POLITICAL ECONOMY OF INFRASTRUCTURE INVESTMENT: A SPATIAL APPROACH

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Abstract. The importance of infrastructure for growth is well established in the macroeconomic literature. Previous research has treated public investment in infrastructure as exogenous. We remedy this shortcoming by providing a political economy analysis of infrastructure choice based upon consumer preferences derived from spatial competition models. The transport cost parameter provides a natural index of infrastructure in these models. In this setting, infrastructure investment has two possible effects: to directly lower transaction costs and indirectly to affect market power. We begin with a single marketplace model in which only the direct effect is present and then bring in the indirect effect by extending the analysis to competition on the circle. Analysis of market structure, consumer participation, entry and transport cost curvature give a rich variety of results. Socially optimal outcomes occur in some cases but infrastructure traps are common. Our results suggest that in less developed countries competition enhancing policies are a key prerequisite for public support of infrastructure investment.

1. Introduction

Whether it is the Internet or freeways, infrastructure improves the functioning of an economy. Road building and the improvements in telecommunications infrastructure have both been found to have a significant impact on productivity and growth for a wide selection of OECD countries. At the same time, in both policy quarters and academic circles, lack of proper infrastructure is often blamed for the poor performance of the less developed countries. This traditional wisdom – of a positive relationship between infrastructure and productivity/growth – has recently found support in the empirical macroeconomic literature (see for example Aschauer (1989), Fernald (1999), Roller and Waverman (2001)). These empirical models, though sophisticated in their treatment, are too macroscopic to show who benefits

Key words and phrases. Spatial Competition, Infrastructure Investment, Political Economy, Voting, Referendum.

from infrastructure and how these individual benefits result in government investment decisions. Thus the macroeconomic literature leaves us with a clear indication of the importance of infrastructure, but no deep understanding of the economic role of infrastructure and the processes determining the level of infrastructure. The endogenous growth models are not satisfactory either, since in those models infrastructure cannot be distinguished from other forms of capital.

Interpreting infrastructure more broadly - so as to include physical as well as institutional infrastructure (e.g. trade liberalization, banking sector reforms) - Aghion and Schankerman (2001) shows how an improvement in infrastructure affects the competitive process. Despite a more micro-oriented approach, their work (like the other works mentioned above) treats infrastructure investment as exogenous. This is unsatisfactory because a full economic investigation of infrastructure should identify its determinants as well as its effects.

The standard theoretical response - infrastructure investment is chosen by a social planner - is too unrealistic to be useful for prediction, except maybe in a handful of dictatorial regimes. Though the social optimum is an important benchmark, choice of infrastructure investment, in any democracy, is a political process. As Bud Shuster, Chair of the US House Transportation Committee puts it - " Angels in heaven do not decide where the highways will be built. This is a political process." And so is every other significant infrastructure decision.

A key feature of infrastructure investment is that the gains/losses are not distributed equally across different agents within a country. To capture this we need to incorporate consumer heterogeneity, which we do with a variety of spatial competition models. The transport cost parameter in a spatial competition model has a natural interpretation as an index of infrastructure. Since consumers have different locations they utilize infrastructure differently. This in turn gives rise to preferences for the level of infrastructure that vary with location which feed into the political process.

We assume infrastructure is provided by the government "at cost" at a level determined by the existing political process. Two related political paradigms are analyzed: referenda and electoral competition. Regional authorities, states and even small countries such as Switzerland frequently use referenda to approve public infrastructure investments and the associated tax levy. Large states and countries more typically employ representative democracy and electoral competition between politicians.

Infrastructure, such as roads, telephones and antitrust regulation, is important because it directly determines the net utility a consumer receives from a purchase. A second, indirect, effect of infrastructure is its influence on the competitive environment. Low levels of infrastructure give differentiated firms strong local monopoly power. Alternatively high level of infrastructure make swapping between differentiated firms a low-cost activity for consumers leading to fierce local competition between firms.

Our approach is different from the standard public goods analysis because voters derive no direct utility from infrastructure. We derived endogenously voter preferences over infrastructure from the dual role of voters as consumers in a spatial market. At an abstract level voter choices over infrastructure affect the " rules of the game" when they make their purchasing decisions. However the final impact of a change in infrastructure on voter/consumers utility depends in a subtle and rich way on the details of the spatial market. Rather than provide a taxonomy of every spatial model we instead focus on cases of practical and theoretical significance to illustrate the rich variety of outcomes possible under our approach.

In a small or underdeveloped region or country agglomeration forces may have produced only a single commercial centre. We refer to this situation as a *single marketplace* [1].

The single marketplace eliminates spatial competition making all firms homogeneous and thus allowing us to focus on the direct effect of infrastructure in facilitating trade. Market structure is important in this situation because under competition the political outcome can be close to, or at, the socially optimal level of infrastructure while under monopoly an infrastructure trap will occur with no investment in welfare in enhancing infrastructure.

In an even less developed country, with lower levels of infrastructure, transport costs may prevent some consumers from accessing the single marketplace at all. In this incomplete market coverage case the political analysis is complicated by the emergence of a group of voters who only pay tax and do not consume the good. Median voter theorems fail in this situation however we show that even competition fails to avoid an infrastructure trap in this case

Large economies are characterised by greater firm differentiation which we analyze by extending our approach to a Salop circle model.

[1]Our single marketplace is related to the single place or monocentric city of regional science/urban economics. Unlike regional science we do not focus on land rents but instead take an industrial organisation approach focusing on the details of product market competition.

This extension introduces a second effect for infrastructure investment, namely to increase spatial competition by lowering transport costs between firm locations. In the short run collusion or multiproduct monopoly still leads to an infrastructure trap. However short run competition on the circle leads to overprovision of infrastructure as opposed to the under provision in the single marketplace model. This overprovision occurs as consumers reap the indirect benefit of increased competition which was not present in the single marketplace.

Free entry in the long run completely transforms our conclusions about the role of competition on the circle. Entry/exit means that an improvement in infrastructure causes not just a drop in per unit transport costs but also a different configuration of firm locations. Forming expectations over possible firm locations causes consumers endogenously to exhibit a status quo bias. The status quo bias manifests itself as a reduced preference for investment leading to either the socially optimal outcome or an infrastructure trap.

