THE POLITICAL ECONOMY OF INFRASTRUCTURE INVESTMENT: COMPETITION, COLLUSION AND UNCERTAINTY

By

Arghya Ghosh and Kieron Meagher

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THE POLITICAL ECONOMY OF INFRASTRUCTURE INVESTMENT: COMPETITION, COLLUSION AND UNCERTAINTY

ARGHYA GHOSH AND KIERON MEAGHER

ABSTRACT. Infrastructure, as it impacts transport costs, is crucial in determining equilibrium outcomes in spatial competition; however, infrastructure investment is typically exogenous. Our political economy analysis of infrastructure choice is based upon consumer preferences derived from Salop’s circular city model. In this setting, infrastructure investment has two effects: it directly lowers costs to consumers and indirectly affects market power. We show how political support for infrastructure investments depends crucially on the details of the market. Competition boosts popular support for infrastructure — often excessively so — while collusion leads to underinvestment. The uncertainty produced by infrastructure induced entry leads to traps and thresholds.

Keywords: Spatial Competition, Infrastructure Investment, Salop’s circular city, Voting, Referendum.

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1. INTRODUCTION

One of the original interpretations of transportation costs in the spatial competition framework is as a reflection of transport infrastructure:

“These particular merchants would do well, instead of organising improvement clubs and booster associations to better the roads, to make transportation as difficult as possible.” Hotelling (1929, page 50).

Implicit in this quote is a recognition of the pro-competitive nature of the transport infrastructure in the model. Since the transport costs determine participation, substitutability and hence competition in a market, one can interpret infrastructure quite broadly as physical (e.g. roads and telecommunications) as well as institutional (e.g. trade liberalization, contract enforcement, anti-trust regulation and banking sector reforms).

Although the spatial competition literature shows the impact of infrastructure on individual welfare, it typically treats the level of infrastructure as exogenous. See, for
and Meagher and Zauner (2004) among others. In this paper we develop a political
economy framework which shows how individual voting can be used to determine the
public provision of infrastructure in Salop’s “circular city” spatial market.

In our approach, citizens play a dual role as both consumers and voters/taxpayers;
as a result, their endogenous voting preferences depend intimately on the details of
competitive conditions in the product market. Infrastructure investment has two ef-
fects in the product market: it directly lowers costs to consumers and it indirectly af-
facts market power. These market-based effects of infrastructure investments on con-
sumers are heterogeneous because consumer locations are heterogeneous. The tax-
based effects on citizens are unambiguously negative because taxes must increase in
order to pay for the investment (we preclude the bundling of redistribution policies
with the infrastructure funding).

Voting is analysed through two related political paradigms — (i) pairwise voting
process in a representative democracy, which produces a Condorcet winner when in-
dividuals vote sincerely for their preferred level of infrastructure and (ii) what ap-
ppears to be a new set based approach to represent a referendum in a representative
democracy where individuals vote yes or no for a proposed increase from the status
quo level of infrastructure provision.

Almost by definition, infrastructure improves the performance of individual mar-
kets and hence in aggregate the performance of an economy. Empirical studies are
typically not at the level of the individual consumers and firms considered in our
model; nonetheless, macro empirical estimates indicate the effects of infrastructure
can be large. In a seminal paper, Aschauer (1989) showed that public capital, es-
pecially core infrastructure (roads, utility networks, etc.) had a strong role in de-
termining productivity. Similarly, Fernald (1999) found that the construction of the
interstate road network had a large one off impact on growth. Röller and Waverman
(2001) showed that about one-third of growth in OECD countries over the period
1971–90 can be attributed to telecommunications investment. Czernich et al (2011)
found a 10 percentage point increase in broadband penetration raised annual per
capita growth by 0.9–1.5 percentage points.

These empirical models, though sophisticated in their treatment, are too macro-
scopic to show who benefits from infrastructure and how these individual benefits
result in government investment decisions. In line with the theoretical move to aug-
ment the traditional social planner approach with a more realistic political economy
approach (see, for example, Persson and Tabellini, 2000; Winer and Hettich, 2004),
a recent empirical literature has considered the political dimensions of public infra-
structure expenditure. Papers such as Knight (2004) and Cadot et al (2006) provide
significant evidence that government expenditure on infrastructure is directed by self
interested politicians to please key voters rather than to maximise social welfare. Evidence that policy is distorted to meet the interests of powerful lobby groups is not conclusive for the simple reasons that lobbying is typically hard to observe and the interests of firms are hard to identify.

Analyzing voting over infrastructure, we find that when market structure is exogenous, competition boosts popular support for infrastructure—often excessively so—while collusion often leads to underinvestment. Infrastructure trap—a situation in which no investment in infrastructure is made despite the existence of social welfare enhancing investment—is common under collusion. Traps and thresholds arise under competition when market structure is endogenously determined through entry and exit. It is the uncertainty caused by infrastructure induced entry, that leads to traps and thresholds.

Infrastructure appears in a number of micro economic models. Transportation infrastructure plays an important role in urban economics, predominantly through commute times. Although this large literature also uses spatial techniques, and occasionally political economy, it is most definitely not a branch of oligopoly theory and hence is mute on the competitive aspects of infrastructure which we investigate here.\(^1\) Aghion and Schankerman (2004) consider some aspects of competition; however, rather than analyzing voting, they consider how differential producer interests, based on asymmetric production costs, impact on regulation. Free entry and uncertainty, which are the key to traps and thresholds under competition in our framework, are not considered in Aghion and Schankerman (2004).

