Essays on Impact Fees and Community Welfare

by

Adam T. Jones

(Under the direction of Arthur A. Snow)

Abstract

Although in recent years many jurisdictions have begun using impact fees to finance infrastructure costs associated with commercial development, few studies have examined how fee-financing compares to other forms of financing. My analysis finds impact-fee financing to be both efficient and welfare enhancing. Using a circular city model, I find that the fees act as a Pigouvian tax that is welfare enhancing for a single jurisdiction as well as for its neighbors. While still welfare enhancing, differing policies between jurisdictions is not efficient and leads to divergence from each jurisdiction's efficient market size. Heterogeneity, restricted household mobility, and costly voting could explain the sporadic pattern of impact fee use observed at the jurisdiction level. This leads me to conclude that regional implementation of impact fees is preferred to individual community policies, a finding consistent with the inefficiency of tax competition.

Many jurisdictions are also considering other alternative forms of revenue such as gas taxes and sales taxes. Modeling these taxes in the circular city model shows them to be less efficient than using impact fees to fund infrastructure required to support commercial development. The main reason gas taxes and sales taxes are less efficient than impact fees is that they do not force firms to consider social costs when making market-entry decisions.

Furthermore, existing research on impact fees assumes that fee revenues are spent on additional infrastructure but this may not be the case. Empirically, there are differences

in the revenue elasticity of expenditure across categories of expenditure type. Fee revenues earmarked for capital expenditures that require large operating costs are more likely to crowd out other revenues than fee revenues in categories that do not require as much future expense.

INDEX WORDS: impact fees, circular city, salop, infrastructure, public finance, gas tax, sales tax

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Adam T. Jones

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Adam T. Jones

Approved:

Major Professor: Arthur A. Snow

Committee: John L. Turner
                    Jeffrey H. Dorfman

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
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To Nancy, my wife and partner, without your love, support and patience, none of this would have been possible.

To my parents for their patience and support over many years and Mary, Bob, and Sarah.

To my brothers and their peer pressure to excel in everything.

To the Lindners, Johns, and Jims – thanks for the support.

TABLE OF CONTENTS

APPENDIX

CHAPTER 1

INTRODUCTION

Impact fees are growing in popularity; most large metropolitan areas use some kind of fee, and over half the states have adopted fee-enabling legislation. See Table B.1. Conceptually, impact fees are large, building-permit fees whose revenue is earmarked to pay for infrastructure serving the permitted development. In most states, per state law, fees can be used for the construction of infrastructure but not for operating expenses; nor can the fees be larger than the amount required to maintain current levels of service. In other words, the fees cannot be used to build infrastructure that is "better" than what currently exists or to fix existing deficiencies.

Most of the existing literature suggests fees are a mechanism for cost shifting from households to developers and do not give sufficient consideration to the fees as a Pigouvian tax. Commercial development requires investment in infrastructure to maintain existing per-capita levels of service. When all households in a jurisdiction are taxed to finance these investments, some pay for commercial development from which they do not benefit. Impact fees paid by developers are passed forward to their customers or backward to sellers of land ensuring that those who use the commercial development pay for the infrastructure required to maintain service levels.

The research presented in this dissertation finds a system of fees to be welfare enhancing in models with either single or multiple jurisdictions when compared to property, gas, or sales taxes. Furthermore, if only one jurisdiction uses impact fees, equilibrium welfare in neighboring jurisdictions–which serve as substitutes for the jurisdiction using fees–is increased, but welfare is greatest if all jurisdictions use a fee system.

1

Property tax revenues in rapidly growing jurisdictions are not large enough to fund infrastructure projects, causing local governments to turn to new and creative revenue sources. A Congressional Budget Office study reports that state and local transportation spending grew, in real terms, from less than $100 billion to more than $200 billion–constant 2006 dollars–over the last 50 years, "From 1987 onward, infrastructure spending by the federal government and by states and localities has grown in real terms by 1.7% and 2.1% percent [per year], respectively," (Musick 2007, 2). Traditionally, bond financing is used in jurisdictions with low or steady growth rates; faster growing jurisdictions often have infrastructure needs that outstrip their bond-financing capacity. Further exacerbating the problem, existing residents often blame development for increased congestion while ignoring the role that their own increased intensity of use plays in the problem. Because existing residents blame new residents for congestion, they resist the tax increases necessary to fund new infrastructure. This situation has left local officials searching for new sources of revenue. One such source is development impact fees.

Fee systems are designed to charge developers for the infrastructure required to maintain the current levels of service in the community and are the result of an evolutionary process. In-kind donations of property or infrastructure in return for development approval from the permitting authority–or "exactions"–were initially used to offset infrastructure requirements. Because residents thought the community was often out-negotiated, exactions became a political liability and fell out of favor with local officials. Developers' dislike of the costly and uncertain nature of the exaction process accelerated their decline. Over time, a general fee structure evolved with each jurisdiction setting its fees and structures based on specific infrastructure plans (Altshuler, Gomez-Ibanez & Howitt 1993). Nelson (1988) found that the resulting administrative costs of an impact fee system are a quarter of those associated with negotiated exactions.

Impact fees are often described in economic literature as a Pigouvian tax correcting negative externalities imposed on existing residents by new development in the form of congestion

and service degradation. However, the fees' inexact and political nature make them far from perfect. A Pigouvian tax is a tax that forces a firm or individual to internalize externalities and yields an optimal outcome. Unfortunately, impact fees are a crude approximation and do not include all externalities. For this reason, welfare improves when using fees but does not obtain the optimal outcome.

Congestion of government-provided services, many of the negative externalities caused by new development, would not occur if a market system was used to provide these services. Fees are often charged to pay for infrastructure associated with water and sewer, roads, parks and recreation, jails, police and fire, and in some cases education. The fee amount for each land-use type is determined through a political process of forecasting the cost of necessary infrastructure improvements, assigning cost shares to each land use, calculating the "maximum" fee amount, and then reducing the amount by some percentage to reach a politically acceptable fee (Nicholas, Nelson & Juergensmeyer 1991). Fees for a single family residence vary from $1,500 in Texas to over $19,000 in California (Mullen 2008).

Various court decisions have established broad guidelines for how jurisdictions should design a fee system, but have opened the door for developers to challenge each jurisdiction's ordinance. The courts have upheld an ambiguous requirement of a "rational nexus," which forces the jurisdiction to show a reasonable connection between development and the externality, and have prohibited jurisdictions from charging developers more than their proportional share of the costs (Nicholas et al. 1991). Many states have tried to reduce the ambiguity by passing impact fee "enabling" legislation. This legislation generally requires jurisdictions to establish levels of service for service delivery regions (often an entire jurisdiction), the cost of infrastructure necessary to provide service at that level, and the share of the cost for each land use type.

Much of the empirical literature focuses on the incidence of impact fees and their effect on housing prices, (Huffman, Nelson, Smith & Stegman 1988, Yinger 1998, Singell & Lillydahl 1990, Ihlanfeldt & Shaughnessy 2004, Evans-Cowley, Forgey & Rutherford 2005), and con-

struction patterns (Brueckner 1997, Anderson 2004, Burge & Ihlanfeldt 2006b, Burge & Ihlanfeldt 2006a). Additional empirical work examines the fees' effects on employment levels and growth (Nelson & Moody 2003, Burge & Ihlanfeldt n.d.). These studies take for granted that new infrastructure and future tax savings are the transmission mechanisms between fees and changes in both property values and employment. The question of whether fee revenues are actually spent on infrastructure or if they crowd out expenditures funded with other revenues has yet to be answered. Only Clarke & Evans (1999) examined the relationship between impact fees and infrastructure spending. They found that jurisdictions with fees spend less on infrastructure than those without. One suggestion given by the authors is that fiscally constrained communities turn to impact fees as an additional source of revenue. The empirical chapter of this dissertation finds that while fees are earmarked for capital expenditure the amount of additional capital actually constructed depends on the amount of future operation expenditures required to operate the infrastructure. Expenditure categories with high operating costs have smaller responses to earmarked revenues than those with small operating costs.

Though few researchers offer rigorous theoretical examination of impact fees, two studies that stand out as particularly relevant are: Brueckner's (1997) work finding impact fees to be an efficient way of paying for residential infrastructure and Anderson's (2004) model of development timing. Brueckner uses a linear city model with an employment center at one end to compare impact-fee financing of incremental infrastructure with two cost-sharing approaches. His model does not incorporate a spatial distribution of firms. Comparing impact fees, a current resident cost-sharing regime, and a perpetual cost-sharing regime, Brueckner finds impact fees to be the efficient financing system for residential development. This dissertation complements Brueckner's work by examining the efficiency of impact fees for commercial development using a circular city model. The basic model used in my analysis assumes even distribution of firms throughout a jurisdiction and compares fees to the traditional property, sales, and gas taxes for financing the firms' required infrastructure. Anderson's work builds

on Turnbull (2005) and is concerned with the timing and density of development. Whereas Turnbull used a relatively simple model of development timing to examine different land use restrictions including impact fees, Anderson extended the model to include externalities such as congestion and the loss of open space. My analysis contributes to this literature by taking an externality approach to investigating the use of fees to pay for infrastructure required by commercial development.

The Efficiency of Impact Fee Financing for Commercial Infrastructure
Requirements [1]

2.1 Introduction

Impact fees are growing in popularity; most large metropolitan areas use some kind of fee, and over half the states have adopted fee-enabling legislation. See Table B.1. Conceptually, impact fees are large, building-permit fees whose revenue is earmarked to pay for infrastructure serving the permitted development. In most states, per state law, fees can be used for the construction of infrastructure but not for operating expenses; nor can the fees be larger than the amount required to maintain current levels of service. In other words, the fees cannot be used to build infrastructure that is "better" than what currently exists or to fix existing deficiencies.

Most of the existing literature suggests fees are a mechanism for cost shifting from households to developers and do not give sufficient consideration to the fees as a Pigouvian tax. We identify an externality that is internalized by the use of impact fees. Commercial development requires investment in infrastructure to maintain existing levels of service. When all households in a jurisdiction are taxed to finance these investments, some pay for commercial development from which they do not benefit. Impact fees paid by developers are passed forward to their customers ensuring that those who benefit from the commercial development pay for the infrastructure required to maintain service levels.

We find a system of fees to be welfare enhancing in models with either single or multiple jurisdictions. Furthermore, we find that if only one jurisdiction uses impact fees, equilibrium welfare in neighboring jurisdictions–which serve as substitutes for the jurisdiction using fees– is increased, but welfare is greatest if all jurisdictions use a fee system. After some background and a brief survey of the literature we use a circular city model to examine the effects of a fee system on welfare and jurisdiction size. We then expand our analysis using a median voter model that includes two potential frictions–a degree of household immobility and costly voting–to explain the sporadic pattern of impact fee usage.

2.2 BACKGROUND

Property tax revenues in rapidly growing jurisdictions are not large enough to fund infrastructure projects, causing local governments to turn to new and creative revenue sources. A Congressional Budget Office study reports that state and local transportation spending grew, in real terms, from less than $100 billion to more than $200 billion–constant 2006 dollars–over the last 50 years, "From 1987 onward, infrastructure spending by the federal government and by states and localities has grown in real terms by 1.7% and 2.1% percent [per year], respectively," (Musick 2007, 2). Traditionally, bond financing is used in jurisdictions with low or steady growth rates; faster growing jurisdictions often have infrastructure needs that outstrip their bond-financing capacity. Further exacerbating the problem, existing residents often blame development for increased congestion while ignoring the role that their own increased intensity of use plays in the problem. Because existing residents blame new residents for congestion, they resist the tax increases necessary to fund new infrastructure. This situation has left local officials searching for new sources of revenue. One such source is development impact fees.

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extended the model to include externalities such as congestion and the loss of open space. Our analysis contributes to this literature by taking an externality approach to investigating the use of fees to pay for infrastructure required by commercial development.

2.3   THE BASIC MODEL: ONE HOMOGENEOUS JURISDICTION

To model the effect of impact fees on household welfare, we adopt Salop's (1979) circular city model and assume a mass of households, M, located uniformly around a circle of unit circumference. We shall refer to M as the size of the market.[2] We assume all travel takes place around the circumference of the circle and that transport costs are proportional to the distance traveled and the size of the market. Because this model is based on the consumers traveling to the firm from which they purchase, it is a natural assumption that transport costs per unit of distance increase with density.[3] We assume that each firm requires a standard amount of publicly provided infrastructure.

To examine the effect of a jurisdiction using an impact-fee system instead of a property-tax system to finance infrastructure costs, we model *impact fees* as infrastructure costs paid by the firms and *taxes* as infrastructure costs related to firms' entry decisions that are paid directly by households. The default mechanism of service degradation (if no additional infrastructure is built) is analogous to taxes because households pay the cost in terms of increased congestion. For simplicity we assume household and firm infrastructure requirements are separable and consider only the infrastructure required by firms.