2. A Model of Infrastructure Investment

Assume that a unit mass of consumers are uniformly distributed in a region, represented as a closed interval $[-\frac{1}{2}, \frac{1}{2}]$ and $n(\geq 1)$ firms producing a product with marginal cost $c \geq 0$ are located at the center. There are no fixed costs.[2] Each consumer buys either zero or one unit of the product which yields gross utility of A per unit of consumption. In addition to paying $p = \min\{p_1, p_2, ..., p_n\}$, a consumer living at an address y, $y \in [-\frac{1}{2}, \frac{1}{2}]$, bears transport cost $t|y|^\beta$ ($\beta \geq 1$) to purchase the product. Consumer y's net utility from consumption, denoted by $V(y)$ is given by

$$V(y) = A - p - t|y|^\beta. \tag{2.1}$$

The consumers have a generic outside option which yields zero utility. This implies that consumer y purchases the product as long as $V(y) \geq 0$.

We interpret the transport cost parameter t as an index of infrastructure. More specifically we consider a reduction in t as resulting from an investment in infrastructure. The interpretation is quite natural in the geographical context where improvements in roads or rail connections, or the construction of a free way system naturally lead to lower physical transportation costs. More generally we might think of the consumers being located in a characteristic space. Aghion and Schankerman (2001) suggest that the transportation cost parameter in

[2]We relax this in the spatial competition model with free entry.

a characteristic space measures the level of competition between firms. As a result they claim t would be reduced by infrastructure investments which increase competition, for example law and order, or anti-trust regulation and enforcement.

We assume t is determined by consumers/voters through a political process.[3]. Starting from an initial t_0, an investment of I reduces transport cost to $t_0 - I$. An investment of amount I costs $\frac{\gamma I^2}{2}$ and is financed by lumpsum tax of g per consumer. Since there is unit mass of consumers the total tax revenue is $g.1 = g$ as well. This implies that in equilibrium $g = \frac{\gamma I^2}{2}$.[4] The tax g or equivalently the level of investment I is determined by political process.

The sequence of events is as follows. Initially the political process determines the level of infrastructure investment I which determines transport cost $t = t_0 - I$. Subsequently, firms set prices, then a consumer decides whether to purchase or not.

Market Coverage: Since the consumers are symmetrically distributed in $[-\frac{1}{2}, \frac{1}{2}]$ around the center, hereafter we focus our analysis on the closed interval $[0, \frac{1}{2}]$. Given an investment level I determined by the political process (which implies $t = t_0 - I$) and equilibrium price p^*, we rewrite the indirect utility given in (2.1) as follows:

$$V(y, I) = A - p^* - (t_0 - I)y^\beta \tag{2.2}$$

where $y \in [0, \frac{1}{2}]$. Denote $\hat{y}(I)$ as the address of the farthest consumer who buys the the product. If $V(\frac{1}{2}, I) \geq 0$, $\hat{y}(I) = \frac{1}{2}$, else $\hat{y}(I)$ satisfies $A - p^* - (t_0 - I)\hat{y}(I)^\beta = 0$ implying $\hat{y}(I) = (\frac{A-p^*}{t_0-I})^{\frac{1}{\beta}}$. Combining these two possibilities yields

$$\hat{y}(I) = \min\{(\frac{A - p^*}{t_0 - I})^{\frac{1}{\beta}}, \frac{1}{2}\}, \tag{2.3}$$

For a given investment level I, market coverage is complete if $\hat{y}(I) = \frac{1}{2}$ and incomplete if $\hat{y}(I) < \frac{1}{2}$.

Price equilibria: In presence of $n \geq 2$ firms, Bertrand competition yields $p_i^* = c$ for all i and accordingly $p^* = \min\{p_1^*, p_2^*, ..., p_n^*\} = c$. For the monopoly case, $n = 1$, there are two possible scenario. First, for $I < t_0 - 2^\beta(\frac{A-c}{1+\beta})$, market is not fully covered and $p^* = \text{argmax}_p(p - c)\hat{y}(I) = \text{argmax}_p(p - c)(\frac{A-p}{t_0-I})^{\frac{1}{\beta}} = \frac{\beta A + c}{1+\beta}$. For $I \geq t_0 - 2^\beta(\frac{A-c}{1+\beta})$, the monopolist finds it optimal to serve the entire market and p^* is such

[3]There are a handful of papers which treats t as endogenous .....

[4]We implicitly assume that the proceeds from lumpsum tax cannot be used for redistributive purposes.

$V(\frac{1}{2}, I) = 0$ implying $p^* = A - \frac{t_0 - I}{2^\beta}$. Observe that, except for the complete coverage under monopoly, prices are independent of the level of infrastructure provision.[5] With monopoly and complete coverage, lower t allows the monopoly to extract more rent from the farthest as well as other consumers and hence p^* is increasing in I.

In order to focus on voting behavior of consumers, we assume that profits, if any, accrue to a measure zero of elite. This accords well with findings in developing countries where shareholding is extremely skewed. For $n \geq 2$ firms in this section, and free entry in spatial competition model discussed in section 4, the profits are zero and hence it does not affect the voting behaviour or the surplus measures (defined below). For other cases — e.g $n = 1$ and fixed number of firms case in spatial competition setup — the assumption has some bite. We discuss the effect of positive shareholding in section 5. In absence of shareholding by consumers, surplus of a consumer y, denoted by $S(y, I)$, is the indirect utiility from consumption less tax, i.e.

$$S(y, I) = \max\{V(y, I), 0\} - \frac{\gamma I^2}{2}. \tag{2.4}$$

Aggregate Surplus Measures: Though individual surplus measure is useful in determining the voting behavior of an individual the cost-benefit comparison requires aggregate measures. Two aggregate surplus measures are introduced below. The measures are defined generally so that they can be used for comparison in the later sections. The first measure, denoted by $B(I)$ is simply the sum of consumer surplus for all y —

$$B(I) = 2\int_0^{\frac{1}{2}} S(y, I)dy \equiv 2\int_0^{\hat{y}(I)} V(y, I)dy - \frac{\gamma I^2}{2}. \tag{2.5}$$

The second measure, aggregate social surplus, denoted by $W(I)$, is the sum of aggregate consumer surplus $B(I)$ and aggregate profits $\Pi \equiv \sum_{i=1}^n \pi_i \equiv \sum_{i=1}^n [(p_i^* - c) - K]$, where K denotes fixed costs.[6] Using (2.5), $W(I)$ can be expressed as follows:

$$W(I) = 2\int_0^{\hat{y}(I)} V(y, I)dy + \Pi - \frac{\gamma I^2}{2}. \tag{2.6}$$

[5] The intermediate values $p \in [c, \frac{\beta A + c}{1+\beta}]$ are possible as well — e.g.(i) a price ceiling with $n = 1$ and (ii) a price floor with $n \geq 2$.

[6] K is assumed to be zero in this section.