Individual uncertainty, in the context of public goods, is considered in Jain and Mukand (2003). The public good is valued directly as an input to a production function, as opposed to our approach which distinguishes infrastructure as a conduit for accessing the market. Individual uncertainty in their two-sector model is a random cost of switching to work in a different sector. Thus uncertainty has nothing to do with the public good. Fernandez and Rodrik (1991) show how individual specific uncertainty can stall reforms and generate status quo bias even if a majority benefit from the reforms ex-post. Key to our infrastructure traps—akin to status quo bias—are the details of market environment which have little role to play in Fernandez and Rodrik (1991) and Jain and Mukand (2003). Status quo bias is also considered in Majumdar and Mukand (2004). Political economy forces also generate this bias in

\(^1\)Felbermayr (2006) introduces transport infrastructure in a multi-country trade setting and shows that infrastructure investments are often suboptimal because the independent governments ignore positive externalities of infrastructure projects on foreign consumers. The effects of multiple jurisdictions on infrastructure are also considered by Ghosh et al (2007) in the context of country integration. To highlight the subtle interaction between the market environment and political economy, we abstract from the multiple jurisdiction issue as it provides a separate rationale for suboptimal investment, even when political economy concerns are absent.
their model, but the driver of inefficient policy choice is a government’s reputation rather than voter heterogeneity.

While spatial models are used extensively in the industrial organization literature, the underlying infrastructure provision, as well as the institutional details determining the provision, are treated as exogenous. On the other hand the public economics literature, despite its richness in tax and voting structures, has typically not analysed spatial markets. By embedding voting over infrastructure in spatial oligopoly models we provide an explicit link between market environment and infrastructure. The link between infrastructure and prices is not only of theoretical interest but is also of practical concern to policy makers:

“The obvious benefit to regional Australia lies in the continuing reduction of the cost of transporting goods ... will increase the scope for competitive pricing ... [and] should eventually result in price reductions at the consumer level.”

In the subsequent sections, in all scenarios, there exist strictly positive investment levels that increase aggregate surplus. This suggests that the results arise for political economy reasons rather than from the existence of fixed costs or increasing returns. Though it is well known in general that political outcomes can differ from the social optimum, to our knowledge, our work is the first to explore how the difference between the two depend on the subtleties of the market environment within a voting setup.

2. A MODEL OF INFRASTRUCTURE INVESTMENT

Following Salop (1979), assume that a unit mass of consumers is uniformly distributed around a circle $C$ of circumference $1$ with density $1$, which can be interpreted either geographically or as a type space. 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 $x_i$. We will make the standard assumption that firms are evenly dispersed around the circle.$^3$

Assume that the $n(>1)$ firms produce a product with marginal cost $m \geq 0$ and fixed cost $K$. Each consumer buys either zero or one unit of the product which yields gross utility of $A$ per unit of consumption. If a consumer living at $y$ purchases from firm $i$ then he incurs a price of $p_i$ and a transport cost or utility loss of $t|y-x_i|^{\beta}$ ($\beta \geq 1$). Consumer $y$’s net utility from consumption of good $i$, denoted by $v_i(y)$ is given by

$$v_i(y) = A - p - t|y-x_i|^{\beta},$$

$^2$This statement by the South Australian Government is taken from the Productivity Commission report (1999).

$^3$Economides (1989) shows that this is the unique symmetric equilibrium in a location-then-price game.
where the distance $|y - x_i|$ is measured around the circumference of the circle. The consumers have a generic outside option, whose utility we normalize to zero and they choose whichever option yields the highest net utility. This implies that a consumer $y$ purchases product $i$ as long as $v_i(y) \geq 0$ and $v_i(y) \geq v_j(y), j \neq i$.

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 freeway system, lead to lower physical transportation costs. More generally we might think of the consumers being located in a characteristic space. Aghion and Schankerman (2004) suggest that the transportation cost parameter in a characteristic space measures the level of competition between firms. As a result, they assert $t$ 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, which we describe below. Starting from an initial $t_0$, an investment of $I \geq 0$ reduces transport cost to $t_0 - I$. An investment of amount $I$ costs $\frac{\gamma I^2}{2}$ and is financed by a lumpsum tax of $g$ per consumer. Since there is a unit mass of consumers, the total tax revenue is $g.1 = g$ as well. We assume that the proceeds from the lumpsum tax cannot be used for redistributive purposes. This implies that in equilibrium $g = \frac{\gamma I^2}{2}$. The tax $g$ or equivalently the level of investment $I$ is determined by political process.

The sequence of events is as follows. Given some status quo $t_0$, the political process determines the level of infrastructure investment $I$ which determines transport cost $t = t_0 - I$. Subsequently, firms set prices, then consumers make their purchasing decisions.

In order to focus on the voting behavior of consumers, we assume that profits, if any, accrue to a measure zero elite. In the absence of shareholding by consumers, surplus of a consumer $y$, denoted by $S(y, I)$, is the indirect utility from consumption less tax, i.e.

$$s(y, I) = \max\{v_1(y), ..., v_n(y), 0\} - \frac{\gamma I^2}{2}. \quad (2.2)$$

2.1. **Aggregate Surplus Measures.** Though the individual surplus measure determines the voting behavior of an individual, the cost-benefit comparison requires

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4The results are qualitatively unchanged if a small fraction of the shares are held by a unit mass of consumers and there is no heterogeneity (across consumers) in shareholding. However, the analysis is cleaner if all the shares belong to a measure zero elite, as we assume to be the case in the main text. The assumption on shareholding accords well with the findings in developing countries where shareholding is extremely skewed. In developed countries many people who hold shares do so through pension funds or unit trusts due to the cost saving of delegated diversification or regulation. One observed consequence of the diffusion of ownership and the ensuing free rider problems is that most individuals do not exercise any effective influence over the management of the firms in which they hold shares.
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 $S(I)$ is simply the sum of consumer surplus for all $y$:

$$S(I) = \int s(y, I) dy.$$  

The second measure, aggregate social surplus, denoted by $W(I)$, is the sum of aggregate consumer surplus $S(I)$ and aggregate profits $\Pi$:

$$W(I) = S(I) + \Pi(I).$$

Note $\Pi(I) \equiv \sum_{i=1}^{n} \pi_i(I)$, where $\pi_i(I)$ denotes firm $i$’s profit for a given investment level $I$.

