambda v_2}{\tau}$, jurisdiction 3 always loses τs_3 but will win the competition with probability $Pr[s_1 < s_3]Pr[s_2 < s_3] = \left(\frac{\tau s_3}{\lambda v_2}\right) \left(1 - \frac{v_2}{v_1} + \frac{\tau s_3}{\lambda v_1}\right)$. Thus its expected payoff is

$$\begin{aligned} \pi_3 &= (\lambda v_3) \left(\frac{\tau s_3}{\lambda v_2}\right) \left(1 - \frac{v_2}{v_1} + \frac{\tau s_3}{\lambda v_1}\right) - \tau s_3 \\ &= \tau s_3 \left[\left(\frac{v_3}{v_2}\right) \left(1 - \frac{\lambda v_2 - \tau s_3}{\lambda v_1}\right) - 1\right] \leq 0. \end{aligned} \quad (19)$$

This implies that jurisdiction 3 has already obtained its highest expected payoff (=0) when choosing $s_3 = 0$; it has no incentive to raise its spending above zero. The same is true for any other jurisdiction with an even lower value. That is, each jurisdiction from 3 to n is playing its best response to other jurisdictions' strategies by staying out of the competition. Now consider jurisdictions 1 and 2. Given 2's strategy and that all other jurisdictions are not participating, 1's strategy as specified in Eq. (1) is still its best response. Similarly, jurisdiction 2's strategy specified in Eq. (2) is still its best response. Since every jurisdiction is playing its best response, we have an equilibrium.

This result has an immediate implication: if the government policy does not exclude any of the two jurisdictions with the highest values, then it has no effect at all. All the outcomes will be the same, as if there are only the two jurisdictions with the highest values competing with each other.

For lack of information on values or some other reasons, one or even both of the two jurisdictions with the highest values may be excluded from the competition.²² In that case, the policy will affect the outcome. Most importantly, it may lead to a worse outcome in the sense that not only will the FDI end up in a jurisdiction with a lower value, but also that the total spending on infrastructure will be higher.

Consider a simple example in which the top three jurisdictions have values $v_1 > v_2 > v_3$. Without any policy intervention, we have an equilibrium in which only jurisdictions 1 and 2 will participate in bidding. Their expected total spending, given by Eq. (5), is $\frac{\lambda}{\tau} \left(\frac{v_2}{2} + \frac{v_2}{2v_1}\right)$. Now suppose a new policy restricts the number of competing jurisdictions and let's say for some reason jurisdiction 1 is excluded from the competition by some uninformed central-government officials. Then the expected total spending in equilibrium

²¹ See Hillman and Riley (1989) and Baye et al. (1993) for parallel discussions of similar game-theoretic situations in the context of rent-seeking and political lobbying.

²² For example, China's central government once decided rather arbitrarily that at most one development zone is allowed in each county. If two towns in the same county happen to have the highest values for one FDI project, one of them will be excluded from the competition. Given that the decision at the upper-level government is often made by uninformed officials and based on arbitrary criteria, there is no guarantee that the one with the highest value will always be able to stay in the competition.

is $\frac{\lambda}{\tau} \left(\frac{v_3}{2} + \frac{v_3}{2v_2} \right)$. The difference in total spending is therefore

$$\frac{\lambda}{\tau} \left[\left(\frac{v_3}{2} + \frac{v_3}{2v_2} \right) - \left(\frac{v_2}{2} + \frac{v_2}{2v_1} \right) \right] = \frac{\lambda}{\tau} \cdot \frac{(1+v_2)v_1v_3 - (1+v_1)v_2^2}{2v_1v_2}, \quad (20)$$

which is positive when $\frac{v_2^2}{v_1v_3} < \frac{1+v_2}{1+v_1}$. For the purpose of illustration, consider a numerical example in which $v_1 = 10$, $v_2 = 5$, and $v_3 = 4.8$. Using Eq. (20) we get the difference in total spending $0.954 \frac{\lambda}{\tau} > 0$. That is, the total spending after jurisdiction 1 is excluded from competition is even higher than before. Given that the winner in this scenario also has a lower expected value, this is obviously a worse outcome.

The intuition behind this example is clear. When there is an unmistakable leader with a much larger value than all others, the potential competitors are intimidated. Knowing that they have little chance to win the FDI and will most likely lose their bids for nothing, they will not bid aggressively. Anticipating this, the leader is also unlikely to bid aggressively. As a result, the total spending is not very large. In contrast, when there is not an overwhelming leader among the jurisdictions, the two front-runners each has a reasonable chance to win and both will bid rather aggressively. Consequently, we may see a higher total spending on infrastructure although the winner in this latter case tends to have a lower value. We summarize our discussion in the following proposition:

Proposition 3. Excluding some jurisdictions from competing for the FDI may result in a higher level of spending on infrastructure (and therefore more land used for development zones) and a lower realized value of the FDI.

4.3. Incomplete information and variable FDI

In this section, we extend the simple model introduced above and relax several assumptions. We consider the more general case with $n \geq 2$ jurisdictions competing for an FDI. Unlike in the previous section, we now assume that jurisdictions do not know each other's value. Instead, it is common knowledge that each jurisdiction i independently draws a value v_i from a uniform distribution over $[0, 1]$.²³ Same as before, the FDI will go to the jurisdiction that builds the highest-quality infrastructure, i.e., has the highest s_i . And again, the winner i retains only part of its value (λv_i) and the infrastructure spending is taxed (τs_i) and irreversible.

We need to modify the concept of an equilibrium. Now jurisdiction i 's (pure) strategy is a function $s_i = b(v_i)$ that assigns a spending level s_i to each possible draw of v_i . Note that the function $b(\cdot)$ is not indexed by i because of the symmetry among the jurisdictions. We focus on the symmetric Bayesian Nash equilibrium, which is defined as a set of strategies $\{b(v_1), b(v_2), \dots, b(v_n)\}$ such that for each jurisdiction i , $b(v_i)$ maximizes its expected payoff given that all other jurisdictions are using the same strategy. Jurisdiction i 's expected payoff is written as

$$\pi_i = (\lambda v_i) Pr[i \text{ wins} | s_1, \dots, s_n] - \tau s_i = (\lambda v_i) \prod_{j \neq i} Pr[s_j < s_i] - \tau s_i. \quad (21)$$

4.3.1. Fixed-amount FDI under incomplete information

For the time being, we still assume that the size of the FDI (and thus its value) is independent of the winning jurisdiction's spending on infrastructure. This assumption will be relaxed later.