To further simplify the analysis, we assume that total infrastructure costs are proportional to the size of the market and the number of firms, n. We use s to denote infrastructure cost

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[2]Alternatively, we could think about a mass of households, M, distributed around a circle of circumference M but the results would be qualitatively the same. If the circumference of the circle changes by the same amount as the population then density is constant and transport costs per unit of distance are constant instead of increasing in density.

[3]This observation is starting to be reflected in the *new economic geography* literature (Behrens & Gaigne 2006).

per firm, per household.[4] In other words, for each firm in a jurisdiction, a household pays s under a tax system toward the cost of the infrastructure required for the firm. Thus, each household is charged ns under tax financing. Under impact fee financing, each firm is charged Ms. In Lancaster (1966) fashion, firms are located at equidistant points around the circle, imposing maximum spatial differentiation and the distance between firms is $1/n$. Households consider all firms to be identical and each utility-maximizing household purchases one unit of the good at the lowest total cost, including transport cost. Thus, a household located a distance x from firm i charging price p_i, and a distance $(1/n - x)$ from a firm charging price p, is indifferent to purchasing from either firm if:

$$p_i + Mx = p + M(1/n - x), \tag{2.1}$$

where M times distance is the transport cost.[5] Equivalently, a household is indifferent when

$$x = (p + M/n - p_i)/(2M). \tag{2.2}$$

Because a firm attracts customers from both the clockwise and counterclockwise directions around the circle, firm i faces a demand of

$$2 \int_0^{\frac{p + \frac{M}{n} - p_i}{2M}} M dx = p + \frac{M}{n} - p_i. \tag{2.3}$$

We first determine the equilibrium when tax financing is used to cover infrastructure costs. A firm i chooses its price p_i to maximize profit given by

$$(p_i - c)(p + \frac{M}{n} - p_i) - F, \tag{2.4}$$

where c is the cost of producing one unit of the good and F is a fixed cost, so p_i satisfies the first-order condition

$$\left(p + \frac{M}{n} - p_i\right) - (p_i - c) = 0. \tag{2.5}$$

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[4]We make the assumption that s is the same under impact fees and taxes. If under one financing system there are fewer firms, each firm serves more households. The per-firm infrastructure requirement is increased but split among a larger number of households, so s remains constant.

[5]The transport cost could be multiplied by an additional term to consider per-unit-distance costs. However, because this term cancels out in the analysis, we have omitted it for simplicity.

Assuming free entry of firms, aside from fixed cost F, identical firms all charge the same price, $p_i = p$. Thus,

$$p = \frac{M}{n} + c. \tag{2.6}$$

Free entry also implies that firms earn zero profit in equilibrium. Using a superscript t to denote the equilibrium price and number of firms in the tax-financing regime, the zero-profit condition requires

$$(p^t - c)(M/n^t) - F = 0. \tag{2.7}$$

Combining (2.6) and (2.7) we can solve for the equilibrium number of firms[6],

$$n^t = \left(\frac{M^2}{F}\right)^{1/2} = MF^{-1/2}. \tag{2.8}$$

Using the number of firms under a tax-financing regime, (equation 2.8), and the equation for price (2.6), we get the per-unit price under a tax-financing system,

$$p^t = F^{1/2} + c. \tag{2.9}$$

Using B to denote the benefit from consuming the good, welfare for a household that travels a distance x under the tax-financing regime is given by

$$W^t(x) = B - (p^t + Mx + n^t s): \tag{2.10}$$

the per-unit benefit, B, minus the total cost of acquiring the good, $p^t + Mx$, and taxes paid to cover infrastructure costs, $n^t s$. We can now use the number of firms, (equation 2.8), and the equation for price (2.9), and the household's welfare function, (equation 2.10) to evaluate the household's welfare under tax financing,

$$W^t(x) = B - [F^{1/2} + c + Mx + MF^{-1/2}s]. \tag{2.11}$$

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[6]Matsumura (2000) showed that we can ignore the integer problem with constant marginal cost of production, in our model c, and n$\geq$ 3. Because we are considering commercial development, it is not unlikely for a jurisdiction to have more than three firms competing with each other. However, care should be used when considering policies that may affect speciality retailers where n could be less than three.

Under a tax-financing system, there is a fiscal externality associated with the funding of infrastructure costs occasioned by the entry of a particular firm; part of the burden of these costs is borne by households that do not purchase from the firm. One example might be a fast food restaurant located on the opposite side of town from a particular household. Under a system of tax financing, that household pays for part of the restaurant's required infrastructure even if the household's occupants never eat there. Under an impact-fee system that assigns the infrastructure costs to firms, only households that purchase a firm's product pay–through a higher price than under taxes–for the infrastructure associated with that firm, thereby internalizing the externality.

To determine the equilibrium under an impact-fee-financing regime, observe first that the fee is an additional fixed cost. Hence, the first order condition (equation 2.5) for the profit-maximizing price remains the same. Using superscript f to denote values for the impact-fee regime, the zero-profit condition, including the firm's infrastructure cost, Ms, is now

$$(p^f - c)(M/n^f) - (F + Ms) = 0.[7] \tag{2.12}$$

Solving in a similar manner as above for p^f and n^f, we find that the equilibrium number of firms is

$$n^f = \left(\frac{M^2}{F + Ms}\right)^{1/2} = M(F + Ms)^{-1/2}, \tag{2.13}$$

and the equilibrium price is

$$p^f = (F + Ms)^{1/2} + c.[8] \tag{2.14}$$

Using a system of fees, households are not taxed to cover infrastructure costs. Thus, dropping the infrastructure costs, ns, from equation (2.10), we find the welfare of a household that travels a distance x to reach the nearest firm is given by

$$W^f(x) = B - [(F + Ms)^{1/2} + c + Mx]. \tag{2.15}$$

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[7] $s \int_0^1 M \, dx = sMx|_0^1 = Ms$. Multiplying each household's share of a firm's infrastructure costs by the number of households gives the infrastructure cost per firm: Ms.

[8] A complete derivation is included in the appendix.

From equations (2.9) and (2.14) we see that the price is higher under impact-fee financing than under tax financing, and from equations (2.8) and (2.13) we see that there are fewer firms. It follows that consumers pay more and, on average, travel farther under the impact fee regime, but do not have to pay a tax to finance infrastructure. As a consequence, some households are better off and some are worse off with impact fee instead of tax financing. Nonetheless, we can show that an average household is better off under an impact-fee regime. To establish this result we aggregate the utilities of all households using a utilitarian social welfare function and divide by the market size to obtain the welfare of an average household.

Proposition 1. *For a single homogeneous jurisdiction of fixed market size, average household welfare is higher with impact-fee financing than with tax financing.*

Proof: Observe first that, with all firms charging the same price, equation (2.2) for the distance traveled by households that are indifferent between two firms is $x = 1/2n$. Hence the distances traveled by households lie uniformly on the interval $[0, 1/2n]$. As there are indifferent households located on both sides of a firm, we know that for each firm there are $2n$ households traveling each distance $x \in [0, 1/2n]$. Hence aggregate welfare is given by

$$2Mn \int_0^{1/2n} U(x)dx, \tag{2.16}$$

so that average household welfare is

$$W = 2n \int_0^{1/2n} U(x)dx.^9 \tag{2.17}$$

Thus for the tax financing regime we have

$$W^t = B - \left[\frac{5}{4}F^{1/2} + c + MF^{-1/2}s \right], \tag{2.18}$$

and for the impact-fee regime we have

$$W^f = B - \left[\frac{5}{4}(F + Ms)^{1/2} + c \right]. \tag{2.19}$$

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[9]Because households only vary by distance traveled, this is the equivalent of finding the average distance traveled $x = 2n \int_0^{1/2n} xdx$ and substituting into the welfare equation.

Subtracting equation 2.18 for W^t from equation 2.19 for W^f and simplifying we obtain

$$W^f - W^t = \frac{5}{4}F^{1/2} - \frac{5}{4}(F + Ms)^{1/2} + MsF^{-1/2}$$
$$= F^{-1/2}[\frac{5}{4}F + Ms - \frac{5}{4}(F^2 + FMs)^{1/2}].$$

To see that the final expression is positive, observe that the term in brackets is positive since $[(5/4)F + Ms]^2 > (5/4)^2(F^2 + FMs)$. Therefore, $W^f > W^t$. $\square$

By examining the infrastructure cost paid–directly or indirectly–by each household, we can see that the increase in price and transport costs under fees is less than infrastructure costs paid directly through taxes:

$$p^f - p^t + \frac{1}{2}\left[M\frac{1}{2}\left(\frac{1}{n^f} - \frac{1}{n^t}\right)\right] = \frac{5}{4}[(F + Ms)^{1/2} - F^{1/2}] < MF^{-1/2}s.$$

The average household's increase in welfare is being driven by a reduction in the total fixed and infrastructure costs for the jurisdiction and is only partially offset by increased price and transport costs. The increase in social welfare is evident when we compare the competitive equilibrium under each financing regime to the optimal choice of a social planner whose objective is to choose the number of firms, n^*, to minimize total social costs

$$n^*F + n^*Ms + 2Mn^*\int_0^{1/2n^*} x \, dx, \tag{2.20}$$

which is the sum of firms' fixed costs plus total infrastructure costs, n^*Ms, plus transport costs. Therefore $n^* = (1/2)\sqrt{(M/(F + Ms))} < n^f < n^t$. The inclusion of a firm's infrastructure costs–through the use of fees–in the zero-profit condition improves social welfare by internalizing the firm's fiscal externality, reducing the number of firms, and moving in the direction of the social planner's optimal outcome. However, while the result is a potential Pareto improvement, it is still second best.[10]

Further, we can see from equations 2.8 and 2.13 that the number of firms is lower when a jurisdiction uses fees, $n^f - n^t < 0$.[11] This result is consistent with previous empirical literature

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[10]See appendix for proof of potential Pareto improvement.

[11]The reduction in the number of firms and an increase in welfare is consistent with Salop (1979) and the excess entry theorem. Further, Mankiw & Whinston (1986) draw attention to the two

finding that impact fees on firms reduce employment (Burge & Ihlanfeldt n.d.). Total demand and output are held constant in our single jurisdiction model. Because firms are subject to increasing returns to scale, employment decreases as the number of firms decreases.

2.4   Two Homogeneous Jurisdictions

Up to this point we have held market size constant but the model becomes much richer if we allow market size to vary. As market size increases, the jurisdiction becomes more congested, transport costs increase, and welfare falls. From equations 2.11 and 2.15 for W^t and W^f, we find that welfare under both financing regimes is negatively related to market size:

$$\frac{\partial W^t(x)}{\partial M} = -[sF^{-1/2} + x] < 0 \tag{2.21}$$

and

$$\frac{\partial W^f(x)}{\partial M} = -\left[\frac{3}{4}(F + Ms)^{-1/2}s + x\right] < 0. \tag{2.22}$$

Now assume there are two neighboring jurisdictions, A and B, with identical financing regimes and initial market sizes such that $M_A + M_B = 2M$. Because households in each jurisdiction have the same welfare function which is declining in market size, perfect mobility implies that if jurisdictions have the same infrastructure financing regime, they must be the same size in equilibrium, $M_A = M_B = M$. However, if only jurisdiction B uses impact fees, market sizes denoted $\tilde{M}_A$ and $\tilde{M}_B$ will not be equal and instead will be $\tilde{M}_B > M > \tilde{M}_A$. The intuition is clear. If B were to use an impact fee system we know from *Proposition 1* that–holding market size constant–average welfare in B would be higher than average welfare in A. But assuming free mobility, households would move from A to B reducing average welfare in B as implied by equation 2.22, while at the same time increasing average welfare in A as

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different effects of firm entry: business stealing and variety. Because our model only has a constant benefit B, there is a business stealing effect. The decrease in distance to the firm and subsequent transport costs could be considered analogous to increased variety. To the extent that the extra fixed costs of an additional firm outweigh the reduction in transport costs, households are worse off. To continue the analogy, the business stealing effect outweighs the variety effect.

implied by equation 2.21. In equilibrium, there is no incentive to move and average welfare is the same in both jurisdictions: $\tilde{W}_A^t = \tilde{W}_B^f$.