3. Political Economy

At regional or local levels or even at a country level (especially if the country is small), proposals are often put forward in a popular vote or referendum (see Catt, 1999). For example, in September 2003, the residents of Hampton Roads and Northern Virginia voted on whether to raise sales tax to fund the improvements and extension of existing roads in the area. In September 2002, Mexico City voted on a double deck road plan which promised to relieve the traffic crisis by building elevated freeways over a crosstown artery. Examples of referendum also exist on telecommunication related issues in Slovenia, electricity liberalization in Switzerland, etc. We use referendum in our analysis, not only because some of the decision making or decision approval occur in reality in this fashion, but also because theoretically it provides a useful refinement of the set of proposals in absence of a priori position selection mechanisms.

In the current context, the referendum on infrastructure works as follows. A positive level of income tax $g = \frac{I^2}{2}$ is proposed to finance an 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 favor of a proposed investment level $I_1$ over the alternative $I_2$ if and only if $s(y, I_1) \geq s(y, I_2)$. Let $m(I_1, I_2)$ denote the measure of consumers who vote in favor of the proposal $I_1$ over the alternative investment level $I_2$. We define $R^0$ as the set of investment levels which a majority of voters favour over the status quo $I_2 = 0$, i.e.

$$R^0 = \{I : m(I, 0) \geq \frac{1}{2}\}.$$
In order to understand the extent of distortion in the political outcomes, we consider two benchmarks based on the surplus measures $S(I)$ and $W(I)$ introduced previously.

\begin{align*}
S^0 &= \{ I : S(I) - S(0) \geq 0 \} \\
W^0 &= \{ I : W(I) - W(0) \geq 0 \}
\end{align*}

The set $S^0$ ($W^0$) 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 a Condorcet winner. Excluding abstention, $I^*$ is a Condorcet winner if $m(I^*, I) \geq \frac{1}{2}$ 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

\begin{equation}
I_s = \arg \max_{I \geq 0} S(I)
\end{equation}

and social surplus maximizing investment level

\begin{equation}
I_w = \arg \max_{I \geq 0} W(I).
\end{equation}

Two common features across the models in different sections are that (i) $S(I)$ and $W(I)$ are continuous in $I$ and (ii) $S^0$ and $W^0$ are compact, which guarantee the existence of $I_s$ and $I_w$.

4. Spatial Competition

In this section we assume that the number and locations of firms are fixed, which is appropriate for analyzing situations involving sunk costs, entry barriers or the short run. The spatial competition between firms arising from locational differences links equilibrium prices to the level of infrastructure. As a consequence, when voting, a consumer not only has to consider the effect of infrastructure investment on transport costs but also its effect on prices.

4.1. 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 consumer buys some variety and firms directly compete with their neighbors.\(^5\) We also assume equally spaced firms on the circle, with $1 \leq \beta \leq 6.2$, in order to guarantee the existence of the unique symmetric price equilibrium (see Anderson et al., 1992, pp. 177):

\begin{equation}
p^*(I) = c + \frac{\beta 2^{1-\beta}(t_0 - I)}{n^\beta}.
\end{equation}

\(^5\)If $A$ is low, then each firm becomes a local monopolist. Monopoly power is considered in section 5.
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.

4.2. **Political Economy Results.** Recall the individual surplus measure, $s(y, I)$, introduced in section 2, substituting $p = p^*(I)$ from equation (4.1), for a consumer $y \in C$ we have:

$$s(y, I) = A - p^*(I) - (t_0 - I)|y - x^*_i|^\beta - \frac{\gamma I^2}{2},$$

where $x^*_i$ is the location of the firm nearest to consumer $y$.

Since the $n$ firms are equally spaced around the circle and the equilibrium prices are identical, it suffices to consider a mass of $\frac{1}{2n}$ consumers all located on one side of a representative firm whose location is normalised to 0. A consumer $y \in [0, \frac{1}{2n}]$ votes against the status quo if

$$s(y, I) - s(y, 0) = [p^*(0) - p^*(I)] + Iy^\beta - \frac{\gamma I^2}{2} \geq 0. \tag{4.3}$$

Observe that $s(y, I) - s(y, 0)$ exhibits single crossing in $y$. Thus by an application of Gans and Smart (1996) the voting behavior of the median voter is sufficient to determine the voting behavior of the majority.\(^6\) Noting that $|y| = \frac{1}{4n}$ is the median consumer, the set of investment level that beats the status quo in pairwise voting is given by:

$$R^0 = \left\{ I : s\left(\frac{1}{4n}, I\right) - s\left(\frac{1}{4n}, 0\right) \geq 0 \right\}. \tag{4.4}$$

Solving this inequality for $I$ characterizes the investment levels which will win in a referendum. It also follows from single crossing and Gans and Smart (1996) that the most preferred investment level of the median consumer is the unique Condorcet winner. The results are summarized in the following proposition.

**Proposition 1.** In a circular city model, with $n \geq 2$ firms, voting on infrastructure investment yields the Condorcet winner $I^*$, where

$$I^* = \frac{\beta 2^{1+\beta} + 1}{4^\beta n^\beta \gamma}.$$

The set of investment $R^0$ which dominate the status quo is $R^0 = [0, 2I^*]$.

By inspection $I^*$ is decreasing in $\gamma$ and $n$. $\gamma$ determines the rate at which marginal cost increases, thus quite naturally as the marginal cost of infrastructure increases, the equilibrium choice decreases.

\(^6\)Also see pp 23, Chapter 2 in Persson and Tabellini (2000) for a definition and implication of the single-crossing property.
Increased \( n \), an exogenous increase in the number of firms, lowers the distance travelled by the median consumer which in turn reduces the direct marginal benefit from \( I \). The indirect benefit of increased \( I \), which operates through price reduction, i.e. \( \frac{d(p^*(0) - p^*(I))}{dI} = \beta \frac{I^2}{n} \), is decreasing in \( n \). Hence on both counts, the incentive to invest becomes smaller as the number of firms increases.

Finally, we turn to comparative statics with respect to \( \beta \), the convexity of the transport cost function. The direct marginal benefit of an increase in \( I \) is \((4n)^{-\beta}\), which is decreasing in \( \beta \). This is reinforced by the indirect effect, of price reduction, \( \frac{d(p^*(0) - p^*(I))}{dI} = \frac{2\beta}{(2n)^{\beta}} \) which becomes smaller as \( \beta \) increases. Thus \( I^* \) is decreasing in \( \beta \).