Proposition 4. When $n \geq 2$ jurisdictions compete for a fixed-amount FDI through the all-pay auction with incomplete information, there exists a symmetric equilibrium in which each jurisdiction chooses its

²³ Assuming a uniform distribution greatly simplifies our analysis here. Note that it is innocuous to assume the upper limit of the support to be unity because we can always make it true by choosing a proper unit of measurement.

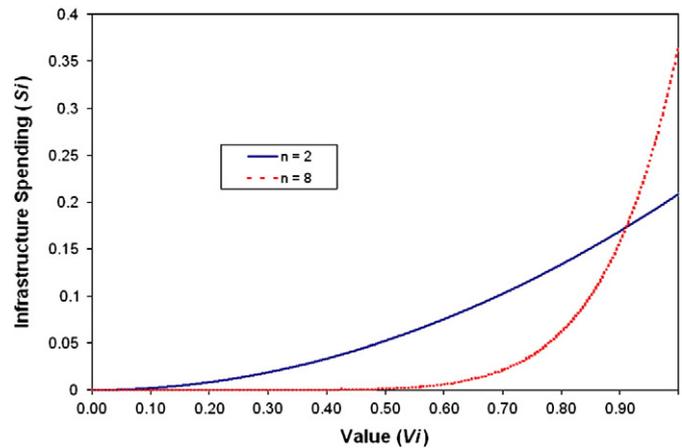


Fig. 2. Equilibrium strategy with $\lambda = 0.5$ and $\tau = 1.2$.

level of spending based on its value. (1) In equilibrium, jurisdiction i 's spending s_i is given by

$$s_i = \frac{(n-1)\lambda v_i^n}{n\tau}. \quad (22)$$

(2) The expected total infrastructure spending increases with λ and n , and decreases with τ . (3) The net gain in the domestic economy increases with n if $\frac{\lambda}{\tau} < \frac{1}{2}$.

See the Appendix for the derivation of the equilibrium. The equilibrium strategy (Eq. 22) indicates that a jurisdiction with a positive value will always spend some money building infrastructure in a development zone to attract FDI, even if it never wins the FDI. Again, this equilibrium outcome gives an impression of a development zone fever.

As an illustration, Fig. 2 plots the equilibrium strategy for $n=2$ and 8, assuming $\lambda=0.5$ and $\tau=1.2$. It is clear that in equilibrium, a jurisdiction's spending on infrastructure is strictly increasing in its value. This implies that a jurisdiction with the highest value will always win the FDI. In addition, the figure shows that with a large n , a jurisdiction with a small v will spend very little on infrastructure because its probability of winning and at the same time maintaining a positive payoff is minimal.

Given the equilibrium strategy and the symmetry among jurisdictions, total infrastructure spending is expected to be

$$E(s_1 + \dots + s_n) = nE(s_i) = n \int_0^1 \frac{(n-1)\lambda v_i^n}{n\tau} dv_i = \frac{(n-1)\lambda}{(n+1)\tau}, \quad (23)$$

which increases with λ and decreases with τ . Therefore, if the local jurisdiction is entitled to a larger share of the value of the FDI, local jurisdictions will spend more on infrastructure and use more land to compete for the FDI. Also, if the tax on the spending is higher, local jurisdictions will spend less. Therefore, to induce local jurisdictions to spend less on infrastructure and use less land to compete for FDI, the central government can either claim a larger share of the value generated by FDI or raise the tax on the land used to build development zones.

Expected total infrastructure spending also increases with n . This implies that excluding some jurisdictions from the competition will tend to reduce the total spending on infrastructure. However, it is not necessarily a good policy once taking into account the overall effect on the net gain. In equilibrium, the jurisdiction with the highest value will always choose the highest level of spending on infrastructure and win the FDI. Given that the n values are independent draws from the uniform distribution on $[0, 1]$, the expectation of the highest value is

$\frac{n}{n+1}$.²⁴ Thus the expected net gain for the domestic economy is

$$G^e = E[\max(v_1, \dots, v_n)] - [nE(s_i)] = \frac{n}{n+1} - \frac{(n-1)\lambda}{(n+1)\tau}. \quad (24)$$

Differentiating the net gain with respect to n , we get $\frac{\partial G^e}{\partial n} = \frac{\tau-2\lambda}{(n+1)^2\tau}$. Thus the net gain increases with n if $\frac{\tau-2\lambda}{(n+1)^2\tau} > 0$, i.e.,

$$\frac{\lambda}{\tau} < \frac{1}{2}. \quad (25)$$

This condition is not stringent and can be easily satisfied. Therefore, the net gain can be smaller when n is smaller. That is, although excluding some jurisdictions from the bidding war generates a gain by reducing the total spending on infrastructure, it also causes a loss because in expectation the winner will have a lower value when the number of bidders is smaller.²⁵ Under the condition $\frac{\lambda}{\tau} < \frac{1}{2}$, the loss is bigger than the gain, making it a bad policy to restrict some jurisdictions from competing for the FDI.

In Eq. (24), we know $\frac{n}{n+1}$ is the expectation of the highest value. It can be shown that $\frac{n-1}{n+1}$ is the expectation of the second highest value.²⁶ So the realized value for the domestic economy is the highest value and the cost is only a fraction ($\frac{\lambda}{\tau}$) of the second highest value. The net gain in Eq. (24) is actually the same as what can be achieved through an English auction (see discussion of Eq. (9)). Note that we still have only one winner; all other jurisdictions fail to attract the FDI although they have all built some infrastructure in their development zones. Again, it appears to be a waste of resources, as most observers have argued about the development zone fever in China. However, one needs a benchmark when talking about wastes. If we believe that the central government can costlessly gather the information about each jurisdiction's value and pick the winner accordingly, then of course the first best solution is to direct the FDI to the winner that way. On the other hand, if there is no cost-effective way to reveal the information about values, then the outcome of an English auction may not be that bad. Once we recognize this, the spending in the unused development zones is not necessarily a waste from the domestic economy's perspective. It is simply an unavoidable cost of finding the jurisdiction that will make the best use of the FDI.²⁷ Again, we should

recognize that local jurisdictions have already taken into account the probability of losing the bid and that they have already factored this possibility into their decisions when they choose their spending on infrastructure in their development zones.