Proposition 2. *If households are perfectly mobile and one of two jurisdictions uses an impact-fee-financing system and the other does not, then the market size of the fee-charging jurisdiction is more than half the total population and the market size of the neighboring jurisdiction is less than half.*

Proof: In equilibrium, with perfect mobility, average welfare must be the same in both jurisdictions, requiring $\tilde{W}_A^t = \tilde{W}_B^f$. Using equations 2.18 and 2.19 this equality implies

$$\frac{5}{4}F + \tilde{M}_A s = \frac{5}{4}(F^2 + \tilde{M}_B)^{1/2}.$$

We know that the left-hand side of this equation would exceed the right-hand side if $\tilde{M}_A$ were equal to $\tilde{M}_B$. Since the left-hand side decreases as $\tilde{M}_A$ declines, while the right-hand side increases as $\tilde{M}_B$ rises, it must be true that $\tilde{M}_B > M > \tilde{M}_A$. $\square$

To put it succinctly, differing policies lead to differing market sizes in equilibrium. This result is intuitive in the context of this model and empirical verification may be of interest.[12]

Proposition 3. *If households are perfectly mobile and one of two jurisdictions uses impact fees and the other does not, then average welfare in both jurisdictions is higher than it would be if both used tax financing, but average welfare in the fee-charging jurisdiction is lower than it would be if the jurisdiction were in isolation.*

Proof: This result follows from *Proposition 2* and equations 2.21 and 2.22 for $\partial W^f / \partial M$ and $\partial W^t / \partial M$. Suppose B uses fees and A does not. At equilibrium, average household welfare in both jurisdictions must be equal, $\tilde{W}_A^t = \tilde{W}_B^f$. We know from *Proposition 2* that $\tilde{M}_B > M > \tilde{M}_A$. It follows from equation 2.21 that average welfare in both jurisdictions is higher than when both use tax financing since $\tilde{M}_A < M$. Comparing average welfare in B–with market size M and average household welfare W_B^f–to average welfare after the

---

[12]Because the model does not allow for inter-jurisdictional commuting and shopping, verifying the above proposition empirically could be difficult.

market size expands to $\tilde{M}_B$–yielding average welfare $\tilde{W}_B^f$–it is clear from equation 2.22 that $W_B^f > \tilde{W}_B^f. \;\square$

The increase in size of the fee-charging jurisdiction leads to welfare being less than if it used fees as an isolated jurisdiction with constant size. This result shows the importance of considering geographic factors–and the resulting spill-over effects–in policy decisions. Welfare in a geographically isolated jurisdiction using fees will be higher than if it is a substitute for neighboring jurisdictions. Neighboring jurisdictions working together to implement fee systems would realize the maximum welfare levels for their residents. This result is consistent with the inefficiency of tax competition. However, if a jurisdiction uses an impact-fee system, the neighboring jurisdiction benefits, though by less than if it also uses the efficient fee system.

Proposition 4. *If households are perfectly mobile and one of two jurisdictions uses impact fees and the other does not, then average welfare in the non-fee jurisdiction is lower than it would be if it also used impact fees.*

Proof: Assume B uses fees. Suppose A's utility is higher than if A also uses an impact-fee system; that is, $\tilde{W}_A^t > W_M^f$, where the latter denotes the average welfare given in equation (2.15) for a jurisdiction using fees with a market size of M. We would then have $\tilde{W}_B^f = \tilde{W}_A^t > W_M^f$. But we know from *Proposition 3* that $\tilde{W}_B^f < W_M^f. \;\square$

While the finding that welfare in A is higher if B uses fees is a surprising result in light of the inefficiency of tax competition, the fact that welfare is less than if A also uses impact fees is not surprising. Intuitively, when B uses fees, holding size constant, average welfare is higher than in A. Free mobility implies that B's market size will increase and A's decrease until $\tilde{W}_B^f$ falls to a level equal to $\tilde{W}_A^t$. The average-equilibrium welfare level is higher than if each jurisdiction uses taxes but less than if both use fees. Thus, the incentive for A to use to the efficient policy is greater than the benefit of free-riding on B's use of fees; a finding consistent with the theory of tax competition being inefficient.

2.5 One Jurisdiction with Heterogeneous Households

The basic model presented above considered jurisdictions with a homogenous population and suggested that impact-fee financing of infrastructure is more efficient than a tax-financing regime. However, casual observation reveals that most jurisdictions are not homogenous and many jurisdictions do not use fees. It is therefore worthwhile to consider heterogeneous consumers.

Assume there is still a mass of households, each demanding one unit of the homogenous good, now denoted M^L, evenly distributed around a circle of unit circumference. But now suppose there is also a mass M^H evenly distributed around the circle with each household in M^H demanding $z > 1$ units of the good. We will refer to the M^L low demanders as "L-types" and the M^H high demanders as "H-types". As with the L-types, the H-types also purchase from the firm that offers the lowest total cost for each unit of the good. Thus, for any household located at distance x from firm i to be indifferent between purchasing from firm i or the closest alternative firm, we must have a condition similar to equation 2.1,

$$p_i + (M^L + M^H)x = p + (M^L + M^H)(1/n - x), \tag{2.23}$$

with transport cost $(M^L + M^H)x$ reflecting the increased density of the jurisdiction. Solving for x we obtain

$$x = \frac{p + \frac{M^L + M^H}{n} - p_i}{2(M^L + M^H)}.$$

Because firm i attracts households of both types from clockwise and counterclockwise directions, the firm faces a demand of:

$$2\int_0^{\frac{p + \frac{M^L + M^H}{n} - p_i}{2(M^L + M^H)}} M^L dx + 2\int_0^{\frac{p + \frac{M^L + M^H}{n} - p_i}{2(M^L + M^H)}} zM^H dx$$

or

$$(M^L + zM^H)\left(\frac{p + \frac{M^L + M^H}{n} - p_i}{M^L + M^H}\right). \tag{2.24}$$

Under tax financing, firm i chooses its price to maximize

$$(p_i - c)(M^L + zM^H)\left(\frac{p + \frac{M^L + M^H}{n} - p_i}{M^L + M^H}\right) - F. \tag{2.25}$$

The first order condition for the firm is

$$(M^L + zM^H)\left(\frac{p + \frac{M^L+M^H}{n^t} - p_i}{M^L + M^H}\right) - (p_i - c)\left(\frac{M^L + zM^H}{M^L + M^H}\right) = 0. \qquad (2.26)$$

In equilibrium $p_i = p$; therefore the identical firms choose p such that

$$p = \frac{M^L + M^H}{n} + c. \qquad (2.27)$$

Allowing again for free entry, aside from the fixed costs F, the zero-profit condition under tax financing is

$$(p - c)(M^L + zM^H)/n^t - F = 0. \qquad (2.28)$$

Substituting equation 2.27 into the zero profit condition, (2.28), and solving for the equilibrium number of firms serving the heterogenous market under tax financing, we obtain

$$n^t = \left[\frac{(M^L + M^H)(M^L + zM^H)}{F}\right]^{1/2}. \qquad (2.29)$$

Substituting the number of firms (equation 2.29) back into the equation for price (2.27), we find the per-unit price under tax financing to be,

$$p^t = \left[\frac{(M^L + M^H)F}{M^L + zM^H}\right]^{1/2} + c. \qquad (2.30)$$

Using the equation for welfare (equation 2.10), n^t (equation 2.29), and p^t (equation 2.30), we see welfare for an L-type household is

$$W_L^t(x) = B - \left[\left(\frac{(M^L + M^H)F}{M^L + zM^H}\right)^{1/2} + c + \frac{1}{2}(M^L + M^H)x \right. \qquad (2.31)$$

$$\left. + s\left(\frac{(M^L + M^H)(M^L + zM^H)}{F}\right)^{1/2}\right],$$

and welfare for an H-type household is

$$W_H^t(x) = zB - \left[z\left(\frac{(M^L + M^H)F}{M^L + zM^H}\right)^{1/2} + zc + \frac{1}{2}(M^L + M^H)x \right. \qquad (2.32)$$

$$\left. + s\left(\frac{(M^L + M^H)(M^L + zM^H)}{F}\right)^{1/2}\right].$$

To find the number of firms and the per-unit price under impact fees, we substitute $(F + (M^L + M^H)s)$ for F in the equations for n^t, (2.29), and p^t, (2.30), and find

$$n^f = \left[\frac{(M^L + M^H)(M^L + zM^H)}{F + (M^L + M^H)s} \right]^{1/2} \tag{2.33}$$

and

$$p^f = \left[\frac{(M^L + M^H)(F + (M^L + M^H)s)}{M^L + zM^H} \right]^{1/2} + c.^{[13]} \tag{2.34}$$

Thus, after dropping the infrastructure costs, ns, from the welfare equation (2.10) we find that under impact-fee financing, welfare for an L-type household is

$$
\begin{aligned}
W_L^f(x) = {} & B - \Bigg[\frac{5}{4} \left(\frac{(M^L + M^H)(F + (M^L + M^H)s)}{M^L + zM^H} \right)^{1/2} + c \\
& + \frac{1}{2}(M^L + M^H)x - \frac{1}{4} \left(\frac{F(M^L + M^H)}{M^L + zM^H} \right)^{1/2} \Bigg],
\end{aligned} \tag{2.35}
$$

and an H-type has welfare

$$
\begin{aligned}
W_H^f(x) = {} & zB - \Bigg[\left(z + \frac{1}{4} \right) \left(\frac{(M^L + M^H)(F + (M^L + M^H)s)}{M^L + zM^H} \right)^{1/2} + zc \\
& + \frac{1}{2}(M^L + M^H)x - \frac{1}{4} \left(\frac{F(M^L + M^H)}{M^L + zM^H} \right)^{1/2} \Bigg].
\end{aligned} \tag{2.36}
$$

From the model with two homogeneous jurisdictions we know that households in both jurisdictions will prefer impact fees over tax financing but with heterogeneity this may not be the case. For a heterogeneous jurisdiction using fees, there are efficiency gains and distributional effects. Because impact fees act as a Pigouvian tax, L-types will benefit from efficiency gains and also from a distributional effect.

Proposition 5 *Low demanders always prefer impact fees over tax financing.*

Proof: Low demanders prefer impact fees when their welfare is higher under fees than under a tax system, $W_L^f > W_L^t$. Using equation 2.35 for W_L^f and equation 2.31 for W_L^t and simplifying, which includes rearranging terms and multiplying through by $F^{1/2}$, we obtain

$$\frac{5}{4}F + (M^L + zM^H)s > \frac{5}{4}(F^2 + F(M^L + M^H)s)^{1/2}.$$

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[13] A full derivation is included in the appendix.

Recalling that $z > 1$ we know that the left-hand side of the last inequality is greater than the right-hand side because $[(5/4)F + (M^L + zM^H)s]^2 > (25/16)F^2 + (25/16)F(M^L + M^H)s.\square$

The intuition for this result is clear. L-types prefer fees because both distributional and efficiency effects are welfare enhancing. Comparing the number of firms from equations 2.33 and 2.29 we can see that $n^f < n^t$, leading to a welfare gain from efficiency. When infrastructure costs are assigned to the firm and reflected in prices, H-types–who purchase a larger percentage of the good–also pay a larger portion of the infrastructure costs, providing a positive distributional effect for L-types.

Under impact fees, H-types bear a larger share of firms' infrastructure costs than under a tax-financing system in which each household pays the same amount.[14] However, it is possible for H-types to prefer tax financing if the negative distributional effect of H-types indirectly bearing a larger share of infrastructure costs through a higher price outweighs the efficiency gain.

Proposition 6. *If M^H is small enough and z is large enough, it is possible for H-type consumers to favor a tax-financing system.*

Proof: H-types prefer tax financing if $W_H^t > W_H^f$. Using equation 2.32 for W_H^t and equation 2.36 for W_H^f, we find

$$\left(z + \frac{1}{4}\right)^2 F(M^L + M^H)s > 2\left(z + \frac{1}{4}\right)Fs(M^L + zM^H) \qquad (2.37)$$

if M^H is small enough and z is large enough.$\square$

For H-types the effects push welfare in opposite directions and the magnitude of each becomes critical. This means it is possible for H-types to favor taxes under certain circumstances. Using the limiting case as an example, if there were a single H-type consuming all of the good, he would prefer to pay a tax that required L-types to pay some of the infrastructure

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[14]Each household having an identical tax liability isn't intuitive if we think of H-types and L-types as being high and low income household. If, however, we think of them instead as identical households with different preferences, the idea becomes clearer. For example, when households with similar incomes have different preferences for dining out, this leads to different demand curves even though income is the same.

costs. Under an impact-fee system, this same H-type consumer would be forced to pay the entire cost himself through a higher price.

2.6 FRICTIONS IN THE MEDIAN VOTER MODEL

Because the efficiency and distributional consequences of using fees have opposing effects on welfare for H-type consumers, we cannot unambiguously state whether H-types will prefer taxes or fees. However, as the number of H-types increases, the efficiency gains from fees will increase compared to the distributional losses.