### 4.3. Welfare Results.

Substituting \( s(y, I) \) as given by equation (4.2) into the definitions of \( S \) and \( W \) gives

\[
S(I) = A - p^*(I) - \frac{t_0 - I}{(2n)^{\beta}(1 + \beta)} - \frac{\gamma I^2}{2},
\]

\[
W(I) = A - c - \frac{t_0 - I}{(2n)^{\beta}(1 + \beta)} - \frac{\gamma I^2}{2}.
\]

We begin by determining \( S^0 \) and \( W^0 \), respectively the set of \( I \) that improves aggregate consumer surplus and welfare compared to the status quo. Using equations (4.5) and (4.6) gives the following proposition.

**Proposition 2.** In a circular city model, with \( n \geq 2 \) firms, the investment levels which maximize consumer surplus \( I_s \) and welfare \( I_w \) are

\[
I_s = \frac{2\beta(1 + \beta) + 1}{(2n)^{\beta}(1 + \beta)^2},
\]

\[
I_w = \frac{1}{(2n)^{\beta}(1 + \beta)^2}.
\]

The set of investments which increases consumer surplus, over the status quo, is \( S^0 = [0, 2I_s] \) and the set of investments which increases welfare is \( W^0 = [0, 2I_w] \).

Comparing \( W^0 \) and \( S^0 \) it follows that \( W^0 \subset S^0 \). The reasoning is simple. An increase in investment level increases \( S(I) \) through two channels - reduction in equilibrium prices and reduction in aggregate transport costs. Change in price 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 \( S(I) \) and accordingly any investment level that increases aggregate social surplus increases aggregate consumer surplus as well. In other words, \( W^0 \subset S^0 \). This argument, appropriately modified, applies to marginal changes in \( I \) too. Since marginal increase in \( W(I) \) is less than that of \( S(I) \), and \( W(I) \) and \( S(I) \)
are strictly concave, it follows that $I_w < I_s$. A complete comparison of welfare and equilibrium outcomes is given by the following proposition.\footnote{Qualitatively $I_o$ (or $I_w$) vary with $n$, $\beta$ and $\gamma$ in the same way was as $I^*$ does and the arguments are similar to those presented immediately after Proposition 3.}

**Proposition 3.** In a circular city model, with $n \geq 2$ firms, voting will lead to over investment:

\begin{align*}
(4.9) & \quad I_w < I^* \leq I_s \\
(4.10) & \quad W^0 \subset R^0 \subseteq S^0
\end{align*}

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 increase $S(I)$ but are not favored by the median consumer, and accordingly not supported by the majority. Hence $R^0 \subseteq S^0$. Since the savings are valued similarly in $W^0$ and $S^0$, 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 the ordering of the investment levels in (4.9).

5. **Collusion**

We take a simple approach to collusion in which the number of firms, $n$ is fixed. We derive the single price that firms set in the market, assuming they are able to collude perfectly.\footnote{Implicit in this derivation is an assumption that discount rates are high enough to sustain collusion or there exists some other collusive mechanism. The impact of infrastructure on the functioning of cartels is left for future research.}

Given the underlying symmetric structure of the model, there is a unique collusive price, which is increasing in $I$ (as the following lemma shows).

**Lemma 1.** In a circular city model, with $n \geq 2$ firms and $A \geq c + \frac{t(1+\beta)}{(2n)^{\beta}}$ the unique collusive price is

$$p^c(I) = A - (t_0 - I)(\frac{1}{2n})^\beta.$$ 

This price is just high enough to reduce the utility of a marginal consumer — midway between two firms — to zero. The gross value of the product $A$ is sufficiently high, relative to costs, to make it unattractive for firms to set a price which excludes any consumer from the market.

In collusion, for pivotal consumers, the loss from increased price exactly offsets the gain from transport cost savings. All other consumers are made strictly worse off by
improving infrastructure. This exploitative aspect of infrastructure under collusion leads to the following:

**Proposition 4.** Collusion in the circular city framework causes an infrastructure trap:

\[ R^0 = S^0 = \{0\} \subset W^0 \]  
\[ I^* = I_s = 0 < I_w \]

Comparing Propositions 1 and 4 highlights the importance of market reforms in generating popular support to undertake infrastructure improvements. Even though welfare improving changes exist, in the absence of competition, those changes might not be politically viable. For many years, global institutions such as the World Bank, have pushed for market reforms before providing any aid in terms of infrastructure improvements. Our framework provides an explicit link between the two and suggests that indeed market structure (or more generally market environment) has important bearings on support for infrastructure provision.

### 6. Free Entry


In our analysis so far, the number and locations of firms were assumed to be given. The assumption is appropriate for short run analysis, but, in the long run, firms can change locations and furthermore entry and exit may occur in the industry.\(^9\) To incorporate these features into our framework and to examine the consequent effects on the voting outcome, we consider a free entry version of our model.

On the production side, in addition to constant marginal cost, we also assume positive fixed cost of production \(K > 0\). 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 firms choose simultaneously at each stage and \(n\) 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 and Anderson et al, 1992):

\[ |\bar{x}_i - \bar{x}_{i+1}| = |\bar{x}_i - \bar{x}_{i-1}| = \frac{1}{n} \]  
\[ \bar{p}_i(n) = \bar{p}(n) = c + \beta 2^{1-\beta} (t_0 - I)(\frac{1}{n})^{\beta}. \]

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

\(^9\)Note if fixed costs are sunk on entry, then the short run analysis is the same as the long run analysis because infrastructure investment increases competition which lowers profits.
profits condition \((\bar{p}(n) - c)\frac{1}{n} = K\). This yields

\[(6.3) \quad n^*(I) = \left(\frac{\beta^{2(1-\beta)(t_0 - I)}}{K}\right)^{\frac{1}{1+\beta}}.\]

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 \((n^*(I), \{x^*_i(I)\}_{i=1}^n, p^*(I))\) where \(n^*(I)\) is as in equation (6.3), and \(x^*_i(I)\) and \(p^*(I)\) are \(\bar{x}_i\) and \(\bar{p}_i\) respectively evaluated at \(n = n^*(I)\).