4.3.2. Constraint on infrastructure spending under incomplete information

Parallel to the discussion of the simple model, we now examine how a budget constraint on infrastructure spending may affect the outcome. From Proposition 4 it is clear that $s^m \geq \frac{(n-1)\lambda}{n\tau}$ is not binding, so we will only consider a constraint that is more stringent.

Proposition 5. When $n \geq 2$ jurisdictions spend on infrastructure to compete for an FDI through the all-pay auction with incomplete information and the maximum allowed spending level is $s^m \in (0, \frac{(n-1)\lambda}{n\tau})$, there exists a symmetric equilibrium in which each jurisdiction chooses its level of spending based on its value. (1) In equilibrium, jurisdiction i 's spending s_i is determined by

$$s_i = \begin{cases} \frac{(n-1)\lambda v_i^n}{n\tau} & v_i \in [0, \theta] \\ s^m & v_i \in (\theta, 1] \end{cases}, \quad (26)$$

where the critical value θ solves the equation $\frac{\lambda(\theta-\theta^n)}{n(1-\theta)\tau} = s^m$. (2) Imposing the budget constraint results in a lower total spending and a lower winner's value in expectation. (3) The expected net gain for the domestic economy may also be lower because of the budget constraint.

See the Appendix for a proof of the equilibrium. Given fixed λ , τ , and n , the cutoff value θ is uniquely determined by the spending cap s^m . In equilibrium, any jurisdiction that draws a value higher than θ will spend the maximum amount allowed; that is, with probability $(1-\theta)$ a jurisdiction will spend s^m . So we can think of θ as an indicator of how stringent the constraint is: the smaller θ is, the more stringent the constraint is and the more likely a jurisdiction will reach the cap amount.

Given $\theta < 1$, it is easy to verify that

$$\frac{\theta-\theta^n}{1-\theta} = \theta(1 + \theta + \dots + \theta^{n-2}) > \theta(n-1)\theta^{n-2} > (n-1)\theta^n. \quad (27)$$

²⁴ If the highest value among the n independent draws is smaller or equal to x , then all n values are smaller or equal to x . Given that every value is drawn from the same uniform distribution over $[0, 1]$, the highest value has a probability function $F(x) \equiv Pr[v_1 \leq x, \dots, v_n \leq x] = x^n$ and a probability density function $f(x) = nx^{n-1}$. Therefore, its expectation is $\int_0^1 x(nx^{n-1})dx = \frac{n}{n+1}$.

²⁵ Here we implicitly assume that the central government has no way to figure out a jurisdiction's value, thus the excluded jurisdiction is a random choice.

²⁶ Let's say the second highest value among the n independent draws is smaller or equal to x . Then one of the following two events must be true: (1) all the n independent draws are smaller or equal to x ; or (2) $(n-1)$ of them are smaller or equal to x and one of them is bigger than x . The second case can occur in n different ways depending on which one of the n draws is bigger than x . Given that all the draws are from the same uniform distribution over $[0, 1]$, the second highest value has a probability function $F(x) = x^n + nx^{n-1}(1-x)$. Differentiate this function to get the probability density function $f(x) = n(n-1)(1-x)x^{n-2}$. Therefore, the second highest value has an expectation $\int_0^1 xn(n-1)(1-x)x^{n-2}dx = \frac{n-1}{n+1}$.

²⁷ Although not a focus of this study, it is worth noting that the foreign investors get less in the all-pay auction than in the English auction. Therefore, they themselves may choose to consider only a small group of competing jurisdictions in order to induce each one to bid more aggressively. Similarly, they also face the tradeoff between higher bids (given the same values) and a lower expected winner's bid (due to the smaller number of bidders).

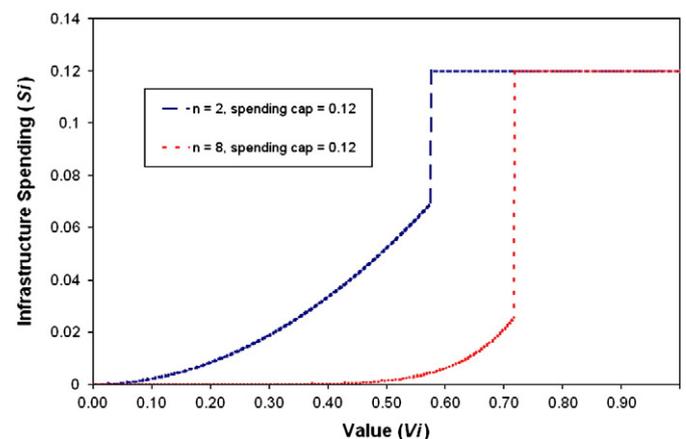


Fig. 3. Equilibrium strategy with $\lambda = 0.5$, $\tau = 1.2$, and $s^m = 0.12$.

The first inequality holds because each of the first $n-2$ items in the sum $(1 + \theta + \theta^2 + \dots + \theta^{n-2})$ is strictly greater than θ^{n-2} . It follows that

$$s^m = \frac{\lambda(\theta - \theta^n)}{n(1-\theta)\tau} > \frac{\lambda(n-1)\theta^n}{n\tau}. \tag{28}$$

From Proposition 4 we know that without the budget constraint, a jurisdiction spends $\frac{\lambda(n-1)\theta^n}{n\tau}$ at value θ , which is less than the spending cap s^m . That is, with the budget constraint, a jurisdiction will jump up to s^m at the cutoff value; it would not have spent that much at the cutoff point if not for the constraint. So a binding constraint not only forces some jurisdictions with high values to lower their bids but also induces some jurisdictions with low values to raise their bids to s^m (see Fig. 3 for an illustration). Note that the equilibrium outcome again appears to be a development zone fever: many jurisdictions will spend on infrastructure and actively compete for the FDI, although only one of them wins.