Proposition 7. *The median household in a heterogeneous jurisdiction always prefers fee financing over tax financing.*

Proof: Holding market size constant, we can compare welfare of the H-types under each financing regime. If H-types outnumber L-types, $M^H \geq M^L$, H-type welfare is greater under fees than under taxes, $W_H^f > W_H^t$. Thus, the median consumer will prefer fee financing. Using equation (2.36) for W_H^f and equation (2.32) for W_H^t we obtain

$$\left(z + \frac{1}{4}\right) F + s(M^L + M^H) > \left(z + \frac{1}{4}\right) (F^2 + (M^L + M^H)sF)^{1/2}. \qquad (2.38)$$

In order for M^H to contain the median household, it must be true that $M^H \geq M^L$. Setting M^H equal to its minimum value of M^L in equation 2.38 we obtain

$$\left(z + \frac{1}{4}\right) F + sM^L(z + 1) > \left(z + \frac{1}{4}\right) (F^2 + 2M^LsF)^{1/2}.$$

After squaring both sides and simplifying, we find

$$2\left(z + \frac{1}{4}\right) FsM^L(1 + z) + [sM^L(1 + z)]^2 > 2\left(z + \frac{1}{4}\right)^2 M^LsF.$$

To see that this is true, notice that $(z + 1/4)(z + 1) > (z + 1/4)^2$. Thus, M^H cannot be the median household and prefer taxes. $\square$

A jurisdiction with a large number of H-types has a large total demand and, thus, a large number of firms. The large number of firms means higher total fixed costs and a greater potential for efficiency gains from using impact-fee financing than for a jurisdiction with

a small number of H-types. At some point M^H is large enough that the efficiency gains outweigh the negative distributional effect and H-types prefer fees to taxes. We can see from above that at this point L-types outnumber H-types, $M^H < M^L$. Thus, the median household always prefers impact-fee financing.

In a two-jurisdiction world of freely mobile households of two different types, if one jurisdiction uses fees, L-types from the other jurisdiction will sort themselves into the fee-charging jurisdiction. Consequently, the H-types, if they are few enough in number and their demand is large enough such that they prefer taxes, will sort into the taxing jurisdiction. If the sorting between jurisdictions is complete, making each jurisdiction homogeneous, there is no longer a distributional effect–only an efficiency gain–so both jurisdictions will use fees. However, casual observation reveals that not all jurisdictions use a fee system, suggesting perfectly mobile households and a median voter model may not adequately explain policy choices.

Relaxing the assumption of perfectly mobile households could yield heterogeneous jurisdictions, even if some sorting does occur. Further, if voting is costly, in terms of the time required to physically vote as well as information costs, it is possible that H-types negatively affected by a fee system will vote and L-types who stand to gain will not. In this case the median voter could prefer taxes even if the median household does not.

Proposition 8. *If households are less than perfectly mobile so that jurisdictions remain heterogeneous and voting is costly, it is possible for the median voter to be a high demander who prefers taxes.*

Proof: We compare the size of the welfare gains for L-types to the size of the losses for H-types and see, $W_H^t(x) - W_H^f(x) > W_L^f(x) - W_L^t(x)$.[15] Substituting for $W_L^f(x)$, $W_L^t(x)$, $W_H^t(x)$, and $W_H^f(x)$ from equations 2.32, 2.36, 2.35, and 2.31 respectively, simplifying, and multiplying through by $F^{1/2}$, we find

$$\left(z + \frac{3}{2}\right)(F^2 + F(M^L + M^H)s)^{1/2} > \left(z + \frac{3}{2}\right)F + 2(M^L + zM^H)S.$$

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[15]Defined such that both values are positive for comparison's sake.

Because the $(z + 3/2)$ term only affects one term on the left-hand side and both terms on the right-hand side of the inequality, it is possible that, $W_H^t(x) - W_H^f(x) > W_L^f(x) - W_L^t(x)$ if z is large enough and M^H is small enough. If voting is costly, the difference in the magnitude of gains by L-types and losses by H-types could lead to a situation where H-types find it worth their time to vote and L-types do not. Thus, the median voter could be an H-type who prefers taxes.[16]$\square$

2.7   CONCLUSIONS

Our analysis finds that using impact fees instead of taxes to finance infrastructure required by commercial development is second-best efficient and welfare enhancing. The fees work as a Pigouvian tax, forcing firms to internalize infrastructure costs. Under the assumption of homogeneity, using a fee system is welfare enhancing for a single jurisdiction as well as for its neighbors compared to a tax-financing system. However, if a neighboring jurisdiction does not use fees, welfare for each jurisdiction is less than if both jurisdictions use fees. If policies between the two jurisdictions differ, then the fee-charging jurisdiction's market size will be larger than the taxing jurisdiction. This leads us to conclude that regional implementation of impact fees is favorable to individual jurisdiction policies: a finding consistent with the inefficiency of tax competition.

Further, the model indicates that for a heterogeneous jurisdiction, using impact-fee financing is welfare enhancing for the majority of households. Additional frictions, such as limited mobility of households and costly voting, allow the model to explain why some jurisdictions use fees and others do not.

2.8   FUTURE RESEARCH

The results presented in this paper suggest both theoretical and empirical avenues for future research. On the theoretical side, while we find that impact fees are more efficient than

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[16]The appendix contains a complete derivation of this result.

taxes for financing infrastructure required by commercial development our results are based on some strong assumptions such as a fixed infrastructure cost per firm, a homogeneous good, and a restriction on interjurisdictional shopping. Future research should explore the implications of relaxing these assumptions.

The basic homogenous, single jurisdiction model presented above is potentially oversimplified; relaxing some assumptions could make it more applicable. The model could be greatly enriched by allowing inter-jurisdiction shopping as well as incorporating multiple goods. Furthermore, future work involving multiple goods should also examine transport costs that are a function of population density as well as business density. The above model incorporates transport costs that are increasing in population density and implicitly decreasing in business density as the distance from household to firm is reduced. However, in a model with multiple goods there is no reason for this to be the case as an additional firm selling one good would not reduce the transport cost for a household purchasing a different good.

Though the heterogeneous model above assumes two types of consumers, future research should look at a wider and more continuous distribution of consumers. As the distribution of consumers is broadened, the assumption of a flat per household tax should also be relaxed. With a homogeneous good, it is not unreasonable to think of households as being similar in income but having different preferences for the good. However, if consumption options are broadened to include a spectrum of goods, it is unlikely that preferences alone would explain variances in total consumption.

Alternative revenue mechanisms also warrant research to help put the findings of this paper into context. The above model finds fees to be efficient when compared to taxes but does not examine other creative funding mechanisms such as sales taxes, tax allocation districts, wage taxes, bond financing, fuel taxes, and local development authority initiatives, including lease-purchase agreements.

Future work, both theoretical and empirical, examining impact-fee adoption patterns should also include feedback mechanisms for tax subsidies from businesses to jurisdiction

residents as discussed in Dorfman, Black, Newman, Dangerfield & Flick (2001). Including these other factors may shed additional light on why some jurisdictions use fees and others do not.

Many of the implications of the model also seem worthy of empirical investigation. The model suggests that using fees results in a lower number of firms with higher per firm revenues than under a tax system. Burge & Ihlanfeldt (n.d.) find that the use of fees results in a lower employment levels–consistent with our results–but they do not examine the number or size of firms.

Our model also assumes that the fee revenues are actually spent on the construction of the infrastructure required by commercial development and this may not be the case. Fee revenues may just serve as another source of revenue and crowd out other revenues, leaving capital expenditure unchanged. While firms would still be forced to internalize their externality, households would still bear the burden of increased congestion but presumably benefit in either reduced taxes or an increase in some other government service. Finally, the model suggests that jurisdictions using impact fees will be more densely populated than those that do not. While the welfare gains from minimizing society's total fixed costs is probably imperceptible to the typical household the construction of infrastructure to serve the commercial development and reduced congestion should be perceptible. However, the difference between communities may not show up in congestion as much as in the value of real estate which capitalizes the additional transport costs caused by increased congestion.

Chapter 3

Gas Tax, Property Tax, Sales Tax, or Fee: The Best Way to Pay for Commercial Infrastructure That Isn't Free[1]

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[1]Jones, Adam. For submission to the Journal of Public Economics.

3.1 INTRODUCTION

With local budget constraints becoming politically tighter and constituents pushing back against property tax increases, state and local governments are turning to alternative methods to raise revenues. These alternatives include various fees, grants, sales taxes, public/private partnerships, and special taxing districts. When local governments consider options for transportation infrastructure funding, gasoline taxes, development impact fees and sales taxes are often under consideration. This paper provides a theoretical analysis of the efficiency of using different financing regimes for infrastructure required to support commercial development. Currently, only a small number of jurisdictions have local fuel taxes but political pressure for state legislatures to expand the options available to local governments is growing. Development impact fees are also increasing in popularity with over half the states having adopted impact-fee enabling legislation authorizing local governments to use fees and providing legal guidelines for structuring the fee system. Local sales tax authority varies across states but it is not hard to imagine a local sales tax earmarked for infrastructure construction.

Fuel taxes are often described as Pigouvian taxes and politically justified as a way to pay for infrastructure and force drivers to internalize externalities such as congestion and pollution. Furthermore, discussion about increasing fuel taxes is a constant, albeit politically unpopular, topic of discussion in state capitals, county seats, and mayoral offices around the country. While a gas tax may be an appropriate and efficient financing mechanism for the maintenance of existing infrastructure, this paper finds it is not the most economically efficient policy for financing the construction of new infrastructure. In the environmental literature there are several effects of a Pigouvian tax, a welfare gain from increased environmental quality, a welfare gain from revenue recycling–typically modeled as a reduction in labor taxes– and a welfare loss due to the reduced real wage resulting from taxes being passed along as higher prices. (Parry & Oates 2000)

Much of the existing economics literature focuses on the appropriate size of a Pigouvian gas tax for congestion, pollution, and accidents. (Bento, Goulder, Henry, Jacobsen & von Haefen 2005, Parry & Small 2005) These models typically assume that revenues are rebated to households through either a reduction in income taxes, lump sum rebates, or other rebate mechanism. The theoretical model presented in this paper compares household welfare under various commercial-infrastructure financing regimes–including property taxes, gas taxes, sales taxes, and impact fees–to that of a social planner whose objective is to minimize total social cost.[2] How revenues are rebated or what they are spent on is important for considering efficiency. For example, spending gas tax revenue on infrastructure to serve commercial development not only subsidizes firms by assigning infrastructure costs to households directly but also increases firms' revenues by increasing the transport costs captured by the firms. In a market with no barrier to entry and zero profits, an increase in firms' revenues leads to more firms entering the market and, consequently, requires a larger amount of total infrastructure.

The importance of considering revenue recycling mechanisms has been well documented in the economics literature including Parry & Oates (2000), Bento et al. (2005), Snow & Warren (1996) and several others. Other topics in the literature include the incidence of the gasoline tax (Poterba 1991) and whether or not commercial transport should be charged for road use (Newbery 1990). The research presented in this paper focuses on the efficiency of fee financing versus gasoline, property, and sales tax financing of infrastructure to serve commercial development.

The model used in this paper reveals that removing a market distortion through the use of a Pigouvian tax can be detrimental to welfare by increasing other distortions. Using a gasoline tax to fund infrastructure improvements for commercial firms and increase the cost of driving results in a larger number and dispersion of firms. This greater number and dispersion of firms leads to higher social costs including increased infrastructure need and

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[2]The social planner in this model is a theoretical construct used for comparison purposes and does not represent a central planning authority

increased total firm-fixed costs. In other words, when transportation costs are increased, residents do not benefit from the potential economies of scale. This result is not surprising in light of the Lipsey & Lancaster (1956) result improving one result may actually move another away from the optimal.

A development impact fee is a one time fee charged to a developer, usually at the time of building permit issuance, whose revenues are earmarked to construct infrastructure needed to offset the development's impact on existing levels of service. The fee revenues can only be used to construct new infrastructure and generally cannot be used for operational expenditures. Fees evolved from a politically controversial and inherently uncertain system of exactions. Exactions are donations of land or on-site improvements from a developer to a jurisdiction in exchange for development approval. However, the system of exactions left local political leaders exposed to criticism that they did not get enough from the developer and left developers with highly uncertain permit costs. Exactions were also limited in that land donated by the developer was often not where the improvements needed to be made, i.e. an adversely affected intersection may not be adjacent to a development. For these reasons, a fixed system of predetermined fees evolved. (Altshuler et al. 1993) While Jones & Snow (2010) compare household welfare under a system of fees to that of traditional property taxes they do not address the possibilities of using a gas tax or a sales tax to finance the infrastructure required to serve commercial development.