3. Political Economy

At regional or local levels or even at a country level (especially if the country is small), proposals for change from existing state — status quo — are often put forward in a referendum. In current context it works as follows. A positive level of income tax $g = \frac{\gamma I^2}{2}$ is proposed to finance a infrastructure investment of amount I which lowers the transport cost from t_0 to $t_0 - I$. The proposal is passed in the referendum if at least 50% of the consumers/voters vote in favor of the proposal against the status quo $I = 0$.

A consumer y votes in favour of the proposed investment level I if and only if $S(y, I) - S(y, 0) \geq 0$. Let $\mu(I)$ denote the measure of consumers who vote in favour of the proposed positive level of investment I. We define R^0 as the set of investment levels which a majority of voters favour over status quo $I = 0$, i.e.

$$R^0 := \{I : \mu(I) \geq \frac{1}{2}\}. \tag{3.1}$$

To facilitate comparison with other benchmarks defined below, we adopt the convention that $0 \in R^0$. In order to understand the extent of distortion in the political outcomes, we consider two benchmarks based on the surplus measures $B(I)$ and $W(I)$ introduced in previous subsection.

$$B^0 := \{I : I \geq 0, B(I) - B(0) \geq 0\} \tag{3.2}$$

$$W^0 := \{I : I \geq 0, W(I) - W(0) \geq 0\} \tag{3.3}$$

The set B^0 (W^0) consists of investment levels for which the aggregate consumer surplus (social surplus) is higher compared to the status quo.

Following the standard practice in the voting literature, in the pairwise voting scenario, we use the concept of Condorcet winner. For any two investment levels I_1 and I_2, let $m_1(I_1, I_2)$ denote the measure of consumers that prefers I_1 to I_2 and similarly let $m_2(I_1, I_2)$ denote the measure of consumers that prefers I_2 to I_1. An investment level I^* is a Condorcet winner if for all $I \neq I^*, m_1(I^*, I) \geq m_2(I^*, I)$. In absence of possibility of abstention this implies I^* is a Condorcet winner if $m_1(I^*, I) \geq \frac{1}{2}$ for all $I \neq I^*$. To determine whether political outcomes yield "underprovision" or "overprovision" of investment, we compare I^* with aggregate consumer surplus maximizing investment level

$$I_b := \arg\max_{I \geq 0} B(I) \equiv \arg\max_{I \in B^0} B^0 \tag{3.4}$$

and social surplus maximizing investment level

$$I_w = \arg\max_{I \geq 0} W(I) \equiv \arg\max_{IinW^0} W^0. \tag{3.5}$$

In the two variants of the political process — referendum and pairwise voting — we analyze the cases $\hat{y}(0) = \frac{1}{2}$ and $\hat{y}(0) < \frac{1}{2}$ separately. The discussion of the complete coverage case brings out the voting mechanics in simple fashion which we utilize in the subsequent sections dealing with spatial competition in circular city model. Moreover, it also highlights the importance of market competition, or actually a lack thereof, in generating infrastructure traps. On the other hand, endogenizing market participation, the incomplete coverage case presents a rich voting behavior and shows that "infrastructure traps" can arise, even with competition, if the initial coverage is too low.

3.1. **Complete Coverage.** First we consider the case where the initial market coverage is complete, i.e. $\hat{y}(0) = \frac{1}{2}$. As we see below, market structure plays an important role in the political outcome.

3.1.1. *Monopoly($n = 1$):* Under monopoly, the market coverage is complete with $t = t_0$ if $t_0 < 2^{\beta}(\frac{A-c}{1+\beta})$. Substituting the monopoly price $p^* = A - \frac{t_0 - I}{2^{\beta}}$ in $V(y, I)$ in (2.2) and subsequently substituting resulting $V(y, I)$ in (2.4) yields $S(y, I) = (t_0 - I)(\frac{1}{2} - y)^{\beta} - \frac{\gamma I^2}{2}$. Then,

$$S(y, I) - S(y, 0) = -I(\frac{1}{2} - y)^{\beta} - \frac{\gamma I^2}{2} < 0, \text{for all} y \in [0, \frac{1}{2}]. \tag{3.6}$$

implying that every consumer is worse off from a positive level of investment. The reasoning is as follows. The monopolist raises the price which exactly offsets the benefit from reduction in transport costs for the farthest consumer. Other consumers face the same increase in prices but enjoys less savings in transport costs. Thus all consumers except the most distant ones are strictly worse off even in absence of tax considerations. The consumer with address $y = \frac{1}{2}$ is strictly worse off because of the strictly positive tax level implied by $I > 0$.

The above analysis implies that no consumer votes in favour of any $I > 0$. Thus, status quo $t = t_0$ is preserved and accordingly $R^0 = \{0\}$. Since there does not exist any $I > 0$ which beats the status quo $I = 0$, it follows that $I = 0$ is the unique Condorcet winner, i.e. $I^* = 0$. Since each consumer is worse off for $I > 0$, the aggregate consumer surplus is strictly lower as well. Hence, $B^0 = \{0\}$ and this in turn implies $I_b = 0$.

Now we turn to W^0. For complete coverage with monopoly,

$$\begin{aligned} W(I) &= 2\int_0^{\frac{1}{2}}[A - p^* - (t_0 - I)y^\beta]dy + (p^* - c) - \frac{\gamma I^2}{2} \\ &= A - c - \frac{(t_0 - I)}{2^\beta(1+\beta)} - \gamma I^2/2. \end{aligned} \tag{3.7}$$

Using equation (), it follows that $W(I) - W(0) = I(\frac{1}{2^\beta(1+\beta)} - \frac{\gamma I}{2})$, which is positive for all $I \leq \frac{1}{2^{\beta-1}(1+\beta)\gamma}$. Hence $W^0 := \{I : 0 \leq I \leq \frac{1}{2^{\beta-1}(1+\beta)\gamma}\}$ and $I_w = \text{argmax} W^0 = \frac{1}{2^\beta(1+\beta)\gamma}$. Proposition 1 summarizes the finding.

Proposition 1: For $t_0 < 2^\beta(\frac{A-c}{1+\beta})$ and $n = 1$,
(i) $R^0 = B^0 = \{0\} \subset W^0$.
(ii) $I^* = I_b = 0 < I_w$.

Proposition 1 suggests that though there are welfare improving positive investment levels, in absence of shareholding, political processes - referendum as well as voting - preserve status quo $t = t_0$. The "infrastructural trap" or zero investment in this case is generated due to monopoly market structure and zero shareholdings.