Using the equilibrium strategy and the symmetry among jurisdictions, we can again calculate the expected total infrastructure spending:

$$\begin{aligned} E(s_1 + \dots + s_n | s^m) &= nE(s_i | s^m) \\ &= n \left[\int_0^\theta \frac{(n-1)\lambda v_i^n}{n\tau} dv_i + s^m(1-\theta) \right] \\ &= \frac{(n-1)\lambda\theta^{n+1}}{(n+1)\tau} + \frac{\lambda(\theta - \theta^n)}{\tau}. \end{aligned} \tag{29}$$

Again, this total increases with λ and decreases with τ . As shown in the Appendix, a binding constraint always lowers the expected total spending, i.e.,

$$\begin{aligned} E(s_1 + \dots + s_n | s^m) - E(s_1 + \dots + s_n) &= \left[\frac{(n-1)\lambda\theta^{n+1}}{(n+1)\tau} + \frac{\lambda(\theta - \theta^n)}{\tau} \right] - \frac{(n-1)\lambda}{(n+1)\tau} < 0. \end{aligned} \tag{30}$$

The constraint also affects the expected winner's value. Without the constraint, in equilibrium, the jurisdiction with the highest value always spends the most on infrastructure and wins the competition. In contrast, now every jurisdiction with a value above the cutoff point will bid s^m , so they all have equal chances to win. To calculate the expected winner's value, we need to consider two cases: (1) Each of the n jurisdictions draws a value smaller than θ , which occurs with probability θ^n . Conditional on this happening, we have n independent draws from a uniform distribution over $[0, \theta]$, then the expectation of the highest value is $\frac{n\theta}{n+1}$. (2) At least one jurisdiction draws a value higher than θ , which occurs with probability $1 - \theta^n$. In this case, no matter how many jurisdictions have values above θ , they all have equal probabilities to win the FDI, so the expected winner's value is always $\frac{1-\theta}{2}$. Therefore, the overall expectation is

$$\begin{aligned} E(\text{winner's value} | s^m) &= \frac{n\theta}{n+1} \theta^n + \frac{1-\theta}{2} (1-\theta^n) \\ &= \frac{n\theta^{n+1}}{n+1} + \frac{(1-\theta)(1-\theta^n)}{2}. \end{aligned} \tag{31}$$

As shown in the Appendix, the winner's value is lower with the budget constraint than without the constraint, i.e.,

$$\begin{aligned} E(\text{winner's value} | s^m) - E[\max(v_1, \dots, v_n)] &= \left[\frac{n\theta^{n+1}}{n+1} + \frac{(1-\theta)(1-\theta^n)}{2} \right] - \frac{n}{n+1} < 0. \end{aligned} \tag{32}$$

We next examine the effect of the budget constraint on the net gain in the domestic economy. With the constraint, this net gain is

$$G^e(s^m) = \left[\frac{n\theta^{n+1}}{n+1} + \frac{(1-\theta)(1-\theta^n)}{2} \right] - \left[\frac{(n-1)\lambda\theta^{n+1}}{(n+1)\tau} + \frac{\lambda(\theta - \theta^n)}{\tau} \right]. \tag{33}$$

Subtracting Eq. (24), the change in the net gain is given by

$$\begin{aligned} G^e(s^m) - G^e &= \left[\frac{n(\theta^{n+1} - 1)}{n+1} + \frac{(1-\theta)(1-\theta^n)}{2} \right] \\ &\quad - \left[\frac{(n-1)\lambda(\theta^{n+1} - 1)}{(n+1)\tau} + \frac{\lambda(\theta - \theta^n)}{\tau} \right]. \end{aligned} \tag{34}$$

The first part is the change in the winner's value and the second part is the change in total spending, both are shown to be negative. After some algebra, we see that $G^e(s^m) < G^e$ if

$$\frac{\lambda}{\tau} < \frac{2n(1-\theta^{n+1}) - (n+1)(1-\theta)(1-\theta^n)}{2(n-1)(1-\theta^{n+1}) - 2(n+1)(\theta - \theta^n)}. \tag{35}$$

It is easy to check that the right hand side is greater than one for all $n < 20$ and $0.3 < \theta < 1$. Given $\frac{\lambda}{\tau} \leq 1$, this implies that $G^e(s^m) < G^e$ as long as there are less than twenty competing jurisdictions and the budget constraint s^m is not stringent enough to push θ below 0.3, both of which are fairly reasonable assumptions.²⁸ Therefore, although a budget constraint tends to reduce the total spending on infrastructure, it may also lead to a lower net gain for the domestic economy.

The key idea here is that with the budget constraint, some jurisdictions with lower values are induced to bid the maximum allowed. Consequently, the winner is not necessarily the jurisdiction with the highest value. Under rather unrestrictive conditions, the loss in the expected winner's value due to the constraint dominates the gain from the decreased total spending, making this policy undesirable.

4.3.3. Variable FDI under incomplete information

If better infrastructure implies lower production cost and higher profit for foreign investors, it is likely that they would invest more when they see better infrastructure. Therefore, we now allow the size of the FDI (and thus its value) to vary with the winning jurisdiction's spending on infrastructure. In particular, we assume that if jurisdiction i wins the competition, it will be awarded $(\lambda v_i)(1 + \beta s_i)$, where v_i is the value of the FDI if the jurisdiction spends nothing on infrastructure to accommodate the FDI and $\beta > 0$ is the parameter indicating the positive relationship between the value of the FDI and the spending on infrastructure.