3.2 The Model

To model the effect of using different financing regimes for infrastructure to serve commercial development, I adopt Salop's (1979) circular city model in a similar manner as Jones & Snow (2010). A mass of homogenous households, M, each demanding one unit of a homogenous good locate uniformly around a circle of unit circumference. All travel takes place around the circle and transport costs are proportional to the distance traveled and are increasing in density. Each of the n identical firms requires a standard amount of infrastructure and I use

s to denote the cost to a household for each firm's infrastructure. Thus the standard amount of infrastructure required for each firm is Ms and total infrastructure costs to a household is ns.

To model the effect of using a gasoline tax instead of a property tax, transport costs in the model are multiplied by a factor such that the difference in transport costs under a gasoline tax and under a system of property taxes equals the revenue required to construct the infrastructure required by the commercial development. In other words, each system generates just enough revenue to support the equilibrium number of firms under that regime. While these rates are not first best they are a reasonable assumption of rates determined through a political process.

In Lancaster (1966) fashion, firms are spread evenly around the circle imposing maximum spatial differentiation and are separated by a distance $1/n$. All households consider firms to be identical and purchase one unit of the good at the lowest total cost possible, including transport cost.

Each welfare maximizing household purchases one unit of the good with the lowest total cost. A household located a distance x from firm i charging p_i and a distance $(1/n) - x$ from a firm charging p is indifferent if

$$p_i + Mx = p + M(1/n - x), \tag{3.1}$$

where M times distance is the transportation cost. Note that by multiplying the distance times the market size, M, the model incorporates congestion as transport costs are increasing in density. Equivalently, a household is indifferent when

$$x = (p + M/n - p_i)/(2M). \tag{3.2}$$

Because a firm attracts consumers from both the clockwise and counterclockwise directions around the circle, firm i faces a demand of

$$2 \int_0^{\frac{p + \frac{M}{n} - p_i}{2M}} M\,dx = p + \frac{M}{n} - p_i. \tag{3.3}$$

Under a system of residential property taxes used to finance infrastructure for commercial development, a firm i chooses its price p_i to maximize profits given by

$$(p_i - c)(p + \frac{M}{n} - p_i) - F, \tag{3.4}$$

where c is the cost of producing one unit of the good and F is a fixed cost yielding the first-order condition

$$\left(p + \frac{M}{n} - p_i\right) - (p_i - c) = 0. \tag{3.5}$$

Aside from fixed cost F, there are no barriers to entry and the identical firms all charge the same price, $p_i = p$. Thus,

$$p^t = \frac{M}{n^t} + c. \tag{3.6}$$

Firms also face a zero profit condition under the assumption of free entry. Denoting the property-tax financing regime with a superscript t, firms face a zero profit condition of

$$(p^t - c)(M/n^t) - F = 0. \tag{3.7}$$

Combining equations 3.6 and 3.7 yields the equilibrium number of firms[3],

$$n^t = \left(\frac{M^2}{F}\right)^{1/2} = MF^{-1/2}. \tag{3.8}$$

Substituting the number of firms under a tax financing regime, (3.8), into the equation for price, (3.6), gives an equation for the per unit price of the good

$$p^t = F^{1/2} + c. \tag{3.9}$$

Using B to denote the benefit from consuming the good, the welfare function of a household located a distance x from the nearest firm, under a regime of property-tax financing of commercial infrastructure is given by

$$W^t(x) = B - (p + Mx + ns), \tag{3.10}$$

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[3]Matsumura (2000) demonstrates that the integer problem can be ignored with constant marginal cost of production, in this model c, and n$\geq$ 3.

the per-unit-benefit, B, minus the total cost of acquiring the good, $p + Mx$, and taxes paid to cover infrastructure costs, ns.[4]

With the number of firms varying under different financing regimes the distance between firms and, thus, travel distances of households also varies. Because the model is linear, I can compare the welfare of the average household under each financing regime to assess whether a financing regime is a potential-Pareto improvement when compared to tax financing. Under the assumption of identical firms the indifferent household, from equation 3.2, is located a distance of $x = 1/2n$ from the firm on either side of it. Thus, household travel distances are uniformly distributed along the interval $x \in [0, 1/2n]$ and it must be the case that the average household travels a distance of $x = 1/4n$. Using the number of firms, (3.8), the equation for price, (3.9), and $1/4n^t$ for x, we can substitute into the household's basic welfare function, (3.10) to obtain the household's welfare under tax financing,

$$W^t = B - [\frac{5}{4}F^{1/2} + c + MsF^{-1/2}].\text{[5]}$$

(3.11)

Now suppose infrastructure required by commercial development is paid for with a gas tax and values for n and p are denoted by a superscript g. The tax is levied at rate r on transportation costs such that household welfare is now

$$W^g(x) = B - [p^g + (1 + r)Mx].$$

(3.12)

The third term in brackets in equation 3.11 has dropped out of equation 3.12 because the direct household cost, ns, in equation 3.10 is zero. A household located at x is indifferent to purchasing from the firm on either side of it if

$$p_i + (1 + r)Mx = p + (1 + r)M(\frac{1}{n^g} - x).$$

(3.13)

Thus the indifferent household is located at

$$x = \frac{p + (1 + r)\frac{M}{n^g} - p_i}{2(1 + r)M}.$$

(3.14)

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[4]If no additional infrastructure were constructed, the consumer would bear the cost of the infrastructure not constructed in the form of additional congestion.

[5]A full derivation can be found in the appendix

Because a firm attracts households, located between it and the indifferent household, from both clockwise and counterclockwise directions, firm i faces a demand of

$$2 \int_0^{\frac{p+(1+r)\frac{M}{n^g}-p_i}{2(1+r)M}} M dx = \frac{p+(1+r)\frac{M}{n^g}-p_i}{1+r}. \tag{3.15}$$

Firm i chooses price p_i to maximize profits

$$(p_i - c)\left(\frac{p+(1+r)\frac{M}{n^g}-p_i}{1+r}\right) - F \tag{3.16}$$

yielding first-order condition

$$\frac{p+(1+r)\frac{M}{n^g}-p_i}{1+r} - \frac{p_i-c}{1+r} = 0. \tag{3.17}$$

Aside from the fixed costs, there are no barriers to entry and thus the identical firms all charge the same price, $p_i = p$, and thus

$$p^g = (1+r)\frac{M}{n^g} + c. \tag{3.18}$$

Because of free entry, firms also face a zero profit condition given by

$$(p^g - c)\frac{M}{n^g} - F = 0 \tag{3.19}$$

yielding the number of firms

$$n^g = \frac{(p^g - c)M}{F}. \tag{3.20}$$

Substituting in for p^g from equation 3.18 we see

$$n^g = M(1+r)^{1/2}F^{-1/2}. \tag{3.21}$$

Using the value for n^g from equation 3.21 we can substitute back into (3.18) to find

$$p^g = (1+r)^{1/2}F^{1/2} + c. \tag{3.22}$$

For comparison purposes I assume the gas tax funds only the commercial infrastructure. Thus the *tax rate * total transport costs* must equal the total revenue needed to

finance the necessary infrastructure improvements.[6] Because the households are distributed evenly around the circle and transportation costs are linear, the average transportation cost times the number of households equals the total transportation cost. A household located at $(1/2)(1/n^g)$ is indifferent to purchasing from the firm located in either direction and the maximum distance from a household to the nearest firm is $(1/2)(1/n^g)$. Thus the average household travels half that distance or $1/(4n^g)$ and faces a transportation cost of $M/(4n^g)$. This makes total travel costs $M * M/(4n^g)$ or $M^2/(4n^g)$. Multiplying total travel costs by the tax rate must equal the revenue required to finance the commercial infrastructure, $(Ms)n$. To find the appropriate tax rate the local government must solve

$$r * \frac{M^2}{4n^g} = (Ms)n^g \tag{3.23}$$

for r. Substituting from equation 3.21 for n^g and solving for r yields

$$r = \frac{4Ms}{F - 4Ms}. \tag{3.24}$$

Note that because $r > 0$, it must be true that $F > 4Ms$. Substituting r from equation 3.24 into the equation for n^g, (3.21), and into the equation for p^g, (3.22), gives the number of firms under a gas tax,

$$n^g = \frac{M(1 + \frac{4Ms}{F-4Ms})^{1/2}}{F^{1/2}} \tag{3.25}$$

and the per-unit price

$$p^g = \left(1 + \frac{4Ms}{F - 4Ms}\right)^{1/2} F^{1/2} + c. \tag{3.26}$$

Comparing the number of firms and price under a gas tax, (3.25) and (3.26), with those under a property tax, (3.8) and (3.9), we see that the there are more firms, $n^g > n^t$, and the price is higher under a gas tax, $p^g > p^t$. This observation indicates the average household's welfare under a gas tax is most likely less than when infrastructure required by commercial development is funded using a property tax. However, because there are more firms under a gas tax the higher price and larger total fixed costs associated with more firms are partially

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[6]While this is not a first-best rate, it is a reasonable assumption of a rate determined through a political process.

offset by a reduction in travel distance. To determine the total effect requires comparing average household welfare and more than just prices and the number of firms.

Using the equation for price under a gas tax, (3.26), the tax rate from (3.24), and the location of the average household, $1/(4n^g)$, for x in the households welfare equation, (3.12), yields average household welfare under a gas tax,

$$W^g = B - \left[\frac{5}{4} \left(1 + \frac{4Ms}{F - 4Ms} \right)^{1/2} F^{1/2} + c \right].^7 \qquad (3.27)$$

Proposition 1. *For a single, homogenous jurisdiction of fixed market size, average household welfare is higher under a system of property-tax financing than under a system of gas-tax financing.*

Proof: Subtracting equation 3.27 for W^g from equation 3.11 for W^t, and simplifying we obtain

$$W^t - W^g = F^{-1/2} \left[\frac{5}{4} \left(1 + \frac{4Ms}{F - 4Ms} \right)^{1/2} F - \frac{5}{4}F - Ms \right] > 0. \qquad (3.28)$$

Observe that the term in brackets is positive because the first term is greater than the second and third combined.[8] Therefore, $W^t > W^g$. □

Evenly spaced homogenous firms capture transportation costs because they essentially have a local monopoly on households between the firm and the indifferent consumer; increasing transport costs causes household welfare to fall. Transport costs and the subsequent prices are higher under a gas tax which leads to a larger number of firms in equilibrium, $n^g > n^t$. The larger number of firms reduces the distance from the average household to the nearest firm and partially offsets the increase in transport costs due to the gasoline tax. However, welfare of the average household still falls because the increase in costs, even with the partially offsetting reduction in travel distance, is greater than the taxes paid by the households. This is evident when the change in transport distance is netted out of the

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[7]A full derivation can be found in the appendix.
[8]A full proof can be found in the appendix.

increase in price and compared to taxes paid by the households under a tax financing regime

$$p^g - p^t + \frac{M}{4}\left[\frac{(1+r)^{1/2}}{n^g} - \frac{1}{n^t}\right] > n^t s. \text{[9]} \tag{3.29}$$

Comparing the number of firms under each financing regime to that of a social planner whose objective is to minimize social costs shows that using gasoline-tax revenues to finance commercial infrastructure increases the over-entry problem typical of homogenous circular city models. A social planner whose objective is to minimize total social costs including total fixed costs, total infrastructure costs, and total transport costs

$$n^* F + n^* M s + 2 M n^* \int_0^{\frac{1}{2n^*}} x \, dx \tag{3.30}$$

finds that

$$n^* = (1/2)\sqrt{(M/(F + Ms))} < n^t < n^g. \tag{3.31}$$

The over-entry problem typical of models with homogenous firms and goods is caused by firms considering their private costs and not the social cost. A gasoline tax does not affect the firms' private costs but increases the firms' revenues leading to more firms in equilibrium. If the policy objective is to move toward the socially optimal number of firms, as determined by the social planner problem, then a financing system where the firms consider the social costs would be more appropriate than the two systems modeled above.