3.1.2. *Competition($n \geq 2$):* For $n \geq 2, p^* = c$ and hence firms earn zero profits. In absence of profits the two surplus measures are equivalent, i.e. $B(I) = W(I)$. Moreover, as long as the market is covered, aggregate social surplus $W(I)$ under competition remains the same as in monopoly since equilibrium price p^* — which differ for these two scenarios — are essentially transfer from consumers to producers and hence does not feature in overall surplus. This implies that, in presence of competition,

$$\begin{aligned} B^0 &= W^0 = \{I : 0 \leq I \leq \frac{1}{2^{\beta-1}(1+\beta)\gamma}\} \\ I_b &= I_w = \frac{1}{2^\beta(1+\beta)\gamma}. \end{aligned}$$

For competition with complete coverage, $S(y, I) = A - c - (t_0 - I)y^\beta - \frac{\gamma I^2}{2}$. Since $\frac{d^2S(y,I)}{dI} = -\gamma < 0$ the preferences(over I) are single peaked. Then, applying the standard median voter theorem, it follows that the investment level most preferred by the median voter is the Condorcet winner. Given the median consumer address $y = \frac{1}{4}$,

$$I^* = \arg\max_{I \geq 0} S(\frac{1}{4}, I) = \frac{1}{4^\beta \gamma}$$

Note that for all $\beta \geq 1$, $4^\beta\gamma \geq 2^\beta(1+\beta)\gamma$, implying $I^* \leq I_b = I_w$. The equality holds only for $\beta = 1$.

Turning to referendum, a consumer $y \in [0, \frac{1}{2}]$ votes against status quo if

$$S(y, I) - S(y, 0) = Iy^\beta - \frac{\gamma I^2}{2} \geq 0 \tag{3.8}$$

Using the fact that $S(y, I) - S(y, 0)$ is strictly increasing in y we find that, an investment level $I > 0$ wins the majority support, and accordingly passed in referendum if and only if the median consumer is better off compared to the status quo. Noting that $|y| = \frac{1}{4}$ median consumer, the above statement can be restated as:

Lemma 1: $I \in R^0 \Leftrightarrow S(\frac{1}{4}, I) - S(\frac{1}{4}, 0) \geq 0$.

Since $S(\frac{1}{4}, I) - S(\frac{1}{4}, 0) \geq 0 \Leftrightarrow I \leq \frac{2}{4^\beta\gamma}$ and for all $\beta \geq 1$, $\frac{2}{4^\beta\gamma} \leq \frac{1}{2^{\beta-1}(1+\beta)\gamma}$, it follows that $R^0 \subseteq B^0 = W^0$. The Proposition below summarizes the discussion from this subsection.

Proposition 2: For $t_0 < 2^\beta(A - c)$ and $n \geq 2$,
(i) $R^0 \subseteq B^0 = W^0$ and
(ii) $I^* \leq I_b = I_w$, where equality in (i) and (ii) holds for $\beta = 1$ only.

Though political process does not generate any infrastructure trap under competition, in presence of strictly convex transportation costs ($\beta > 1$), there exists surplus enhancing investment levels (which increases aggregate consumer surplus well as the aggregate social surplus) which are not politically feasible — gets beaten by status quo in pairwise voting. Similarly, $I^* < I_w$ for all $\beta > 1$. The underlying reason for the underprovision is that the distance travelled by the median voter $\frac{1}{4^\beta}$ is less than the average distance travelled $\frac{1}{2^{\beta-1}(1+\beta)}$ and hence the savings in transportation cost for a given investment level is valued less to a median voter compared to the social planner.

3.2. **Incomplete Coverage:** Complete coverage only occurs if infrastructure investment is "cheap". However this is hardly the case in developing countries and low level of infrastructure provision creates barriers for market participation. In such cases, additional infrastructure investment not only creates differential benefits for existing consumers but also draws new consumer to the market. To focus on the conflicting interests and infrastructure traps arising from incomplete coverage alone, we abstract away from monopoly and strictly convex transportation cost - the factors responsible for "infrastructure traps" and "underprovision" for the complete coverage case. In particular we assume that

(i) $n \geq 2$ implying $p^* = c$ and (ii) $\beta = 1$. Also, implicit in the incomplete coverage case, is the fact that $\hat{y}(0) = \frac{A-c}{t_0} < \frac{1}{2} \Rightarrow t_0 > 2(A-c)$. We further assume that

Assumption 1 (A1): $t_0 > \sqrt{\frac{2(A-c)}{\gamma}}$.

Assumption 1 implies that $S(y, t_0) = A - c - \frac{\gamma t_0^2}{2} < 0$, i.e. $I = t_0$ is too costly.[7]

Corresponding to any investment level $I > 0$, the surplus for a consumer y is given by:

$$\begin{aligned} S(y, I) &= A - c - (t_0 - I)y - \frac{\gamma I^2}{2}, \text{if} y < \hat{y}(I) \\ &= -\frac{\gamma I^2}{2}, \text{otherwise.} \end{aligned} \tag{3.9}$$

Consider $y < \hat{y}(0)$. Amongst these consumers, the savings from reduction in transport cost from t_0 to $t_0 - I$ is zero for $y = 0$, and higher the farther the consumer. Hence, accounting for taxes, a consumer does not receive any positive benefit unless she lives beyond a certain distance. Let $y_L(I)$ denote the least distant consumer who is not worse off from investment I. That is, $y_L(I)$ satisfies $S(y_L(I), I) - S(y_L(I), 0) = 0 \Leftrightarrow I y_L(I) - \frac{\gamma I^2}{2} = 0$. This yields

$$y_L(I) = \frac{\gamma I}{2}. \tag{3.10}$$

Now consider $y > \hat{y}(0)$. Investment increases market participation and for the new participants the surplus from consumption $V(y, I) = A - c - (t_0 - I)y$ is positive. However, unless the surplus from consumption $V(y, I)$ exceeds the taxes $\frac{\gamma I^2}{2}$, the net surplus $S(y, I) < 0$. Since $V(y, I)$ is decreasing in y, the consumer living beyond a certain distance become worse off due to additional investment. For an investment level I, let $y_U(I)$ denote the address of farthest consumer who is no worse off. If $S(\frac{1}{2}, I) \geq 0$, $y_U(I) = \frac{1}{2}$ else $y_U(I)$ satisfies $S(y_U(I), I) = 0 \Leftrightarrow A - c - (t_0 - I)y_U(I) - \frac{\gamma I^2}{2} = 0$. Hence

$$y_U(I) = \min\{\frac{A - c - \frac{\gamma I^2}{2}}{t_0 - I}, \frac{1}{2}\}. \tag{3.11}$$

From the discussion above it follows that, corresponding to a given level of investment, the measure of net beneficiaries are given by $y_U(I) - y_L(I)$. Given that a half of the unit mass of consumers are uniformly distributed in $[0, \frac{1}{2}]$, a proposal of an investment level I is passed in