### 6.2. Welfare and Uncertainty

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 \(n^*(0)\), \(\{x^*_i(0)\}_{i=1}^n\) and \(p^*(0)\) respectively. While voting for \(I > 0\), a consumer \(y\) correctly anticipates \(n^*(I)\) and \(p^*(I)\). However, since any equispaced location of \(n^*(I)\) firms constitutes an equilibrium, a consumer computes the expected utility over all possible distances \(|y - x^*_i(I)|\) where \(x^*_i(I)\) denotes the location of the nearest firm. Assuming a uniform prior for equilibrium distance \(|y - x^*_i(I)|\) over the support \([0, \frac{1}{2\pi I}]\), the expected surplus from an investment \(I > 0\) is:

\[(6.4) \quad E[s(y, I)] = A - p^*(I) - (t_0 - I)2n^*(I) \int_{y}^{y+\frac{1}{2\pi n^*(I)}} |y - x_i|^\beta dx_i - \frac{\gamma I^2}{2},\]

\[= A - p^*(I) - \frac{t_0 - I}{(2n^*(I))^{\beta(1+\beta)}} - \frac{\gamma I^2}{2},\]

\[\equiv S(I).\]

We use a constrained optimal approach to welfare in considering free entry—constrained in the sense that we take as given the way in which market forces determine equilibrium prices and the equilibrium number of firms. This seems a natural way to examine in isolation the distortions caused by the political process in determining infrastructure investments.

Since \(s(y, I) = \tilde{S}(I)\) for all \(y\) on the circle \(C\), and there is a unit mass of consumers, it follows that \(S(I) = \tilde{S}(I)\). Moreover, since profits are zero in free-entry equilibrium, the two aggregate surplus measures are equivalent: \(W(I) = S(I) = \tilde{S}(I)\) for all \(I > 0\). This equivalence in turn implies that for all \(\beta \geq 1\),

\[(6.5) \quad W^0 = S^0 \supset \{0\},\]

\[(6.6) \quad I_w = I_s = \text{arg max}_{I \geq 0} \tilde{S}(I) > 0.\]

As in the previous sections, the existence of strictly positive, surplus enhancing \(I\), follows from the observation that infinitesimally small levels of \(I\) have zero cost and \(W(I)\) and \(S(I)\) are continuous in \(I\) for all \(I \geq 0\). However, those surplus enhancing \(I\) are politically viable only if

\[\tilde{S}(I) - s(y_{\text{median}}, 0) > 0,\]
where $y_{\text{median}}$ is the location of the median consumer. To check whether this inequality holds, we first compute $s(y, 0)$ and then identify the median consumer.

Note that if no investment is undertaken and the status quo is preserved it is natural to assume that the firms maintain the initial locations. This yields

\begin{equation}
(6.7) \quad s(y, 0) = A - p^*(0) - t_0|y - x_{i}(0)|^\beta.
\end{equation}

Since $s(y, I) = \bar{S}(I)$ for all $y$ when $I > 0$, and $s(y, 0)$ is decreasing in $y$ it follows that

\begin{equation}
(6.7) \quad s(y, I) - s(y, 0) = \bar{S}(I) - s(y, 0)
\end{equation}

is increasing in $y$. Exploiting this, it can be shown that, $I > 0$ beats the status quo if and only if the median consumer votes against the status quo. The relevant median is the one with respect to initial equilibrium configuration, which means that the median consumer(s) is located at distance $\frac{1}{4n^*(0)}$ from the nearest firm.

6.3. Political Economy Results. Having identified the relevant aspects of the preferences of voters, we now turn to some results. An interesting and somewhat surprising property of the free entry model is the following threshold result.

**Proposition 5 (Referendum Threshold).** For all $\beta > 1$, there exists a threshold $I(\beta) > 0$ such that investments below the threshold cannot beat the status quo in a referendum, i.e. if $I < I(\beta)$ then $I \notin R^0$.

Infinitesimally small levels of investment decrease the transportation costs at each location by an infinitesimal amount. At the same time, they cause firms to shift in the long run so the median consumer now faces the average transportation cost which is higher than the median transportation cost. As $I \to 0$, $p^*(I) \to p^*(0)$ and $n^*(I) \to n^*(0)$, implying that the indirect effects that work through price reduction or entry/exit are negligible. However, the negative effect of increased expected transport costs arising as a result of switching from median to average does not vanish as long as $\beta > 1$. This in turn implies that unless the proposed investment level is higher than a certain threshold, it could not win a referendum. Thus, our referendum can generate an endogenous investment threshold — a feature which typically arises in the presence of fixed costs and/or increasing returns. Also note that this threshold feature is only reflected in $R^0$ and not in $W^0$ or $S^0$ which once again highlights the qualitative differences between socially beneficial and politically viable outcomes.

Proposition 5 shows that $I > 0$ is politically viable only if $I > \bar{I}$. On the other hand, $I$ cannot be too large either, since $\gamma > 0$. Let $\bar{I}(\beta)$ denote the upper bound of politically viable investments. Indeed, if $\gamma$ is suitably large there does not exist any $I$ that satisfies both: $I < \bar{I}$ and $I > \bar{I}$.

**Proposition 6 (Free Entry Infrastructure Trap).** For all $\beta > 1$ there exists a $\bar{\gamma}(\beta)$ such that if $\gamma > \bar{\gamma}(\beta)$ there is an infrastructure trap: $R_0 = \{0\}$ and $I^* = 0$. 
Previously we showed that an infrastructure trap can arise due to collusion/monopoly, but here, the cause is different. The uncertainty regarding the distance ex post — in particular the possibility that distance can increase — renders small changes politically non-viable and if \( \gamma \) is suitably large, the moderate or high level of investment levels are not feasible either, leading to the “trap” or persistence of the status quo.