Proposition 6. When $n \geq 2$ jurisdictions compete for a variable FDI through the all-pay auction with incomplete information described above, there exists a symmetric equilibrium in which each jurisdiction chooses its level of spending based on its value. (1) In equilibrium, jurisdiction i 's spending s_i is determined by

$$s_i = \frac{1}{\beta} \left\{ \left[1 - \frac{\beta \lambda v_i^n}{\tau} \right]^{\frac{n-1}{n}} - 1 \right\}. \tag{36}$$

²⁸ To have $\theta = 0.3$, the spending cap needs to be so low that it induces any jurisdiction to spend the maximum allowed amount with a 70% probability. Consider the example with $\lambda = 0.5$ and $\tau = 1.2$, as assumed in Fig. 3; $\theta = 0.3$ implies that $s^m = 0.0625$ for two competing jurisdictions or $s^m = 0.0223$ for eight competing jurisdictions. Given that each jurisdiction randomly draws a value from $[0, 1]$ and will keep half of the value, such spending constraints seem extremely tight.

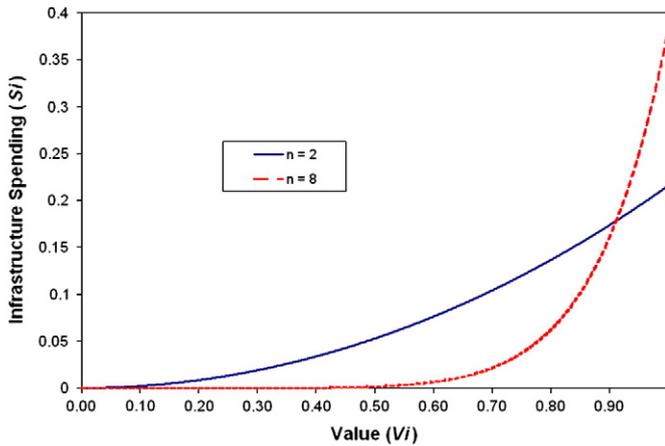


Fig. 4. Equilibrium strategy with $\lambda = 0.5$, $\tau = 1.2$, and $\beta = 0.1$.

(2) Each jurisdiction's spending increases with λ and decreases with τ .

The proof of this proposition is given in the Appendix. We plot the equilibrium strategy in Fig. 4. This is almost identical to Fig. 2. Indeed, the change in the equilibrium spending after introducing β (and assuming $\beta = 0.1$) is very small; it is almost indiscernible if we combine Figs. 2 and 4 into one. And again, this equilibrium outcome corresponds to a situation of development zone fever.

In principle, the net gain for the domestic economy can be expressed as a function of λ , τ , and n . Therefore, the first best policy involves maximizing the net gain by choosing proper values for λ , τ , and n . However, this is not practical because in reality, this game is played in different groups of competing jurisdictions and over different times. It is impossible to adjust these parameters case by case.

We want to emphasize that as with the previous cases, an individual jurisdiction will still spend less on infrastructure and use less land if its share of the value is smaller and/or if the tax on the infrastructure spending is higher, holding β and n constant. The advantage of using these policies to control infrastructure spending and land use in development zones is that they do not affect which jurisdiction wins the competition. The jurisdiction with the highest value will still get the FDI.

We again want to examine how reducing the number of competing jurisdictions would affect the net gain for the domestic economy, holding β , λ , and τ constant. Notice that Eq. (36) does not have an elementary integral when $n > 2$. So we use a discrete version of the uniform

distribution of v_i , $Pr\left[v_i = \frac{j}{1000}\right] = \frac{1}{1001}$, where $j = 0, 1, 2, \dots, 1000$, and then approximate the expectation of s_i as

$$\hat{E}(s_i) = \frac{1}{1001} \sum_{j=0}^{1000} \frac{1}{\beta} \left\{ \left[1 - \frac{\beta \lambda \left(\frac{j}{1000}\right)^n}{\tau} \right]^{\frac{n-1}{n}} - 1 \right\}, \quad (37)$$

where the parameters are chosen as $\beta = 0.1$, $\lambda = 0.5$, and $\tau = 1.2$. We calculate the net gain at different n and present the results in Table 1. While the expected spending of a single jurisdiction decreases with n , the total spending of the n jurisdictions increases with n . However, as n increases, the expected winner's value also increases. Consequently, the net gain for the domestic economy increases with n . Therefore, same as before, reducing the number of competing jurisdictions could lower the net gain for the domestic economy.

The intuition behind this result is the same as in the case with a fixed-amount FDI. When there is a larger number of competing jurisdictions, each expects to win with a lower probability given any bid, so each will spend less on infrastructure and use less land for development zones. In spite of this, the total spending may become higher as the number of competing jurisdictions rises. However, the increase in spending is induced by λv , only a share of the value; the increase in the expected winner's value is directly related to v itself. Therefore, there is always a critical value of λ , below which the increase in total spending (from an increase in n) is smaller than the increase in the expected winner's value, making it a bad policy to reduce the number of competing jurisdictions.

4.4. Other possible extensions

Our analysis has focused on simple cases for tractability and the ease of exposition. Here we discuss some complications and possible extensions of the model.

4.4.1. Revision of the bid

We have always assumed that the competition for FDI by investing in infrastructure is a one-shot game. If jurisdictions are allowed to revise their bids after observing their competitors' moves, this game's outcome can be very different. In particular, the competition can become heated over time and we would expect an escalation of the bidding war. In such cases, active participants tend to overbid and the winning jurisdiction's spending on infrastructure may even exceed its value of the FDI. An outcome like that would be similar to the "race to the bottom" analyzed in the tax competition literature. These situations with bid revisions may be treated as a "dollar auction," a type of all-pay auction formally analyzed by O'Neill (1986). However, given that the locational decision of an FDI is usually made in a short period of time relative to the planning and budgeting cycles of local jurisdictions, it is probably more appropriate to model the competition as a one-shot game as we have done. Moreover, "races to the bottom" do not seem to be commonly observed during the development zone fever in China. In fact, many local jurisdictions did very well economically by investing in infrastructure to attract FDI, which is perhaps more consistent with the "winner-takes-all" equilibrium outcome in a one-shot game.