[7]This was implicit in other cases as well. We explicitly state this here, as the proofs of some claims in this subsection use this assumption quite heavily.

referendum if and only if $y_U(I) - y_L(I) \geq \frac{1}{4}$. Thus, for the incomplete coverage case

$$R^0 = \{I : y_U(I) - y_L(I) \geq \frac{1}{4}\} \tag{3.12}$$

Consider the scenario where initially less than half of the consumers are served, i.e. $\hat{y}(0) = \frac{A-c}{t_0} < \frac{1}{4}$. We show in appendix that it suffices to consider $I \leq \frac{2(A-c)}{\gamma t_0}$ since for $I > \frac{2(A-c)}{\gamma t_0}$, $S(y,I) - S(y,0) < 0$ for all I. [8] For all such investment levels,

$$y_U(I) - y_L(I) \geq \frac{1}{4} \Leftrightarrow (4(A-c) - t_0) + (1 - 2\gamma t_0)I \geq 0. \tag{3.13}$$

Note that as $4(A-c) - t_0 < 0$ and $1 - 2\gamma t_0 < 0$, there does not exist any $I > 0$ satisfying (), leading to infrastructure trap. Hence $R^0 = \{0\}$ and accordingly $I^* = 0$. The condition $1 - 2\gamma t_0 < 0$ implies that cost of infrastructure provision is large ($\gamma > \frac{1}{2t_0}$) which renders some investment levels politically infeasible. However given the quadratic investment cost specification $\frac{\gamma I^2}{2}$ — which implies that the marginal cost of investment of the first unit is zero — one might expect that small investment levels should be feasible. In determining political feasibility of small investment levels one needs to consider whether those will be favored by a majority. Since $4(A-c) - t_0 < 0$, it follows that

$$\lim_{I \to 0} y_U(I) - y_L(I) = \frac{A-c}{t_0} - 0 = \hat{y}(0) < \frac{1}{4},$$

implying small investment levels cannot garner majority support.

Given $4(A-c) - t_0 < 0$, it follows that positive investment levels are able to win majority only if $1 - 2\gamma t_0 > 0$, i.e. $\gamma < \frac{1}{2t_0}$. For such parameter values, it follows from (3.11) that the set of politically feasible investments are given by $I > \frac{t_0 - 4(A-c)}{1 - 2\gamma t_0}$. However, it turns out that, there does not exist any investment level $I > 0$, which satisfies (i) $I \leq \frac{2(A-c)}{\gamma t_0}$ as well as (ii) $I > \frac{t_0 - 4(A-c)}{1 - 2\gamma t_0}$. Though there is no strictly positive investment level that beats status quo and hence set of politically feasible outcomes $R^0 = \{0\}$, the set $B^0 = \{I : B(I) - B(0) \geq 0\}$ contains $I > 0$. Note that

$$B(I) = 2\int_0^{\hat{y}(I)} A - c - (t_0 - I)y dy - \frac{\gamma I^2}{2} = \frac{(A-c)^2}{t_0 - I} - \frac{\gamma I^2}{2}.$$

[8] Furthermore, for all such investment levels, $S(\frac{1}{2}, I) < 0 \Rightarrow S(\frac{1}{2}, I) - S(\frac{1}{2}, 0) < 0$ and hence $y_U(I) = \frac{A - c - \frac{\gamma I^2}{2}}{t_0 - I}$. See Appendix for a formal proof of this claim.

Then, $B^0 \supset \{0\}$ follows from noting that (i) $B(I) - B(0)$ is continuous in I for all $I \geq 0$, and (ii) $\frac{d}{dI}[B(I) - B(0)]|_{I=0} = (\frac{A-c}{t_0})^2 > 0$. Clearly $I^* = \arg\max_{I \in B^0} B^0 > 0$. Since $p^* = c$ and $\Pi = 0$, $B^0 = W^0$ and accordingly $I_w = \arg\max_{I \in W^0} W^0 = \arg\max_{I \in B^0} B^0 = I_b$. Proposition 3 summarizes the finding.

Proposition 3: If $t_0 > \max\{\sqrt{\frac{2(A-c)}{\gamma}}, 4(A-c)\}$,
(i) $R^0 = \{0\} \subset B_0 = W_0$, and
(ii) $I^* = 0 < I_b = I_w$.

The future versions of the paper will incorporate detailed description of the case $t_0 < 4(A-c)$, i.e. $\hat{y}(0) > \frac{1}{4}$. Here we just point out that, since more than half of the consumers are served at $t = t_0$, the infrastructure trap cannot arise in such a scenario since $\lim_{I \to 0} y_U(I) - y_L(I) = \frac{A-c}{t_0} - 0 = \hat{y}(0) > \frac{1}{4}$.

4. Spatial Competition

The central marketplace framework captures the differential benefits for consumers arising from the difference in their distances from the center. However it assumes all firms are located at same place, and as a consequence, price is driven down to marginal cost. This in turn implies that price is independent of the level of infrastructure in the economy. In this section, we adopt the circular city model a la Salop (1979), where firms locate at different points on the circle. In the short run version of the model the number and locations of firms are assumed to be fixed and the spatial competition between firms arising from locational differences links equilibrium prices to level of infrastructure provision. While voting, consumer not only has to consider the effect of infrastructure investment on transport costs but also its' effect on prices.

As in the previous section, we assume that government provides a level of infrastructure investment I at cost $\frac{\gamma I^2}{2}$ where the choice of I is determined by the political process. Before analyzing infrastructure as the outcome of a political game we first need to determine the payoffs for the players involved arising from the circular city set up.

Assume that a unit mass of consumers are uniformly distributed around a circle C of circumference 1 with density 1. The locations of consumers y are described in a clockwise manner starting from 12 o'clock. Assume there are n firms, with the location of firm i denoted by x_i. As described in section 2, each consumer buys one unit of the product that gives her the highest indirect utility if this is nonnegative; otherwise the consumer chooses not to purchase. That is consumers have a generic outside option, the utility of which we normalize to zero. The indirect utility of a consumer located at $y \in C$ from purchasing variant i is:

$$V_i(y) = A - p_i - \tau|y - x_i|^{\beta}. \tag{4.1}$$

Firms have a constant marginal cost of $c \geq 0$. We will make the standard assumption that firms are evenly dispersed around the circle.[9]

Price Equilibria: We assume that the gross utility from consuming a variety, A, is high enough (or equivalently t_0 is low enough) such that each consumers buys and the firms directly compete with its neighboring firms.[10] If firms are equally spaced around the circle, that is at distance $1/n$ from their nearest neighbor, then the unique symmetric price equilibrium is given by(see Anderson et al. (1992, page 177))

$$p^*(I) = c + \beta 2^{1-\beta}(t_0 - I)(\frac{1}{n})^{\beta}. \tag{4.2}$$

Note that $p^*(I)$ is decreasing in I reflecting the fact that an increase in investment level, i.e. a reduction in t, creates more competition among the existing firms which in turn leads to lower equilibrium prices.