In the context of trade policy reforms in a competitive general equilibrium model, Fernandez and Rodrik (1991) obtained a bias for the status quo trade policy. Like our trap result, their status quo bias arises from individual specific uncertainty. However, the context as well as the focus of their paper is quite different from ours. For example, market environment has little role to play in their model. Furthermore, the threshold result (Proposition 5), offers a novel insight regarding the set of politically viable outcomes.

A comparison of the welfare optimal results and the political economy results is given in the following proposition for a strictly convex transport cost function.

Proposition 7. In a circular city model with free entry, if the transport cost function is strictly convex (i.e. \( \beta > 1 \)) then there exists \( \tilde{\gamma}(\beta) \) such that

(i) if \( \gamma \leq \tilde{\gamma}(\beta) \) then \( \{0\} \subset R^0 \subset S^0 = W^0 \) and \( I^* = I_s = I_w > 0 \),

(ii) while if \( \gamma > \tilde{\gamma}(\beta) \) then \( R^0 = \{0\} \subset S^0 = W^0 \) and \( I^* = 0 < I_s = I_w \).

The relationships between \( S^0 \) and \( W^0 \), \( I_s \) and \( I_w \) as well as the “trap” for large \( \gamma \) (i.e. part (ii) of Proposition 7) has already been explained in this section. What remains to be explained is the political outcome when \( \gamma \) is small, i.e. \( \gamma \leq \tilde{\gamma} \). Recall that, for \( I > 0 \), each individual’s (and hence the median voter’s) expected consumer surplus is the same as the consumer surplus for the population. This in turn implies that the political outcome from the electoral competition setting (i.e. Condorcet winner) is socially optimal, if there exists \( I \) that wins a referendum. Such \( I \) exists if \( \gamma \leq \tilde{\gamma} \).

Despite the identical point outcomes (i.e. \( I^* = I_s = I_w \)), the set of politically viable investments, \( R_0 \), is strictly smaller than the set of welfare enhancing investments (\( S^0 \) or \( W^0 \)). The median transportation cost is lower than the average transportation costs under \( t = t_0 \) and accordingly the net benefit from a positive investment is valued less by the median consumer. This explains the strict inclusion: \( R_0 \subset B_0 \) — the existence of \( I \) that improves welfare and yet immiserizes the median consumer.

Finally, note that under linear transport costs and uniform distribution of consumers, socially desirable investments are also politically viable and vice versa.

Proposition 8 (Equivalence under Linearity). In a circular city model with free entry, if the transport cost function is linear (i.e. \( \beta = 1 \)) then \( R^0 = S^0 = W^0 \) and \( I^* = I_s = I_w > 0 \).

In this case, the median voter’s transport costs are the same as the average transport costs and hence the median voter behaves in a socially optimal way.
7. Conclusion

Despite the importance of public infrastructure investments, theory, especially with regard to competition, is underdeveloped. We consider a spatial competition model where we interpret the transport cost parameter as an index of infrastructure. By incorporating voting over infrastructure by consumers, we provide an explicit political economy foundation for infrastructure investment. As one might expect, political processes do not necessarily generate socially optimal or efficient outcomes. However, as our analysis shows, the source and magnitude of the inefficiency depend in subtle ways on the characteristics of the market environment.

We analyze a number of aspects of the market environment: market structure (competition versus collusion/monopoly); transport cost curvature (linear versus strictly convex); and entry (short run versus long run). Across the models, competition was infrastructure promoting (excessively so) while collusion and the uncertainty caused by free entry both led to infrastructure traps: choice of zero infrastructure investment in a referendum or election where positive investment is socially optimal.

By focusing on consumers and voting, we have ignored the other side of the story: producers and the political apparatus they employ to protect their profits — lobbying. In the applied literature (e.g. trade policy literature) the presence of lobbying is often captured by considering weighted social surplus as the objective function, with profits being assigned higher weights than aggregate consumer surplus. Our preliminary investigation suggests that inefficiencies and the possibility of an infrastructure trap exist under this setting as well.

Though we covered some distance in the analysis of market environments — competition, collusion and free entry— on the political economy front we have been more selective. Two recent advances, in modelling electoral competition, which we do not consider, are the citizen-candidate framework, à la Besley and Coate (1997) or Osborne and Slivinski (1996) and the party competition approach of Roemer (2001) and Levy (2004). However, we would like to highlight the novelty our analysis offers by considering both point outcomes (e.g. electoral competition) as well as set outcomes (e.g. referendum outcomes). As we have shown, the referendum set can display unique features which cannot be described with point outcomes (e.g. investment thresholds). Also, the comparison between referendum and surplus enhancing sets does not necessarily mirror the results from the electoral competition setting. For example in Proposition 7(i), there is strict equality in the point outcomes, $I^* = I_s$, while the corresponding set outcomes do not exhibit equality, $R^0 \subset S^0$.

By endogenizing the transport cost parameter as a politically determined infrastructure investment, we allow consumers, in their dual role as voters, to partially

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10 See Grossman and Helpman (1994) and Mitra (2001) for a microfoundation of this approach.
determine the environment they face when they make purchasing decisions. This approach, of allowing consumers some role in choosing the “rules of the game”, appears to produce a rich framework without a great deal of additional technical complexity. Our results highlight how market environment and political economy concerns can subtly impact public investment in infrastructure.
Proof of Proposition 1. Substituting equation (4.2) into the winning referendum equation (4.4) gives

\[(7.1) \quad [p^*(0) - p^*(I)] + \frac{I}{4n^\beta} - \frac{\gamma I^2}{2} \geq 0.\]

Substituting the equilibrium prices from equation (4.1) gives

\[(7.2) \quad I \left[ \beta 2^{1-\beta} \left( \frac{1}{n} \right)^\beta + \frac{1}{(4n)^\beta} - \frac{\gamma I}{2} \right] \geq 0.\]

Solving for \( I \) gives the expression for \( I^* \) in Proposition 1. Note the upper bound on \( R^0 \) is indeed positive if, as assumed, \( \beta \geq 1 \). As the discussion preceding the proposition shows the voting outcome is the median voter’s preferred policy, which is given by the following:

\[ I^* = \arg \max_{I \in R^0} \left( s\left( \frac{1}{4n}, I \right) - s\left( \frac{1}{4n}, 0 \right) \right) \]
\[ = \frac{1}{\gamma} \left( \beta 2^{1-\beta} \left( \frac{1}{n} \right)^\beta + \frac{1}{(4n)^\beta} \right) \]
\[ = \frac{\beta 2^{1+\beta} + 1}{(4n)^\beta \gamma}. \]

Since \( I^* \) is the maximum of the same quadratic equation which defines \( R^0 \) by two horizontal intercepts it follows that \( I^* \) is exactly half the upper bound of \( R^0 \) (since quadratic functions are symmetric).