4.4.2. More than one prize

We have always assumed that there is only one indivisible FDI project to compete for. At least for the complete information case, we can easily extend this analysis to the case with n FDI projects. The most basic result of our simple model is still valid in the n -prize case in that we will still see more than n jurisdictions actively participate in

Table 1
Expected net gain varies with the number of competing jurisdictions.

n	2	4	6	8	10	12
Expected spending: $\hat{E}(s_i)$	0.071	0.064	0.051	0.042	0.035	0.030
Total spending: $n\hat{E}(s_i)$	0.142	0.256	0.305	0.332	0.350	0.362
Winner's value:	0.667	0.800	0.857	0.889	0.909	0.923
$E(\max\{v_1, \dots, v_n\}) = \frac{n}{n+1}$						
Net gain: $\frac{n}{n+1} \left[1 + \beta s_i \left(\frac{n}{n+1} \right) \right] - n\hat{E}(s_i)$	0.531	0.555	0.564	0.570	0.573	0.575

Note: These calculations are based on $\beta = 0.1$, $\lambda = 0.5$, and $\tau = 1.2$. The expected

spending is calculated according to Eq. (37). $s_i \left(\frac{n}{n+1} \right)$ represents jurisdiction i 's

spending level in equilibrium if $v_i = \frac{n}{n+1}$, given by Eq. (36).

the bidding. That is, there will still be unused development zones. Indeed, this is true whether the n FDI projects arrive simultaneously or sequentially, similar to the outcome of a game analyzed by Clark and Riis (1998) in the context of job promotion.

4.4.3. Design of competition procedure

Our analysis has always treated the competition procedure as given. However, in reality the rules of the game can be manipulated. Given that foreign investors themselves have a strong profit incentive, they may design a procedure to induce competing jurisdictions to submit the most favorable incentive packages. The design of such a procedure can be sophisticated. For example, they may consider dividing a large group of competing jurisdictions into subgroups, select a front runner from each group through a primary contest, and then choose a winner in a run-off among the group leaders (Moldovanu and Sela, 2006). Whereas this type of contest procedure design is not the focus of our study here, it is important to point out that the foreign investor's objective is to maximize the highest bid yet the domestic policy often aims to minimize the total bids, two goals that are not directly opposing each other.

5. Conclusion

The development zone fever has been a recurring phenomenon in China during the past two decades. It is one of the defining features of China's steady march toward urbanization. We propose a simple model to explain this phenomenon. Using analytical tools developed in other fields, we analyze interjurisdictional competition for FDI in China's context as an all-pay auction in which local governments choose to build infrastructure in development zones to attract investment. In equilibrium, the number of jurisdictions actively participating in the competition exceeds the number of FDI projects, resulting in seemingly excessive spending on infrastructure and underused development zones, an outcome that appears to be a "fever."

The model provides a framework for analyzing the effects of different policies. We have considered several alternative policies and showed that the total local spending on development zones can be reduced by either increasing the central government's share of the benefit created by the FDI or making it more costly for local governments to build infrastructure in development zones. Both can be achieved through properly-designed tax policies. Other policies, such as those directly restricting local governments' spending in development zones or excluding some jurisdictions from competing for FDI, either cannot achieve the goal or will have some undesirable consequences.

Interestingly, despite many attempts of using administrative measures to cool the development zone fever, China never tried any specifically-designed tax incentives to solve this problem. In January 2007, coinciding with the end of the last campaign against the expansion of development zones, China's central government amended a regulation to increase the taxes on urban land uses by twenty times. However, whether this tax applies to land uses in development zones is left for the discretion of local jurisdictions and this tax revenue is all allocated to local governments. According to our model, such a policy is unlikely to help prevent a recurrence of the development zone fever.

Appendix

Derivation of the equilibrium in Proposition 4

Let jurisdiction i 's strategy, its bidding function, be $s_i = b(v_i)$, so $v_i = b^{-1}(s_i)$. Note that because of symmetry, the bidding function is not indexed by i . In equilibrium, given all other jurisdictions' strategies, jurisdiction i 's strategy maximizes its expected payoff.

That is, $b(v_i)$ can be solved for by maximizing

$$\pi_i(s_i) = \prod_{j \neq i} \Pr[b(v_j) < b(v_i)] (\lambda v_i) - \tau s_i.$$

This all-pay auction satisfies the single-crossing condition and thus has a pure-strategy equilibrium that consists of monotonically increasing bidding functions (Athey, 2001). Assuming the bidding function is strictly increasing, we have $\Pr[b(v_j) < b(v_i)] = \Pr[v_j < b^{-1}(s_i)] = b^{-1}(s_i)$. The last step follows because v_j is uniformly distributed over $[0, 1]$. Therefore, by symmetry among all jurisdictions, i 's expected payoff is

$$\pi_i(s_i) = [b^{-1}(s_i)]^{n-1} (\lambda v_i) - \tau s_i.$$

Maximizing this payoff requires the first-order condition

$$\pi_i'(s_i) = (n-1) [b^{-1}(s_i)]^{n-2} \frac{db^{-1}(s_i)}{ds_i} (\lambda v_i) - \tau = 0.$$

Substituting $v_i = b^{-1}(s_i)$, we rewrite this equation as

$$(n-1) [b^{-1}(s_i)]^{n-1} \frac{db^{-1}(s_i)}{ds_i} \lambda - \tau = 0.$$

This is a differential equation in terms of $[b^{-1}(s_i)]^n$:

$$\frac{d[b^{-1}(s_i)]^n}{ds_i} = \frac{n\tau}{(n-1)\lambda}.$$

Solve the differential equation and use the boundary condition $b^{-1}(0) = 0$ to obtain

$$[b^{-1}(s_i)]^n = \frac{n\tau s_i}{(n-1)\lambda}.$$

Substituting $v_i = b^{-1}(s_i)$ into this equation we have

$$s_i = \frac{(n-1)\lambda v_i^n}{n\tau}.$$

Note that this function is indeed strictly increasing in v_i as assumed.