Surplus Measures: Recall the individual and aggregate surplus measures, $S(y, I), B(I)$ and $W(I)$, introduced in section 2. Reinstating the power transportation cost function in the circular city setup and incorporating $p = p^*(I)$ from (), we find that for a consumer $y \in C$,

$$S(y, I) = A - p^*(I) - (t_0 - I)|y - x_i^*|^{\beta} - \frac{\gamma I^2}{2}. \tag{4.3}$$

where x_i^* is location of the firm nearest to consumer y. the equilibrium Since n firms are equally spaced around the circle and equilibrium price faced by each consumer is same it suffices to consider $\frac{1}{n}$ mass of consumers served by a representative firm. Also, since those consumers are symmetrically distributed around firm's location we focus on $\frac{1}{2n}$ mass of consumers located on one side of a particular firm. Given that consumers are uniformly distributed and the market consist of $2n$ such

[9]Economides (1989) shows that this is the unique symmetric equilibrium in a location-then-price game.

[10]If A is low, then each firm becomes a local monopolist. This case is analogous to the incomplete coverage case described in subsection 3.2 with a mass $\frac{1}{n}$ of consumers evenly distributed in $[-\frac{1}{2n}, \frac{1}{2n}]$ and $p^* = \frac{A+c}{2}$ — the monopoly price.

groups, it follows that

$$B(I) = 2n\int_{x_i^*}^{\frac{1}{2n}+x_i^*} S(y,I)dy = A - p^*(I) - \frac{t_0 - I}{(2n)^\beta(1+\beta)} - \frac{\gamma I^2}{2} \tag{4.4}$$

$$W(I) = 2n\int_{x_i^*}^{\frac{1}{2n}+x_i^*} S(y,I)dy + \Pi = A - c - \frac{t_0 - I}{(2n)^\beta(1+\beta)} - \frac{\gamma I^2}{2} \tag{4.5}$$

4.1. **Political Economy.** We begin by comparing $B^0 := \{I : I \geq 0, B(I)-B(0) \geq 0\}$ and $W^0 := \{I : I \geq 0, W(I)-W(0) \geq 0\}$ — the set of I that improves aggregate consumer surplus and welfare respectively compared to the status quo. Using (4.3), it follows that $B(I)-B(0) = [p(0)-p^*(I)] + I(\frac{1}{2n^\beta(1+\beta)} - \frac{\gamma I}{2}) = I(\beta 2^{1-\beta}(\frac{1}{n})^\beta + \frac{1}{(2n)^\beta(1+\beta)} - \frac{\gamma I}{2})$, which is positive for all $I \leq \frac{2}{\gamma}(\beta 2^{1-\beta}(\frac{1}{n})^\beta + \frac{1}{(2n)^\beta(1+\beta)})$. Hence

$$\begin{aligned} B^0 : &= \{I : 0 \leq I \leq \frac{2}{\gamma}(\beta 2^{1-\beta}\frac{1}{n}^\beta + \frac{1}{(2n)^\beta(1+\beta)})\} \\ I_b &= \arg\max_{I\in B^0} B^0 = \frac{1}{\gamma}(\beta 2^{1-\beta}\frac{1}{n}^\beta + \frac{1}{(2n)^\beta(1+\beta)}). \end{aligned}$$

Similarly using (4.4) we find that

$$\begin{aligned} W^0 : &= \{I : 0 \leq I \leq \frac{2}{(2n)^\beta(1+\beta)\gamma}\} \\ I_w &= \arg\max_{I\in W^0} W^0 = \frac{1}{(2n)^\beta(1+\beta)\gamma} \end{aligned}$$

Comparing W^0 and B^0 it follows that $W^0 \subset B^0$. The reasoning is simple. An increase in investment level increases $B(I)$ through two channels - reduction in equilibrium prices and reduction in aggregate transport costs. However change in prices do not affect $W(I)$. This implies that, corresponding to any change in I, the increase in $W(I)$ is less than the increase in $B(I)$ and accordingly any investment level that increases aggregate social surplus increases aggregate consumer surplus as well. In other words, $W^0 \subset B^0$. The argument above given above applies for marginal changes in I too. Since marginal increase in $W(I)$ is less than that of $B(I)$, and $W(I)$ and $B(I)$ are strictly concave, it follows that $I_w < I_b$.

Now we turn to voting pattern of the consumers. Consider firm i and the consumers on one side of firm i, i.e. $y \in [x_i^*, x_i^* + \frac{1}{2n}]$. A consumer $y \in [0, \frac{1}{2n}]$ votes against status quo if

$$S(y,I) - S(y,0) = [p^*(0) - p^*(I)] + Iy^\beta - \frac{\gamma I^2}{2} \geq 0 \tag{4.6}$$

Observe that $S(y, I) - S(y, 0)$ is continuous in I and y and strictly increasing in y. This implies that if a consumer $\tilde{y}$ votes for the proposed investment level all consumers $y \geq \tilde{y}$ votes for it as well. Utilizing this property we find that find an investment level I wins majority support over status quo if and only if the median consumer is better off compared to the status quo. Noting that $|y| = \frac{1}{4n}$ is the median consumer, the set of investment level that beats status quo in pairwise voting is given by:

$$\begin{aligned} R^0 &= \{I : S(\frac{1}{4n}, I) - S(\frac{1}{4n}, 0) \geq 0\} \\ &= \{I : 0 \leq I \leq \frac{2}{\gamma}(\beta 2^{1-\beta}(\frac{1}{n})^\beta + \frac{1}{(4n)^\beta})\} \end{aligned}$$

Also, since preferences are single peaked — follows from strict concavity of $S(y, I)$ — the most preferred investment level of the median consumer is the unique Condorcet winner.

$$\begin{aligned} I^* &= \arg\max_{I \in R^0}(S(\frac{1}{4n}, I) - S(\frac{1}{4n}, 0)) \\ &= \frac{1}{\gamma}(\beta 2^{1-\beta}(\frac{1}{n})^\beta + \frac{1}{(4n)^\beta}) \end{aligned}$$

Comparing the voting outcomes with the surplus benchmarks yields

Proposition 4: In a circular city model, with $n \geq 2$,
(i) $W^0 \subset R^0 \subseteq B^0$, and
(ii) $I_w < I^* \leq I_b$, where equality holds only for $\beta = 1$.