Proof of Proposition 2. By definition \( S^0 := \{ I : I \geq 0, S(I) - S(0) \geq 0 \} \). Using (4.5) it follows that

\[(7.3) \quad S(I) - S(0) = [p(0) - p^*(I)] + I \left( \frac{1}{2n^\beta (1 + \beta)} - \frac{\gamma I}{2} \right) \]
\[(7.4) \quad = I \left( \beta 2^{1-\beta} \left( \frac{1}{n} \right)^\beta + \frac{1}{(2n)^\beta (1 + \beta)} - \frac{\gamma I}{2} \right), \]

which is positive for all \( I \leq \frac{2}{\gamma} \left( \beta 2^{1-\beta} \left( \frac{1}{n} \right)^\beta + \frac{1}{(2n)^\beta (1 + \beta)} \right) \). Hence

\[ S^0 := \{ I : 0 \leq I \leq \frac{2}{\gamma} \left( \beta 2^{1-\beta} \left( \frac{1}{n} \right)^\beta + \frac{1}{(2n)^\beta (1 + \beta)} \right) \} = \{ I : 0 \leq I \leq 2I_s \} \]

where

\[ I_s = \arg \max_{I \in S^0} \left( \frac{1}{\gamma} \left( \beta 2^{1-\beta} \left( \frac{1}{n} \right)^\beta + \frac{1}{(2n)^\beta (1 + \beta)} \right) \right) = \frac{2\beta(1 + \beta) + 1}{(2n)^\beta (1 + \beta) \gamma}. \]

Similarly \( W^0 := \{ I : I \geq 0, W(I) - W(0) \geq 0 \} \). Thus using equation (4.6) we find that

\[ W^0 : = \{ I : 0 \leq I \leq \frac{2}{(2n)^\beta (1 + \beta) \gamma} \} = \{ I : 0 \leq I \leq 2I_w \} \]
where

\[ I_w = \arg \max_{I \in W_0} W^0 = \frac{1}{(2n)^\beta(1 + \beta)\gamma} \]

\[ I^* = \beta^{2\beta + 1} \frac{1}{4^\gamma n^\beta} \geq \frac{1}{(2n)^\beta(1 + \beta)\gamma} = I_w \]

\[ \Leftrightarrow \beta^{2\beta + 1} \frac{1}{4^\gamma} \geq \frac{1}{2^\beta(1 + \beta)} \]

\[ \Leftrightarrow (\beta^{2\beta + 1} + 1)(1 + \beta) > 2^\beta. \]

which holds for all \( \beta \geq 1 \) since \( \beta^{2\beta + 1} + 1 > 2^\beta \).

Proof of Proposition 3. Direct substitution of \( \beta = 1 \) yields \( I^* = 5/(4n\gamma) = I_s \), from which the equality result follows immediately.

From propositions 1 and 2 the upper boundaries of the appropriate sets are simply double the correspond \( I \) value (with lower boundaries all zero). Hence it suffices to establish the ranking of the \( I \)'s. First comparing \( I^* \) and \( I_w \) from propositions 1 and 2:

\[ I^* = \beta^{2\beta + 1} \frac{1}{4^\gamma n^\beta} \leq \frac{2\beta(1 + \beta) + 1}{(2n)^\beta(1 + \beta)\gamma} = I_s \]

\[ \Leftrightarrow 2\beta + \frac{1}{2^\beta} \leq 2\beta + \frac{1}{1 + \beta}. \]

which holds because \( \beta \geq 1 \). ■

Proof of Lemma 1. Suppose \( n \) firms cooperatively set a single price \( p \) to maximize industry profits. The value of \( p \) that solves this maximization problem is the unique collusive price.

As firms have identical costs and are evenly dispersed around the circle \( C \), maximizing industry profits is equivalent to maximizing profit per firm. For a given \( p \) and \( t \), each firm’s output and profit respectively are

\[ q(p, t) = 2 \min\{\frac{A - p}{t}, \frac{1}{2n}\}, \]

\[ \pi(p, t) = (p - c)q(p, t), \]

where \( \min\{\frac{A - p}{t}, \frac{1}{2n}\} = (\frac{A - p}{t})^{\frac{1}{\beta}} \) if market is not completely covered and \( \frac{1}{2n} \) otherwise.

First consider \( p \in [A - \frac{t}{(2n)^\beta}, A] \) for which \( q(p, t) = (\frac{A - p}{t})^{\frac{1}{\beta}} \) and consequently \( \pi(p, t) = (p - c)(\frac{A - p}{t})^{\frac{1}{\beta}} \). We have that

\[ \frac{d\pi(p, t)}{dp} = - \frac{(1 + \beta)(A - p)^{\frac{1}{\beta} - 1}}{\beta t^{\frac{1}{\beta}}} [p - \beta A + c]. \]
We find that \( A \geq c + \frac{t(1+\beta)}{(2n)^\beta} \Rightarrow A - \frac{t}{(2n)^\beta} > \frac{\beta A + c}{1+\beta} \Rightarrow p - \frac{\beta A + c}{1+\beta} > 0 \iff \frac{d\pi(p,t)}{dp} < 0 \) for all \( p \in [A - \frac{t}{(2n)^\beta}, A] \). This implies \( p = A - \frac{t}{(2n)^\beta} \) maximizes \( \pi(p,t) \) in the interval \( p \in [A - \frac{t}{(2n)^\beta}, A] \). Now consider \( p \leq A - \frac{t}{(2n)^\beta} \) for which \( q(p,t) = \frac{1}{7t} \). As \( q(p,t) \) is not affected by \( p \), \( \pi(p,t) \) is maximized at the highest possible price that satisfy \( p \leq A - \frac{t}{(2n)^\beta} \) which is \( p = A - \frac{t}{(2n)^\beta} \). Thus at any given \( t \), \( p = A - \frac{t}{(2n)^\beta} \) maximizes \( \pi(p,t) \) which immediately implies that for all \( I \geq 0 \), \( A - \frac{t_0 - I}{(2n)^\beta} \equiv p^c(I) \) is the unique collusive price. 