Proof of parts (1) and (2) of Proposition 5

● Proof of part (1)

Define jurisdiction i 's bidding function as $s_i = b(v_i)$. In equilibrium, each jurisdiction i 's bidding function maximizes its expected payoff:

$$\pi_i(s_i) = \prod_{j \neq i} \Pr[b(v_j) < b(v_i)] (\lambda v_i) - \tau s_i.$$

We need to show that the bidding function

$$s_i = \begin{cases} \frac{(n-1)\lambda v_i^n}{n\tau} & v_i \in [0, \theta] \\ s^m & v_i \in (\theta, 1] \end{cases}$$

where θ is given by $\frac{\lambda(\theta - \theta^n)}{n(1 - \theta)\tau} = s^m$

is jurisdiction i 's best response to the same strategy used by all other jurisdictions.

From the proof of Proposition 4, we already know that when $v_i \leq \theta$, $s_i = \frac{(n-1)\lambda v_i^n}{n\tau}$ satisfies the first order condition of function

$\pi_i(s_i)$ and thus maximizes this expected payoff. Therefore, this strategy is indeed the best response to other players who are using the same strategy.

If $v_i > \theta$ and given that this strategy says nobody will choose a bid in $\left(\frac{(n-1)\lambda\theta^n}{n\tau}, s^m\right)$, i too will never choose a bid in $\left(\frac{(n-1)\lambda\theta^n}{n\tau}, s^m\right)$ because it is always dominated by a bid that is just a little lower. A slightly lower bid does not change the probability of winning but reduces the cost and thus increases the expected payoff.

Now we will show that a bid in $\left(0, \frac{(n-1)\lambda\theta^n}{n\tau}\right]$ is dominated by bidding s^m when $v_i > \theta$.

To accomplish this, we shall first show that if $v_i = \theta$, i is indifferent between bidding $\frac{(n-1)\lambda\theta^n}{n\tau}$ and s^m . If i bids s^m , its expected payoff is

$$\begin{aligned} & \lambda\theta \sum_{j=1}^n \frac{1}{j} C_{j-1}^{n-1} \left\{ \Pr[b(v_j) < b(\theta)] \right\}^{n-j} \left\{ 1 - \Pr[b(v_j) < b(\theta)] \right\}^{j-1} - \tau s^m \\ & = \lambda\theta \sum_{j=1}^n \frac{1}{j} C_{j-1}^{n-1} \theta^{n-j} (1-\theta)^{j-1} - \tau s^m, \end{aligned}$$

where C_k^n represents the number of size- k combinations in a group of n members. Note that each item in the sum corresponds to i 's chance of winning when $j-1$ other jurisdictions also have a value equal to or higher than θ and each of them bids s^m . The sum of the probabilities can be simplified as follows:

$$\begin{aligned} & \sum_{j=1}^n \frac{1}{j} C_{j-1}^{n-1} \theta^{n-j} (1-\theta)^{j-1} \\ & = \frac{1}{n(1-\theta)} \sum_{j=1}^n C_j^n \theta^{n-j} (1-\theta)^j = \frac{1-\theta^n}{n(1-\theta)}. \end{aligned}$$

The last step uses the fact that the sum of probability masses of a binomial distribution is identically equal to 1, i.e., $\sum_{j=0}^n C_j^n \theta^j (1-\theta)^{n-j} = 1$ for any arbitrary $\theta \in (0, 1)$. Therefore, i 's expected payoff from bidding s^m is $\frac{\lambda\theta(1-\theta^n)}{n(1-\theta)} - \tau s^m$. If i bids $\frac{(n-1)\lambda\theta^n}{n\tau}$, its expected payoff is

$$\begin{aligned} & \lambda\theta \prod_{j \neq i} \Pr\left[b(v_j) < \frac{(n-1)\lambda\theta^n}{n\tau}\right] - \tau \frac{(n-1)\lambda\theta^n}{n\tau} \\ & = \lambda\theta^n - \frac{(n-1)\lambda\theta^n}{n} = \frac{\lambda\theta^n}{n}. \end{aligned}$$

It is easy to verify that when $s^m = \frac{\lambda(\theta-\theta^n)}{n(1-\theta)\tau}$, these two payoffs are equal:

$$\frac{\lambda\theta(1-\theta^n)}{n(1-\theta)} - \tau s^m = \frac{\lambda\theta^n}{n} \equiv \pi^*.$$

Consider any $v_i > \theta$. If i bids s^m , its expected payoff is $\frac{\lambda v_i(1-\theta^n)}{n(1-\theta)} - \tau s^m = \pi^* + \frac{\lambda(v_i-\theta)(1-\theta^n)}{n(1-\theta)}$. If i bids $\frac{(n-1)\lambda\theta^n}{n\tau}$, its expected payoff is $\lambda v_i \theta^{n-1} - \frac{(n-1)\lambda\theta^n}{n} = \pi^* + \lambda(v_i-\theta)\theta^{n-1}$. Notice that

$$\begin{aligned} \frac{(1-\theta^n)}{n(1-\theta)} & = \frac{(1-\theta + \theta - \theta^2 + \theta^2 - \dots + \theta^{n-1} - \theta^n)}{n(1-\theta)} \\ & = \frac{1}{n} (1 + \theta + \theta^2 + \dots + \theta^{n-1}) > \theta^{n-1}, \end{aligned}$$

given $\theta < 1$. It follows that $\frac{\lambda v_i(1-\theta^n)}{n(1-\theta)} - \tau s^m > \lambda v_i \theta^{n-1} - \frac{(n-1)\lambda\theta^n}{n}$ for all $v_i > \theta$, i.e., bidding s^m generates a higher payoff than bidding $\frac{(n-1)\lambda\theta^n}{n\tau}$. Finally, consider the case when i bids $b < \frac{(n-1)\lambda\theta^n}{n\tau}$. Define θ' such that $b = \frac{(n-1)\lambda\theta'^n}{n\tau}$; clearly $\theta' < \theta$. The payoff from bidding b is $\lambda v_i \theta'^{n-1} - \frac{(n-1)\lambda\theta'^n}{n}$, which is smaller than $\lambda v_i \theta^{n-1} - \frac{(n-1)\lambda\theta^n}{n}$, the payoff from bidding $\frac{(n-1)\lambda\theta^n}{n\tau}$. This completes the proof that when $v_i > \theta$ any bid smaller than $\frac{(n-1)\lambda\theta^n}{n\tau}$ gives a lower payoff than s^m .