The savings in transport costs for the median consumer, due to improved infrastructure, is less than the average savings. This implies that there are investment levels I which increases $B(I)$ but not favoured by the median consumer, and accordingly not supported by the majority. Hence $R^0 \subseteq B^0$. Since the savings are valued similarly in W^0 and B^0, the argument described above would suggest that $R^0 \subseteq W^0$ as well. However, recall that the change in aggregate social surplus, $W(I) - W(0)$, does not take into account the beneficial effect of price reduction due to improved infrastructure. This enlarges the set R^0, and in fact for the specification chosen, it turns out that $W^0 \subset R^0$. Similar arguments can be used to establish Proposition 4(ii).

In contrast to our findings in the central marketplace framework with complete coverage, we find that there is "overprovision" of infrastructure. However, the finding is contingent on the competitive behavior of firms. In presence of collusion — analogous to complete coverage and monopoly in the previous section — $p^*(I)(= A - (t_0 - I)(\frac{1}{2n})^\beta)$ is increasing in I. The loss from increased prices outweighs gains from transport cost savings which in turn leads to the following:

Proposition 5: In presence of collusion in the circular city framework,
(i) $R^0 = B^0 = \{0\} \subset W^0$.
(ii) $I^* = I_b = 0 < I_w$.

The findings in Proposition 4 and 5 highlights the importance of market reforms in representative democracies willing to undertake infrastructural changes. Even though welfare improving changes exist, in absence of competition, those changes might not be politically viable. For many years, global institutions such as World bank have pushed for market reforms before providing any aid in terms of infrastrcutural improvements. Also, there is a folk wisdom that market structure and infrastructure provisions are related. Our framework provides a explicit link between the two and suggest that indeed workings of the market has important bearings on infrastructure provision.

4.2. **Spatial Competition with Free Entry.** In our analysis so far, the number and locations of firms are assumed to be given. The assumption is appropriate for short run analysis, but, in the long run, the firms can change locations and furthermore entry and exit occurs in the industry. To incorporate these features into our framework and examine the consequent effects on the voting outcome we consider a slightly modified set up.

On the production side, in addition to marginal cost $c \geq 0$, now assume that the each firm has to incur fixed cost $K > 0$ whenever it produces a positive amount. Consider a sequential game, where corresponding to a given level of infrastructure provision $t = t_0 - I$, a firm i first decides whether to enter and subsequently post-entry it chooses location (x_i) and then price (p_i). If n firms have entered in the first stage, the location and price of firm i in the unique symmetric equilibrium, denoted by $\bar{x}_i$ and $\bar{p}_i$ respectively, are as follows(see Economides(1989):

$$|\bar{x}_i - \bar{x}_{i+1}| = |\bar{x}_i - \bar{x}_{i-1}| = \frac{1}{n} \tag{4.7}$$

$$\bar{p}_i(n) = \bar{p}(n) = c + \beta 2^{1-\beta}(t_0 - I)(\frac{1}{n})^{\beta}. \tag{4.8}$$

Treating n as a continuous variable, the free-entry number of firms corresponding to a given level of investment I, denoted by $n^*(I)$ is obtained from solving the zero profits condition $(\bar{p} - c)\frac{1}{n} = K$. This yields

$$n^*(I) = (\frac{\beta 2^{1-\beta}(t_0 - I)}{K})^{\frac{1}{1+\beta}}. \tag{4.9}$$

For a given $I \geq 0$, the subgame perfect Nash equilibrium outcome of the three-stage game — entry(stage 1), location choice(stage 2) and price competition (stage 3) — can be summarized by a triplet $(n^*(I), \{x_i^*(I)\}_{i=1}^{n^*(I)}, p^*(I))$ where $n^*(I)$ is as in (), and $x_i^*(I)$ and $p^*(I)$ are $\bar{x}_i$ and $\bar{p}_i$ respectively evaluated at $n = n^*(I)$.

Suppose the initial level of infrastructure provision in the economy is $t = t_0$ and the number of firms, locations and prices are given by $n^*(0)$, $\{x_i^*(0)\}_{i=1}^{n^*(0)}$ and $p^*(0)$ respectively. While voting for a $I > 0$, a consumer y correctly anticipates $n^*(I)$ and $p^*(I)$. However, since any equispaced location of $n^*(I)$ firms constitutes an equilibrium, a consumer needs to compute the expected utility over all possible values of distances $|y - x_i^*(I)|$ where $x_i^*(I)$ denote the location of the nearest firm. Clearly $|y - x_i^*(I)| \in [0, \frac{1}{2n^*(I)}]$, and using this, the expected surplus from a investment $I > 0$ is:

$$\begin{aligned} S(y, I) &= A - p^*(I) - (t_0 - I)2n^*(I) \int_y^{y+\frac{1}{2n^*(I)}} |y - x_i|^\beta dx_i - \frac{\gamma I^2}{2} \\ &= A - p^*(I) - \frac{t_0 - I}{(2n^*(I))^\beta(1+\beta)} - \frac{\gamma I^2}{2}, \\ &= \bar{S}(I)\text{say}, \end{aligned}$$

Since $S(y, I) = \bar{S}(I)$ for all $y \in C$,$B(I) = \int_{y \in C} \bar{S}(I)dy = \bar{S}(I)$ and moreover since profits are zero in free-entry equilibrium, the two aggregate surplus measures are equivalent, i.e. $W(I) = B(I)$. Combining these two observations yields that, for all $I > 0$,

$$W(I) = B(I) = \bar{S}(I) = A - p^*(I) - \frac{t_0 - I}{(2n^*(I))^\beta(1+\beta)} - \frac{\gamma I^2}{2}. \tag{4.10}$$

Note that a consumer is uncertain of the distance travelled (and accordingly the magnitude of change in transport costs) only if a strictly positive level of investment is voted for. If no investment is undertaken and the status quo is preserved the firms are assumed to maintain the initial locations. This yields

$$S(y, 0) = A - p^*(0) - (t_0 - I)|y - x_i^*(I)|^\beta - \frac{\gamma I^2}{2}. \tag{4.11}$$

and summing up $S(y, 0)$ for all y yields

$$B(0) = \int_{y \in C} S(y, 0) = A - p^*(0) - \frac{t_0 - I}{(2n^*(0))^\beta(1+\beta)} - \frac{\gamma I^2}{2} \tag{4.12}$$