A third way of financing infrastructure is the use of an impact-fee system to pay for capital. The fees are one-time charges earmarked for infrastructure improvements required by the new development. Jones & Snow (2010) use a process similar to the one above but assign the per firm infrastructure costs, Ms, to the firm as an additional fixed cost when modeling fees. They find the number of firms under a system of fees, denoted with a superscript f, to be

$$n^f = M(F + Ms)^{-1/2}, \tag{3.32}$$

and per unit price to be

$$p^f = (F + Ms)^{1/2} + c. \tag{3.33}$$

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[9]A full derivation can be found in the appendix

Thus, the welfare of the average household under and impact fee regime is

$$W^f = B - [\frac{5}{4}(F + Ms)^{1/2} + c].^{10}$$ (3.34)

Proposition 2. *For a single, homogenous jurisdiction of fixed market size, average household welfare under impact-fee financing of infrastructure to support commercial development is higher than under a gas tax system.*

Proof: Subtracting equation 3.27 for W^g from equation 3.34 for W^f, and simplifying shows that

$$W^f - W^g = \frac{5}{4}F^{-1/2}[(F^2 + \frac{4MsF^2}{F - 4Ms})^{1/2} - (F^2 + MsF)^{1/2}] > 0.$$ (3.35)

Observe that the term in brackets is positive because the first term is greater than the second.[11] Therefore, $W^f > W^g$. □

Of the three potential funding mechanisms, gas tax, property tax, and impact fees, the impact fees yield an outcome closest to that of a social planner, although still second best. (Jones & Snow 2010) Because the fees force firms to consider at least a portion of the social cost when determining whether to enter a market the gap between social costs and private costs is reduced and welfare approaches that of the social planner outcome.

Another alternative mechanism for raising revenues is a sales tax. Adding a sales tax to the model makes solving for household utility intractable because of the endogeneity of the tax rate to equate infrastructure need with revenues. However, without actually determining the sales tax rate, denoted v, it is possible to solve for the number of firms and compare the number of firms to outcomes presented above. Setting up the model such that the consumer is indifferent when

$$(1 + v)p_i + Mx = (1 + v)p + M(\frac{1}{n} - x),$$ (3.36)

and the indifferent consumer is located at

$$x = \frac{(1 + v)p + \frac{M}{n} - (1 + v)p_i}{2M}.$$ (3.37)

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[10]A full derivation can be found in the appendix.
[11]A full proof can be found in the appendix.

Thus, a firm maximizing profits

$$(P_i - c)[(1 + v)p + \frac{M}{n} - (1 + v)P_i] - F \tag{3.38}$$

faces a first order condition of

$$(1 + v)P + \frac{M}{n} - (1 + v)p_i - (1 + t)(p_i - c) = 0.^{12} \tag{3.39}$$

Because there are no barriers to entry, I again assume homogeneous firms and symmetric prices, $p = p_i$. Solving the first order condition for price yields

$$p_i^v = \frac{M}{n(1 + v)} + c. \tag{3.40}$$

Setting up the firm's zero profit condition,

$$(p_i - c)\frac{M}{n} - F = 0, \tag{3.41}$$

and substituting for price from equation 3.40, and solving for the number of firms, n^v yields

$$n^v = MF^{-1/2}(1 + v)^{-1/2}. \tag{3.42}$$

Substituting the number of firms under a sales tax regime back into the equation for price, 3.40, we find price to be

$$p^v = F^{1/2}(1 + v)^{-1/2} + c. \tag{3.43}$$

Proposition 3. *For a single homogenous jurisdiction of fixed market size, there are fewer firms in equilibrium when using sales tax financing than under property tax financing of infrastructure required by commercial development.*

Proof: $n^v = MF^{-1/2}(1 + v)^{-1/2} < MF^{-1/2} = n^t$ □

Comparing the number of firms under sales taxes, n^v to the number under a system of property taxes, n^t, shows that the number of firms under a sales tax is less than under a property tax and closer to the socially optimal number of the social planner. However the

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[12]The profit function assumes the consumer remits the sales tax and the derivation of the firm's demand equation, found the same as above, is omitted.

number of firms is still larger than the socially optimal number and larger than that under an impact fee financing regime.

Proposition 4 *For a single homogeneous jurisdiction of fixed market size, there are more firms in equilibrium under a sales-tax financing regime than under an impact-fee financing regime.*

Proof: Comparing the number of firms under impact fees to that under a sales tax I find

$$n^f = M(F + Ms)^{-1/2} < M(F + Fv)^{-1/2} = n^v. \tag{3.44}$$

To see from the preceding equation that $n^f < n^v$ note that $Ms > Fv$. This must be true because Ms represents the infrastructure cost for a single firm which is equal to the sales tax revenue generated by the firm. Canceling market size, M, and substituting $(pM/n) * v$ for Ms yields $(F + (PM/n)v)^{-1/2} < (F + Fv)^{-1/2}$. To see that this last inequality is true, note that from the firm's zero-profit condition, (3.19), PM/n, firm revenue, must be greater than its fixed costs, F. $\square$

Thus we see that there are more firms under a sales tax regime than under an impact fee regime. This result is not surprising because under a sales tax regime firms do not internalize the fiscal externality of their infrastructure costs; they're still considering only private costs of entry and not social costs. Of the four financing regimes considered in this paper, impact fees yields an equilibrium number of firms closest to that of a social planner, $n^* < n^f < n^v < n^t < n^g$. While not first-best efficient, impact fees have been revealed to be the second-best efficient mechanism–of the options analyzed here–for financing infrastructure required by commercial development with an equilibrium number of firms closest–of the four financing options–to that of the social planner. Both impact fees and sales taxes are more efficient than property taxes and a gas tax is less efficient than a property tax.

3.3   Two Homogeneous Jurisdictions

In a multijurisdiction model with mobile households, similar to Jones & Snow (2010), it should be possible to show that adoption of a gas tax by either jurisdiction is welfare reducing

for both jurisdictions. Just as there are external benefits to adopting the efficient policy of impact fees, there are negative external effects to neighboring jurisdictions, that serve as substitutes, of adopting an inefficient policy. For example, suppose one jurisdiction decided to use a gas tax; welfare would be lower in that jurisdiction than in a neighboring jurisdiction with property taxes. Households would move from the gas tax jurisdiction–reducing congestion–to the property tax jurisdiction and increase congestion in the property tax jurisdiction. This movement would continue until welfare in the gas tax jurisdiction rises to meet the declining level of welfare in the increasingly congested property tax jurisdiction.

3.4 Conclusion

Modeling different financing mechanisms in a model of homogenous firms finds that impact-fee financing of commercial infrastructure is more efficient than either property, gas, or sales taxes. This finding suggests that infrastructure construction should be paid for using impact fees but leaves open the possibility that paying for maintenance, operation, and environmental externalities using gas-taxes is efficient. Furthermore, the research in this paper shows the importance of considering how gas-tax revenues are rebated to the households. Rebating in the form of infrastructure construction potentially increases another distortion such as the over-entry problem and reduces welfare. The evidence from this model shows that estimating an optimal gas tax is more complicated than previous estimates. In addition to modeling environmental externalities and changes in fleet composition we must also include changes in business location decisions in order to calculate a long-run optimal tax.

3.5 Future Research

Future research on alternative funding for infrastructure should include other regimes such as tax-allocation districts also called tax-increment financing. As jurisdictions continue to search for alternative revenue sources it is imperative that academic research keep pace with

the creative funding mechanisms being implemented. Another alternative funding mechanism to be considered is the use of fees on vehicle registrations or taxation of vehicles.

The model presented in this paper is also restrictive in that it does not allow interjurisdictional shopping but casual observation tells us that consumers are willing to bypass a store closer to their residence to purchase from another at a lower price. The model presented here also assumes free mobility of consumers which might be true in the long run but transaction costs certainly limit household mobility in the short run. Furthermore, the above model also assumes a constant demand for the good of one unit per household. The assumptions should be relaxed to more accurately reflect a downward sloping demand curve.

CHAPTER 4

THE LIGHTER THE MONEY THE BETTER IT STICKS: IMPACT FEES AS EVIDENCE OF

A FLYPAPER EFFECT[1]

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[1]Jones, Adam. For submission to the Journal of Urban Economics.

4.1 INTRODUCTION

Economic theory modeling politicians as agents of their constituents predicts that grants to local governments will be spent the same as if the grant had been given directly to constituents as an increase in income; grant revenues will crowd out other revenues. A larger expenditure response by local government to a grant than the response to an equal size increase in constituent income is referred to as the flypaper effect because "money sticks where it hits." In 2006 over $452 billion was transferred from the federal to state and local governments; it is critical that we understand how lower levels of government respond to these transfers if we wish to design efficient grant programs. As shown in figure D.1, these revenues represent almost 20% of local government revenues. (Rueben & Rosenberg 2008) While there is some debate in the empirical literature about the proper technique for estimating the size of the effect, casual observation tells us that local governments are much more likely to spend grant revenues than tax and spend an increase in income of constituents. In other words local government spends the grant instead of passing it on. Assuming impact fees are essentially grants from future residents, I examine Florida county impact-fee revenue and expenditure data and find that capital expenditure categories with low future operating costs exhibit a larger expenditure response to earmarked revenues than expenditure categories with high operating costs.

Impact fees are one-time charges on new development that are earmarked for capital improvements needed to offset the development's negative impact on per-capita public service levels. While the fees are not universal they are becoming more widespread as local governments search for alternatives to the traditional property tax. Over half the states have adopted "impact-fee-enabling legislation" which gives formal authority to local governments to use fee systems and a basic structure to be used in designing the system. Proponents of impact fees argue that the revenue generated allows the community to build the necessary infrastructure and purchase capital to support new development, while opponents argue the fees are just another tax and a windfall to existing residents. Critics, especially in the devel-

opment community, believe the fee revenues will crowd out expenditures from the general fund and that no additional infrastructure will be built. In other words, the critics believe there is no flypaper effect. Their argument is supported by Clarke & Evans (1999) who find that cities charging fees spend less on infrastructure than those without fees.

It should not be surprising to even the casual observer that governments are much more likely to spend grants and intergovernmental revenues than to reduce taxes and pass the grant revenues through to constituents. Politicians' time horizons are much shorter than citizens' because the next election is always quickly approaching. Furthermore, even if a politician wanted to pass the revenues to residents it is difficult to do. Institutional requirements make adjusting taxes in the current year difficult and carrying funds from one year to the next is often difficult as well. For these reasons, among others, politicians are likely to view intergovernmental revenues and grants as windfalls to be spent as quickly as possible. The object of this paper is not to examine whether politicians spend the windfalls, I take that as a given, but rather whether windfalls are spent as the earmark intends.

Most intergovernmental revenues and grants are earmarked for a specific purpose but may in fact be fungible. For example, suppose an intersection needs a traffic light to alleviate congestion and a jurisdiction is budgeting to install one from general revenues. If the jurisdiction is able to secure a grant for the traffic light the funds originally allocated for the light can be used for another project, say a playground. The grant funds earmarked for the traffic light have essentially been redirected to building a playground and the grant for transportation improvements did not lead to any additional improvements.

Whether grant revenues and other windfalls are spent as intended is an important consideration when designing systems of intergovernmental grants. Impact fees are ideal for determining differences in local government responses to non-tax revenues across sectors. The total fee paid by a developer is made up of fees for multiple expenditure categories and is charged in a similar manner for all types of development, i.e. on a per housing unit or per square foot basis. Unlike grant programs which may have different explicit or implicit

matching requirements for different expenditure categories or programs, the uniformity of impact-fee systems make their revenues ideal for comparison.

Fee amounts are set by examining the impact of each type of development on public services and determining the amount of capital expenditure required to maintain the current per-capita level of service.[2] This amount is considered the maximum impact fee but is often politically untenable and fee levels are set at some percentage of the maximum amount. Assuming fees are determined through this process, fee revenues from different types of development represent the same percentage of expected capital requirements for each expenditure type. Thus, it should not matter whether revenues come from residential, commercial, or industrial development in terms of the amount of capital required. For example, if fees are set at fifty percent of the maximum fee amount, then residential fee revenues, commercial fee revenues, etc. each fund fifty percent of the necessary public capital for the development. It follows that the response of capital expenditure should be uniform across expenditure categories if local leaders are trying to maintain current levels of service. However, if the revenue elasticity of expenditure differs across sectors then local leaders are making decisions considering other objectives and potentially diverting funds to other uses.

This paper briefly outlines the flypaper literature, before deriving and estimating a model using cross section data from Florida counties. After a discussion of the results I suggest some directions for future research.

4.2   LITERATURE

The debate over the flypaper effect of intergovernmental grants spans several decades and continues to evolve. The early literature is well summarized in Gramlich (1977), Inman (1979), and Fisher (1982), while the more recent literature is surveyed in Hines & Thaler (1995) and Bailey & Connolly (1998). The early empirical literature typically used federal

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[2]Several court decisions have set the precedent that impact-fee revenues may not be used to construct infrastructure providing a higher level of service than currently exists or to alleviate existing deficiencies.

grant receipts to demonstrate the inconsistency between economic theory and the data but has been criticized for failing to allow for the potential endogeneity of grants as demonstrated by Chernick (1979) and King (1984), and for the sensitivity of the estimates to changes in functional form (Becker 1996). Becker finds that evidence of a flypaper effect based on estimates of linear models is misleading, and suggests that the proper log-linear form gives little support for a flypaper effect. Further, Megdal (1987) demonstrates that if the grants are endogenously determined through negotiations or a bureaucratic process of implicit matching criteria, the coefficient estimates used to support a flypaper effect are biased upward.