Therefore, this bidding function is the best response when all other jurisdictions use the same bidding function. Then by definition it is an equilibrium when every jurisdiction uses this same strategy.

● Proof of part (2)

From Eqs. (23) and (29), we know the change in the total spending from adding the budget constraint is

$$\begin{aligned} & E(s_1 + \dots + s_n | s^m) - E(s_1 + \dots + s_n) \\ & = \left[\frac{(n-1)\lambda\theta^{n+1}}{(n+1)\tau} + \frac{\lambda(\theta-\theta^n)}{\tau} \right] - \frac{(n-1)\lambda}{(n+1)\tau} \\ & = \frac{\lambda}{(n+1)\tau} \left[(n-1)(\theta^{n+1}-1) + (n+1)(\theta-\theta^n) \right] \\ & = \frac{\lambda}{(n+1)\tau} \left[n\theta^{n+1} - n - \theta^{n+1} + 1 + n\theta - n\theta^n + \theta - \theta^n \right] \\ & = \frac{\lambda}{(n+1)\tau} \left[(1+\theta)(1-\theta^n) - n(1-\theta)(1+\theta^n) \right] \\ & = \frac{(1-\theta)\lambda}{(n+1)\tau} \left[(1+\theta)(1+\theta+\dots+\theta^{n-1}) - n(1+\theta^n) \right] \\ & = \frac{(1-\theta)\lambda}{(n+1)\tau} \left[(1+2\theta+2\theta^2+\dots+2\theta^{n-1}+\theta^n) - n(1+\theta^n) \right] \\ & = \frac{(1-\theta)\lambda}{(n+1)\tau} \left[\sum_{i=1}^n (\theta^{i-1} + \theta^{n-i+1}) - n(1+\theta^n) \right] < 0. \end{aligned}$$

The last inequality follows because given $\theta < 1$, $\theta^{i-1} + \theta^{n-i+1} < 1 + \theta^n \forall i \in \{2, 3, \dots, n\}$.

Without the budget constraint, the jurisdiction with the highest value will win the FDI and its expected value is $E[\max(v_1, \dots, v_n)] = \frac{n}{n+1}$. Together with Eq. (31), it implies that

$$\begin{aligned} & E(\text{winner's value} | s^m) - E[\max(v_1, \dots, v_n)] \\ & = \left[\frac{n\theta^{n+1}}{n+1} + \frac{(1-\theta)(1-\theta^n)}{2} \right] - \frac{n}{n+1} \\ & = \frac{(1-\theta)(1-\theta^n)}{2} - \frac{n(\theta^{n+1}-1)}{n+1} \\ & = (1-\theta) \left[\frac{(1-\theta^n)(n+1) - 2n(\theta^n + \dots + \theta + 1)}{2(n+1)} \right] \\ & < (1-\theta) \left[\frac{2n - 2n(\theta^n + \dots + \theta + 1)}{2(n+1)} \right] \\ & = \frac{-n\theta(1-\theta^n)}{(n+1)} < 0. \end{aligned}$$

That is, the winner's value is lower with the budget constraint.

Proof of Proposition 6

The proof here follows exactly the same steps as in the derivation of the equilibrium in Proposition 4 above, except that the expected payoff function to be maximized is different. Let jurisdiction i 's

bidding function be $s_i = b(v_i)$, so $v_i = b^{-1}(s_i)$. Then $b(v_i)$ can be solved for by maximizing

$$\pi_i(s_i) = \prod_{j \neq i} Pr[b(v_j) < b(v_i)] (\lambda v_i)(1 + \beta s_i) - \tau s_i.$$

Again, by assuming a strictly increasing bidding function and invoking symmetry among all jurisdictions, we write i 's expected payoff as

$$\pi_i(s_i) = [b^{-1}(s_i)]^{n-1} (\lambda v_i)(1 + \beta s_i) - \tau s_i.$$

The first order condition is then

$$\begin{aligned} \pi_i'(s_i) &= (n-1) [b^{-1}(s_i)]^{n-2} \frac{db^{-1}(s_i)}{ds_i} (\lambda v_i)(1 + \beta s_i) \\ &\quad + [b^{-1}(s_i)]^{n-1} (\lambda v_i) \beta - \tau = 0. \end{aligned}$$

Substituting $v_i = b^{-1}(s_i)$ we obtain

$$(n-1) [b^{-1}(s_i)]^{n-1} \frac{db^{-1}(s_i)}{ds_i} \lambda (1 + \beta s_i) + [b^{-1}(s_i)]^n \lambda \beta - \tau = 0.$$

Letting $y(s_i) \equiv [b^{-1}(s_i)]^n$ we rewrite this equation as

$$y'(s_i) = y(s_i) \frac{-n\beta}{(n-1)(1 + \beta s_i)} + \frac{n\tau}{(n-1)\lambda(1 + \beta s_i)}.$$

Here we need to use the fact that any differential equation of the form $y'(x) = y(x)g(x) + h(x)$ has the solution $y(x) = \exp\left[\int_0^x g(t)dt\right]$

$\left\{ \int_0^x \frac{h(t)}{\exp\left[\int_0^t g(z)dz\right]} dt + c \right\}$, where c is an arbitrary constant. Plug

$g(s_i) = \frac{-n\beta}{(n-1)(1 + \beta s_i)}$ and $h(s_i) = \frac{n\tau}{(n-1)\lambda(1 + \beta s_i)}$ into the formula and use the boundary condition $y(0) = 0$ to obtain

$$y(s_i) = \frac{\tau}{\lambda\beta} \left[1 - (1 + \beta s_i)^{-\frac{n}{\beta}} \right].$$

Substituting $y(s_i) \equiv [b^{-1}(s_i)]^n = v_i^n$ into this equation we have

$$s_i = \frac{1}{\beta} \left\{ \left[1 - \frac{\beta \lambda v_i^n}{\tau} \right]^{-\frac{n-1}{n}} - 1 \right\}.$$

It is obvious that $\frac{\partial s_i}{\partial \lambda} > 0$ and $\frac{\partial s_i}{\partial \tau} < 0$.

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