**Proof of Proposition 4.** Substituting the collusive price \( p^c \) into the change in individual surplus from equation (4.3) gives

\[
-\frac{t_0}{2} \left( \frac{1}{2n_0} \right)^{\beta} + Iy^{\beta} - \gamma I_0^{2}.
\]

Now on the circle with \( n \) fixed we \( y \in [0, \frac{1}{2n}] \) thus \( y^{\beta} \leq \left( \frac{1}{2n} \right)^{\beta} \) for all \( y \) since \( \beta \geq 1 \). Thus the surplus change for any consumer from an increase in infrastructure under collusion is non-positive and strictly negative for all but the most distant consumer. Therefore all consumers are hurt by infrastructure improvements and hence \( R^0 = S^0 = \{0\} \) and \( I^* = I_n = 0 \). Notice the collusive price is just sufficient to ensure that the most distant (lowest surplus from consumption) consumers still purchase. Thus under collusion all consumers still purchase and hence the effects of infrastructure improvements on social welfare are the same as under competition just with a different distribution of benefits. Thus, as in proposition 2, \( W^0 \neq \{0\} \) and \( I_w > 0 \). 

**Proof of Proposition 5.** Evaluating the median consumer's change in net surplus from arbitrarily small levels of investment yields,

\[
\lim_{I \to 0} (\bar{S}(I) - s(x^*_i + \frac{1}{4n^*(0)}, 0)) = (\bar{S}(0) - s(x^*_i + \frac{1}{4n^*(0)}, 0)) = -\frac{t_0}{(2n^*(0))^{\beta}(1+\beta)}(2^\beta - 1 - \beta) < 0,
\]

where the strict inequality follows from noting that \( 2^\beta - 1 - \beta > 0 \) for all \( \beta > 1 \). Thus for a given \( \beta > 1 \), there exists \( I(\beta) \) such that no \( I < I(\beta) \) beats status quo. 

**Proof of Proposition 6.** Consider \( I > 0 \). \( I \in R^0 \) requires

\[
s(y_{\text{median}}, I) - s(y_{\text{median}}, 0) = \bar{S}(I) - s(y_{\text{median}}, 0) \geq 0.
\]

where \( \bar{S}(I) \) is the expected consumer surplus for median consumer (and in fact all consumers). For a given \( \beta > 1 \), let \( I_{\text{max}}(\beta) \) denote the value of \( I \) that maximizes \( \bar{S}(I) \). Given the quadratic specification of cost of investment, i.e., \( \frac{t^2}{2} \), it is easy to show that (i) \( I_{\text{max}}(\beta) > 0 \) and (ii) \( \lim_{\gamma \to \infty} I_{\text{max}}(\beta) = 0 \). The latter one, i.e. (ii), imply that for any given \( \beta > 1 \), there exists \( \gamma(\beta) \) large enough such that \( I_{\text{max}}(\beta) < I(\beta) \). 

\[
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\]
whenever $\gamma > \gamma(\beta)$. Then the result follows from noting that no $I < I(\beta)$ beats status quo (Proposition 5).

**Proof of Proposition 7.** Summing $s(y, 0)$, as given in equation (6.7) over $y$ yields

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

Similarly

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

Since $n^*(I)$ and $p^*(I)$ are continuous in $I$ for all $I \geq 0$, $\lim_{I \rightarrow 0} S(I) - S(0) = 0$. Furthermore, $\frac{dS(I)}{dI} |_{I=0} = \frac{1}{2n^*(0))^{\beta}(1 + \beta)} > 0$. 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

(7.12) \hspace{1cm} W^0 = S^0 \supset \{0\},

(7.13) \hspace{1cm} I_w = I_s = \arg \max_{I \geq 0} S^0 = \arg \max_{I \geq 0} \bar{S}(I) > 0

Although expected utility from a positive level of investment is $\bar{S}(I)$ for all consumers the expected change in utility varies according to the initial transportation cost of each consumer. Since transport costs are convex, the transportation costs incurred by the median consumer is lower than the average transportation costs in the status quo. Consequently, the average expected surplus is less than the surplus for median consumers:

$$S(0) \leq s(x^*_y + \frac{1}{4n^*(0)}, 0).$$

Since $S(I) = \bar{S}(I)$, we have that $S(I) - S(0) \geq \bar{S}(I) - s(x^*_y + \frac{1}{4n^*(0)}, 0)$ which in turn implies that $S^0 \supset R^0$, where equality only holds for $\beta = 1$.

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

**Proof of Proposition 8.** If transport costs are linear in distance, $\beta = 1$, then the expected transport costs overall locations are the same as transport costs for the median voter (in the uniform case the median voter is also the mean voter). Thus, in the linear case the median voters preferences are the same as the social planners and hence the outcomes of the political process are equivalent to the appropriate welfare optimal outcomes.
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SCHOOL OF ECONOMICS, UNIVERSITY OF NEW SOUTH WALES, SYDNEY, NSW 2052, AUSTRALIA.

Fax:+61-2-9313 6337

E-mail address: a.ghosh@unsw.edu.au

RESEARCH SCHOOL OF ECONOMICS, AUSTRALIAN NATIONAL UNIVERSITY.

E-mail address: kieron.meagher@anu.edu.au