More recent research has attempted to avoid these pitfalls by using more sophisticated econometrics and revenue windfalls other than traditional grants to look for evidence of a flypaper effect. Examples include the use of regression discontinuity methods in education grant expenditures (Dahlberg, Mork, Rattso & Agren 2008) and instrumental variable estimation using lobbying strength as an instrument for grant size (Knight 2002). While Dahlberg et. al. find evidence of a flypaper effect, Knight's findings suggest that federal transportation grants do crowd out state transportation expenditures but cannot rule out partial or over-crowding because of large confidence intervals surrounding the estimates.

Creative solutions to the endogeneity and functional-form criticisms often use expenditure responses to revenues other than grants. Olmsted, Denzau & Roberts (1993) examine the effect of school bond retirements and changes in state tax laws using Missouri school data and find that the obscured tax increases lead to substantial increases in operating expenditures. Ladd (1993) notes that the 1986 federal tax reform widening the base and lowering the rate created revenue windfalls to states levying income taxes based on federal tax return calculations of income and finds evidence of large expenditure increases instead of a reduction in tax rates. Finally, in an attempt to build a predictive index of the flypaper effect, Strumpf (1998) finds evidence of larger effects in jurisdictions with high government overhead expenses and reasons that constituents in those communities are not well informed. Using data on local earned income tax revenues, Strumpf also finds a higher propensity for earned income

tax revenues to crowd in spending if a larger portion of the tax revenues are received from residents living outside the jurisdiction. Because of the uniform determination of fee amounts for all different land-use types, I am able to ignore the source of the revenues and compare capital expenditure responses to increased revenues across expenditure category.

Assuming the empirical finding of the flypaper effect is correct, the process that leads to it is still up for debate. There are several theories for the empirical findings including deadweight loss, transaction costs, income constraints, tax capitalization, bureaucratic behavior, self interested politicians, and uncertainty. Bailey & Connolly (1998) provide a nice summary of the existing literature.

This paper contributes to the non-grant evidence of a flypaper effect, and finds evidence of a larger effect when revenues are used for capital projects with lower operational costs in the future. Lighter revenues, those not weighed down by future maintenance and operation costs, are much more likely to stick where they hit.

4.3 THEORETICAL MODEL

Using the median voter model, it is possible to construct an estimable equation for capital expenditure by local government. Despite the inherent shortcomings of this model, it is still widely accepted for modeling local government spending decisions.[3] I assume residents derive utility from two goods, a publicly provided good G and a private numeraire good x.[4] For ease of modeling, I assume the consumer maximizes the Cobb-Douglas utility function

$$U_i = \alpha x_i^{\beta} G_i^{\gamma} \tag{4.1}$$

subject to the budget constraint

$$Y_i = x_i + p_i G_i, \tag{4.2}$$

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[3]The shortcomings of the median voter model include: median voter not being median resident, multiple decisions by governments, multipeaked preferences, etc. See (Bailey & Connolly 1998)

[4]The notation in this section follows Tresch (2002)

where Y_i is the household's income and p_i is the price of the publicly provided good.[5] This yields the estimating equation

$$ln\, G_i = a + b\, ln\, Y_i + c\, ln\, p_i + e_i.\text{[6]} \tag{4.3}$$

The price of G is less straightforward than for the private good because households pay for G through taxes. Assuming local governments use a property tax system to finance the provision of G, a household pays taxes at a rate t on property valued at V_i where the subscript i denotes the household. The government's revenues equal the tax rate times total taxable property V. Therefore, a household's tax price is equal to its share of total taxable property,

$$tV_i = tV(V_i/V). \tag{4.4}$$

Because local governments cannot run deficits and very rarely run surpluses of any substantial size, it is reasonable to assume that their revenues equal their expenses. Thus, if the local government pays price q to supply the service, G, then

$$tV = qG. \tag{4.5}$$

Substituting equation 4.5 into equation 4.4 we can divide through by G to find the household's price per unit of G

$$\frac{tV_i}{G} = p_i = (V_i/V)q \tag{4.6}$$

Following Borcherding & Deacon (1972) we can also allow for congestion of government services, G, by letting N represent the population in the equation for government services provided,

$$G_i^* = G/N^\eta \tag{4.7}$$

where the $*$ denotes levels after controlling for congestion. In the case where $\eta = 0$, the publicly provided good is a pure public good and if $\eta = 1$ the good is a purely private good.

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[5]Using household income implicity assumes that voting decisions take place at the household level.

[6]The Lagrangian formed from (4.1) and (4.2) is $\mathcal{L} = \alpha x_i^\beta G_i^\gamma + \lambda(Y_i - x_i - p_i G_i)$ yielding FOCs of $\frac{\partial \mathcal{L}}{\partial x_i} = \beta \alpha x_i^{\beta-1} G_i^\gamma - \lambda = 0$ and $\frac{\partial \mathcal{L}}{\partial G_i} = \alpha \gamma x_i^\beta G_i^{\gamma-1} - \lambda p_i = 0 \Rightarrow \frac{Bp_i}{x_i} = \frac{\gamma}{G_i} \Rightarrow x_i = \frac{Bp_i G_i}{\gamma}$. Substituting back into the budget constraint (4.2) and solving for G_i yields (4.3).

After substituting the congested public good, equation 4.7, back into the equation for price (4.6) the congested price is thus

$$p_i^* = p_i N^\eta = (V_i/V)qN^\eta. \tag{4.8}$$

After using a log transformation of equations 4.7 and 4.8 and substituting into equation 4.3 for $ln\, G_i$ and $ln\, p_i$, the estimating equation becomes

$$ln\, G^* = a + b\, ln\, Y_i + c\, ln\, (V_i/V) + c\, ln\, q + \eta(1+c)\, ln\, N + e_i. \tag{4.9}$$

Because government service outputs are very difficult to measure, I am forced to use government expenditures, E, as a proxy for service outputs. To find the measure for G, I use expenditure per capita

$$\frac{E}{N} = \frac{tV}{N} = \frac{qG_i}{N}.$$

After a log transformation, per capita expenditure is

$$ln\left(\frac{E}{N}\right) = ln\, q + ln\, G_i - ln\, N, \tag{4.10}$$

and thus,

$$ln\, G = ln\left(\frac{E}{N}\right) + ln\, N - ln\, q \tag{4.11}$$

which can then be substituted into the estimating equation, (4.9).

This resulting equation gives a good foundation for the equation to be estimated. In addition to the variables that fall out of the theory above, there are several additional variables including per-capita impact-fee revenues, Fee, per-capita intergovernmental grants, $Grants$, interaction terms between revenues type and per-capita fee amounts, $Type * ln\, Fee\_Revenue$ and $\bar{Z}$ representing demographic variables that need to be added to the estimating equation. When estimating the effect of income on government services it is also appropriate to consider other sources of income that do not show up in the standard measurement of household income. These would include grants to the community and impact fees–considered

grants from future residents–which if not passed through to households is essentially the government taxing away the marginal income if the grants were given directly to the household. Adding these variables yields the equation to be estimated

$$ln \frac{E}{N} = a + b \, ln \, Y_i + c \, ln \, (V_i/V) + (1+c) \, ln \, q + [\eta(1+c) - 1] \, ln \, N$$
$$+ d \, ln \, Fee\_Revenue + f \, ln \, Grant + \vec{g} \, (\overrightarrow{Type * ln \, Fee\_Revenue}) + \vec{h} \, ln \, \vec{Z} + e_i$$

$$(4.12)$$

which can be estimated if wages are used as a proxy for q.[7]

4.4 Empirical Analysis

To examine the affect of impact fee revenues on capital expenditures, I use Florida county data for 2002. The data were obtained from Census Bureau population estimates, BEA "State and Local Area Personal Income" estimates, and the 2000 decennial census when 2002 data was not available. Revenue and expenditure data for the counties were provided by the Florida Department of Financial Services office and the 2002 Census of Local Governments.

The flypaper effect refers to a larger effect of grants or windfalls on government spending than an equivalent increase in income, the money "sticks where it hits." The question in this paper is whether the money sticks in one sector or if it is "fungible." To examine the effect of revenues ear-marked for capital improvements in different expenditure categories the interaction terms between fee revenues and a dummy for expenditure type included in equation 4.12 are of particular interest.[8] In other words, a significant interaction term tells us that the non-transportation capital expenditure responds differently to impact fee revenues than transportation's capital expenditures.

The log-linear relation in (4.12) is estimated using both ordinary least squares and two-state least squares. Data for household median income is used for Y_i, per-capita capital

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[7]This assumes least-cost efficient production with constant returns to scale. While wages may not be a perfect proxy, I am unaware of local-government construction price indices that span sectors and counties in a consistent manner.

[8]The interaction term for transportation revenues is omitted to avoid collinearity.

expenditure by type of expenditure is used for E/N, household tax share, V_iV, is approximated by dividing median household price, V_i by aggregate household value in the county V. County population estimates are used for N, and employment and payroll data is used to approximate public sector wages in each sector, a proxy for q the price of the government service.[9] While wages are a crude proxy for service costs, using them as such makes the implicit assumption of constant returns production and similar production technology for services across jurisdictions. This assumption was validated by Borcherding & Deacon (1972). Because grants are potentially endogenous, I use density and political preference of county voters as an instrument a la Knight's (2002) use of state delegations' representation on the transportation committee in his instrumental variable estimation. Observations on political preference are created by dividing the number of registered republican voters, the majority party, by the total number of registered voters.[10]

The relationship between revenues and expenditures was estimated using data for three different expenditure categories: transportation, public safety, and recreation; as well as an aggregated total capital expenditure.[11] The data contain observations on all four categories and an interaction term between the log of fee revenues and a dummy for expenditure type is included to reveal expenditure response differences across categories. The estimated coefficient on each interaction term represents the difference in response to revenues earmarked for the expenditure category and revenues earmarked for transportation capital, the omitted term.

The summary statistics presented in table E.1 show that, on average, jurisdictions without fees spend more on transportation infrastructure than jurisdictions with fees. This result is

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[9]Estimates were also obtained after calculating tax share as median home value divided by the total taxable value but the estimates changed little.

[10]Estimation using other measures of political preference showed little variation from the reported results. However, the first-stage F scores range from 15.52 to 1.33 and are declining in smaller samples signalling potentially weak instruments. Weak instruments are most likely not a large concern here because the instrumented variable is not the variable of interest and only affects the coefficient of interest to the degree that the variables are correlated.

[11]"Recreation" includes libraries as well as parks and recreation.

in line with Clarke & Evans's (1999) result. It is also noteworthy that jurisdictions with fees tend to be growing much faster, have substantially larger populations, and higher debt to revenue ratios. These observations are consistent with the suggestion in the literature that fees are most prevalent in urban and growing jurisdictions; jurisdictions under financial strain as demonstrated by their higher debt-to-revenue ratios. Further, an examination of the table reveals that counties without fees rely more heavily, per-capita, on grants.

4.5 REGRESSION RESULTS

Tables E.3 and E.4 present the results of the ordinary least squares and instrumental variable regression analysis. The dependent variable in each regression is the log of per-capita capital expenditure and the independent variables are the logs of corresponding per-capita revenues, demographics, and wage rates for each expenditure category. Each regression reports heteroskedasticity-robust standard errors and is clustered on the county because the data contains observations for multiple types of expenditures for each county. Clustering the observations allows for correlations between expenditure categories for each county.

The odd numbered columns in tables E.3 and E.4 give the coefficients for the original data which, when logged, drops all the counties that do not impose impact-fees. The even numbered columns, and variables denoted with an "_all", represent a modified data set where $1 was added to the per-capita revenues and expenditures for all counties. While this may slightly bias the coefficients it serves as a robustness check to make sure the results from the fee-charging counties are generalizable to all counties.[12] Columns in the tables are labeled by estimation type, *OLS* vs. *IV*, number of categories included, *#cat*, and whether the data is modified to include observations with zero values, *m*. In each table the first two columns include data for transportation, public safety, recreation, and total capital expenditures. The sample size for the even numbered columns is always larger than for the odd numbered

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[12]While this method may not prove the validity of the regressions differing results would certainly raise questions as to whether the results can be generalized to the broader population of counties. This is a potentially weak robustness check.

columns because the even numbered column are based on the modified data that contains all counties including those without fees.

Because total capital expenditure is an aggregate value and includes the other expenditure types it is dropped in columns (3) through (6) for tables E.3 and E.4. Columns (3) and (4) show the results for the transportation, public safety, and recreation data. Finally, because capital expenditure is lumpy and a small percentage of total expenditure for public safety, it is left out in columns (5) and (6) to compare expenditure response to impact-fee revenues for recreation directly to that of transportation. The last two columns, (5) and (6), show the results for transportation, and recreation only. Again the even numbered columns report results from the larger modified data set.