Since $n^*(I)$ and $p^*(I)$ are continuous in I for all $I \geq 0$, $\lim_{I \to 0} B(I) - B(0) = 0$. Furthermore, $\frac{dB(I)}{dI}|_{I=0} > 0$. This implies that there exists strictly positive investment levels which increases aggregate consumer surplus. Also, since the two surplus measures are equivalent, it follows that

$$\begin{aligned} W^0 &= B^0 \supset \{0\}, && (4.13)\\ I_w &= I_b = \arg\max_{I\geq 0} B^0 = \arg\max_{I\geq 0} \bar{S}(I) > 0 && (4.14) \end{aligned}$$

Now we turn to voting. Since $S(y, I) = \bar{S}(I)$ for all y, and $S(y, 0)$ is decreasing in y it follows that $S(y, I) - S(y, 0)$ is increasing in y. Exploiting this, it can be shown that, $I > 0$ beats status quo if and only if the median consumer votes for status quo. The relevant median is the one with respect to initial equilibrium configuration. Noting that the median is located at the $\frac{1}{4n^*(0)}$ distance from the nearest firm, the claim can be stated as follows.

Lemma 3: For $I > 0, I \in R^0 \Leftrightarrow S(x_i^* + \frac{1}{4n^*(0)}, I) - S(x_i^* + \frac{1}{4n^*(0)}, 0) \geq 0 \Leftrightarrow \bar{S}(I) - S(x_i^* + \frac{1}{4n^*(0)}, 0)$.

Though $B(I) = \bar{S}(I)$ for $I > 0$, the transportation costs incurred by the median consumer is less than the average transportation costs in the status quo and hence $B(0) \leq S(x_i^* + \frac{1}{4n^*(0)}, 0)$. This implies that $B(I) - B(0) \geq \bar{S}(I) - S(x_i^* + \frac{1}{4n^*(0)}, 0)$ which in turn implies that $B^0 \supseteq R^0$, where equality only holds for $\beta = 1$. Furthermore we find that

Lemma 4: For $\beta > 1$, $I(> 0) \in R^0$ only if $I > \bar{I}(\beta)$.

The lemma suggests that, unless the proposed investment level is higher than a certain threshold, it cannot win referendum. Since an infinitesimally small investment requires zero cost this might seem surprising. However, whether infinitesimally small investment levels are politically viable (i.e. can win referendum) depends on the preferences of the median consumer. Evaluating the median consumer's change in net surplus from arbitrarily small levels of investment yields,

$$\begin{aligned} \lim_{I\to 0}(\bar{S}(I) - S(x_i^* + \frac{1}{4n^*(0)}, 0)) &= (\bar{S}(0) - S(x_i^* + \frac{1}{4n^*(0)}, 0)) \\ &= t_0(\frac{1}{(4n^*(0))^\beta} - \frac{1}{(2n^*(0))^\beta(1+\beta)}) \\ &\leq 0, \end{aligned}$$

where the inequality follows from the fact that $4^\beta \geq 2^\beta(1+\beta)$ (the inequality is strict for $\beta > 1$). The median consumer dislikes infinitesimally small levels of investment since that only increases the transportation costs by discrete amount — she now has to bear the average transportation cost which is higher than the median transportation cost — while the other benefits, e.g. from lower p^* and lower t, are negligible.

Note that since $B(I) = \bar{S(I)}$, the most preferred investment level for any consumer y, amongst the strictly positive ones is $\arg\max_{I>0} \bar{S}(I) = \arg\max_{I>0} B(I) = I_b$. If $\bar{S}(I_b) - S(x_i^* + \frac{1}{4n^*(0)}, 0)) > 0$ then $I_b = I^*$. Else $I^* = 0$ which occurs if γ is larger than a critical value, $\bar{\gamma}$ say. Obviously, when $I^* = 0$, $R^0 = 0$.

Proposition 6: In a circular city model with free entry and $\beta > 1$, $R^0 \subset B^0 = W^0$ and $I^* = I_b = I_w > 0$ provided $\gamma \leq \bar{\gamma}$. For $\gamma > \bar{\gamma}$, $R_0 = 0$ and $I^* = 0$. For $\beta = 1$,$R^0 = B^0 = W^0$ as well as $I^* = I_b = I_w > 0$.

In the previous sections we have shown that the infrastructure trap can arise due to monopoly, zero share-holdings and incomplete coverage. None of these features contribute to the possibility of trap shown here. The uncertainty regarding the distance ex post —in particular the possibility that distance can be larger — renders small changes politically non-viable and if γ is suitably large, the moderate or high level of investment levels cannot do not remain feasible either leading to the "trap".

5. Conclusion

Despite the importance of public infrastructure investments, little attention has been paid to the determinants of investment levels. We provide a political economy foundation for the decision on investment for a variety of market structures based upon the variants of spatial competition. In all these models we interpret a reduction in transport cost as investment in infrastructure.

The government's choice of infrastructure investment is financed by a lump sum tax on individuals. Governmental choice of investment level is considered under two related political paradigms - (i) a referendum in a representative democracy where individuals vote yes or no for a proposed increase to the status quo level of infrastructure and (ii) a pairwise voting process in a representative democracy which produces a Condorcet winner when individuals vote sincerely for their preferred level of infrastructure.

The political process tends not to produce socially optimal infrastructure investment. However the source and magnitude of the inefficiency depend in subtle ways on the characteristics of the market environment. We analyse a number of aspects of the market environment: market structure (competition versus collusion/monopoly); supply dispersion (single marketplace versus multiple firm locations); initial level of development (incomplete versus complete coverage); transport cost curvature (linear versus strictly convex); and entry (short run versus long-running equilibrium).

Rather than provide a complete taxonomy of dozens of configurations we instead consider a number of key cases, based on significant real-world situations. Analysing the inefficiency in these key cases illustrates that the effect of each of the market environment aspects is not constant but depends on subtle interactions with other aspects of the market environment. For example, competition with convex transport costs in a single marketplace produces under provision but competition on the circle produces overprovision.

An interesting and frequent finding is that of infrastructure traps: choice of zero infrastructure investment in a referendum or election where and positive investment is socially optimal. We identify a number of quite distinct causes: monopoly and complete coverage either in a single marketplace or on the circle; competition in a single marketplace with incomplete coverage; and free entry on the circle (under certain cost conditions).

By endogenizing the transport cost parameter as a politically determined infrastructure investment we allow consumers, in their dual role as voters, to partially determine the environment they face when they make purchasing decisions. From the cases considered here this approach, of allowing consumers some role in choosing the " rules of the game", appears to produce a rich new model without a great deal of additional technical complexity. Our results highlight the importance of combining political economy and industrial organisation analysis when considering infrastructure investment.

6. References

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