It is possible that the error term in the regression is correlated with revenues received as larger revenues may lead to larger per-capita expenditures. This correlation biases the coefficients on revenues upward. However, even if the coefficients are biased, as long as the coefficients on each category are biased the same we can still compare coefficients after estimation. It is not unreasonable to assume coefficients are biased in a similar manner across categories. If policy makers look at revenues and a list of potential projects to determine expenditure, it is not unreasonable to assume they determine how far down the list to go in a similar manner across different expenditure categories.

Each regression contains fee revenues as well as an interaction term between the type of fee and fee revenues. The term corresponding to transportation is omitted, thus, the coefficients on the interactions can be interpreted as the difference in response to non-transportation fee-revenues relative to the response to transportation-earmarked revenues. A negative coefficient indicates a revenue elasticity less than the elasticity for transportation revenues.

Tables E.3 and E.4 clearly show a positive response of capital expenditures to impact-fee revenues and a positive but statistically insignificant response to income. These results are evidence of a flypaper effect. Recall that the flypaper effect refers to a larger effect on spending of grants, intergovernmental revenues, etc. than an equal sized increase in constituent income.

If the money lands with the government it is spent by them, again, not surprising to even a casual observer. As a jurisdiction's income levels increase, capital expenditures do not necessarily increase as well.

However, with few exceptions the interaction term is negative for total capital expenditures, public safety, and recreation. The OLS estimates suggest a revenue elasticity of capital expenditure of .34 for transportation, .17 for recreation, and $-.05$ for public safety.[13] The coefficient on the interaction term for total is not statistically significant. This estimate is unsurprising as impact-fees are a small part of the aggregated expenditures which include spending on categories not funded with impact fees. It is important to notice that the magnitude of the negative coefficient on the public-safety interaction term is larger than the coefficient on the interaction term for recreation. This indicates that public-safety capital expenditures respond less to impact fee revenues than recreation capital expenditures which exhibit a smaller, although not always statistically significant, response than transportation. The negative coefficients suggest that policy makers are considering factors other than current revenue when making capital expenditure decisions.

One such factor could easily be future maintenance and operation costs. As shown in table E.2, capital expenditure in the transportation sector averages over 37% of sectoral spending and over 39% for counties with fees. For recreation spending, capital is only about 33% of spending on average and only 27% of sector expenditures for counties with fees. But for public safety, capital is, on average, only 8%.[14] These percentages indicate that on average, 61% of transportation, 73% of recreation, and 92% of public safety expenditures are directed toward non-capital operating costs. Clearly it is more expensive to operate a jail than

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[13]Interpreting the negative elasticity on public safety revenues to mean additional revenues cause a community to spend less than it would if it received no revenues is too strong an interpretation for a number so close to zero.

[14]For some sectors items that appear to be capital, such as police cars, may not be counted as such for accounting purposes. However, because of accounting rules the items cannot be funded with fee revenues either.

a road.[15] Further reinforcing the effect is that transportation often has designated funding sources, such as sales taxes on fuel, to help offset the operating costs, while public safety revenues are presumably much smaller. The larger operating revenue sources associated with transportation combined with a larger capital component makes transportation facilities cheaper to operate in the future than recreation or public safety facilities with relatively small income streams.

When deciding which capital projects to pursue, local leaders must consider not only current cash flow constraints but also future budget constraints. While political leaders are often criticized for myopic decision making, these results suggest the process is more forward looking than often assumed. The results also suggest that economic models of public choice should include forward looking and dynamic elements. These results support the call by Turnbull (2005) for a more dynamic approach to modeling.

4.6 Conclusion

The results of the empirical analysis provide evidence of a flypaper effect, a larger response to grants than to income, that varies across sectors of government spending. Grants and fees to relatively capital-intensive sectors show much larger flypaper effects than do grants to sectors where capital investment requires large maintenance and operation expenditures in the future. The results presented in this paper draw attention to the forward-looking factors that are part of the total effect of grants and fees on local spending. The difference in stickiness of revenues across expenditure categories should be considered when designing fiscal federalism programs or fiscal stimulus packages. While beyond the scope of this paper, the portion of the grant or windfall paid by existing residents is an additional factor in a grant's stickiness. (see Heyndels & Van Driessche (2002) and Strumpf (1998)) Future work

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[15]This result is based on the assumption that capital expenditures represent an increase in capital and a fixed-input mix for government services.

should further distinguish between future operating cost considerations and revenue source effects to generate a more detailed model of grant and aide effectiveness.

4.7 FUTURE RESEARCH

The work presented in this paper is subject to severe data limitations and should be extended to larger samples with more flexible modeling techniques. Future research should also use service levels such as congestion percentage or drive time instead of government expenditure levels. Government expenditure is a crude proxy for the service level received by constituents. For example, the amount spent on transportation may bear little resemblance to the level of service provided. A simultaneous equations model similar to the one used in Duncombe (1991) would be appropriate.

Because many of the sectors partially funded by impact fees are capital intensive, previous levels of expenditure could have an affect on current service levels. Incorporating a measure of the public capital stock would be an appropriate control and may help explain some of the variation. Unfortunately, such data are not easy to come by. For example, assuming transportation services are dominated by automobile transport, a measure of lane mileage would be a good variable to include. However, available estimates such as centerline miles do not factor in multiple lane roads. A less developed county that has built a minimal amount of two lane roads may appear to have more roads than a developed county with larger multi-lane roads.

Future research should also verify this paper's finding of differing responses to revenues depending on future operation costs. One such way would be to use a similar model to examine tax windfalls and see if expenditure patterns are consistent with the pattern presented above.

Regardless of the approach, there is much work to be done if we want to fully explain and predict the flypaper effect. Theoretical models should include both source and use effects on predicted expenditures and need to be dynamic and forward looking models. As research

progresses toward an effective predictive index–which would be invaluable to policy makers–empirical studies should include controls for both the source of the revenue and future operational expenditure requirements. It is with these thoughts in mind that we must proceed in the research of the flypaper effect.

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Derivation of p^f and n^f:

After adding infrastructure costs–which are paid by the firm under a fee system–to the firm's objective function, (2.4), firm i chooses its price to maximize

$$(p_i - c)(p + \frac{M}{n} - p_i) - F - Ms \tag{A.1}$$

with first order condition:

$$(p + \frac{M}{n} - p_i) - (p_i - c) = 0. \tag{A.2}$$

With free entry of firms, all firms charge the same price in equilibrium, $p_i = p^f$, thus

$$p^f = \frac{M}{n} + c. \tag{A.3}$$

Substituting for p in the modified zero profit condition, $(p - c)(M/n) - F - Ms = 0$ and solving for n^f we find

$$n^f = M(F + Ms)^{-1/2}. \tag{A.4}$$

Substituting back into our original equation for price, (A.2), we obtain

$$p^f = (F + Ms)^{1/2} + c. \tag{A.5}$$

Proof of Possible Pareto Improvement for a Single Homogeneous Jurisdiction

Without making assumptions about the magnitude of fixed costs or household infrastructure costs we cannot prove that switching to fees is a Pareto improvement. However, because the model is linear, we can compare the average household under each regime and conclude

that the use of fees is a potential Pareto improvement. The average distance traveled by a household is

$$x = \frac{\int_0^{1/2n} M \, L \, dL}{\int_0^{1/2n} M \, DL} = \frac{1}{4}\frac{1}{n} \tag{A.6}$$

where L is the distance traveled by each household. Using (A.6) and equations (2.11) and (2.15) we find welfare for the average household under taxes to be

$$W^t = B - \left[\frac{5}{4}F^{1/2} + c + MF^{-1/2}s\right] \tag{A.7}$$

and under fees to be

$$W^f = B - \left[\frac{5}{4}(F + Ms)^{1/2} + c\right]. \tag{A.8}$$

Subtracting the average household's welfare under taxes from welfare under fees we find

$$W^f - W^t = -\frac{5}{4}(F + Ms)^{1/2} + \frac{5}{4}F^{1/2} + MF^{-1/2}s$$
$$= F^{-1/2}\left[\frac{5}{4}F + Ms - \frac{5}{4}(F^2 + FMs)^{1/2}\right].$$

To see that the last equation is positive, note that the term in brackets is positive because $((5/4)F + Ms)^2 > (25/16)(F^2 + FMs)$. Thus, a switch to using fees is a potential Pareto improvement.

Derivation of n^f and p^f under heterogeneity:

After adding infrastructure costs paid by the firm under fees to the firms objective function, (2.25), firm i chooses its price to maximize

$$(p_i - c)(M^L + zM^H)\left(\frac{p + \frac{M^L + M^H}{n} - p_i}{M^L + M^H}\right) - F - (M^L + M^H)s \tag{A.9}$$

with first order condition

$$(p + \frac{M}{n} - p_i) - (p_i - c) = 0. \tag{A.10}$$

with free entry of firms, all firms charge the same price in equilibrium, $p_i = p^f$, thus

$$p = \frac{M^L + M^H}{n} + c. \tag{A.11}$$

Substituting for p in the modified zero profit condition of $(p-c)(M^L+M^H)/n^f - F - (M^L + M^H)s = 0$ and solving for n^f we find

$$n^f = \left[\frac{(M^L + M^H)(M^L + zM^H)}{F + (M^L + M^H)s}\right]^{1/2}. \tag{A.12}$$

Substituting back into the equation for price, (A.11) we obtain

$$p^f = \left[\frac{(M^L + M^H)(F + (M^L + M^H)s)}{M^L + zM^H}\right]^{1/2} + c. \tag{A.13}$$

Detailed proof of Proposition 7:

Using equations (2.36) for W_H^f and (2.32) for W_H^t we find it is possible that $W_H^f < W_H^t$ if z is large enough. Substituting for we find

$$zB \quad - \quad \left[\frac{3}{2}z\left(\frac{(M^L + M^H)(F + (M^L + M^H)s)}{M^L + zM^H}\right)^{1/2} + zc + z(M^L + M^H)x \right. \tag{A.14}$$
$$\left. -\frac{1}{2}z\left(\frac{F(M^L + M^H)}{M^L + zM^H}\right)^{1/2}\right] < zB - \left[z\left(\frac{(M^L + M^H)F}{M^L + zM^H}\right)^{1/2} + zc + \right.$$
$$\left. z(M^L + M^H)x + s\left(\frac{(M^L + M^H)(M^L + zM^H)}{F}\right)^{1/2}\right].$$

After factoring out $-[(M^L + M^H)/(M^L + zM^H)]^{1/2}$ and canceling terms we obtain

$$z(F + (M^L + M^H)s)^{1/2} + \frac{1}{2}z(F + (M^L + M^H)s)^{1/2} - \frac{1}{2}zF^{1/2} > zF^{1/2} + s(M^L + zM^H)F^{-1/2}.$$

After multiplying through by $F^{1/2}$, collecting terms, and setting $M^H = M^L$ we finally obtain

$$\frac{3}{2}z(F^2 + 2FM^Ls)^{1/2} > \frac{3}{2}zF + sM^L(1 + z).$$

Detailed proof of Proposition 8:

Substituting for $W_L^f(x)$, $W_L^t(x)$, $W_H^t(x)$, and $W_H^f(x)$ from (2.32), (2.36), (2.35), and (2.31) in $W_H^t(x) - W_H^f(x) > W_L^f(x) - W_L^t(x)$ and factoring out $(M/D)^{1/2}F^{-1/2}$ we obtain

$$\left[\left(z + \frac{1}{4}\right)(F^2 + FMs)^{1/2} - \left(z + \frac{1}{4}\right)F - Ds\right] > \left[\frac{5}{4}F + Ds - \frac{5}{4}(F^2 + FMs)^{1/2}\right].$$

After rearranging terms we find

$$\left(z + \frac{3}{2}\right)(F^2 + FMs)^{1/2} > \left(z + \frac{3}{2}\right)F + 2Ds.$$

Squaring both sides and canceling out common terms yields

$$\left(z + \frac{3}{2}\right)^2 FMs > 4\left(z + \frac{3}{2}\right)FDs + (2Ds)^2.$$

The last equation is true if z is large enough and M^H is small enough.

Proof of Possible Pareto Improvement for a Single Heterogeneous Jurisdiction

Using an equal weighted additive social utility function we find that using fees is a potential Pareto improvement. From *Proposition 5* we know that L-types gain from a switch to fees but the result for H-types is ambiguous. In order for the use of to be a potential Pareto improvement, total social welfare under fees must be greater than under taxes.

For simplicity, let M represent the number of households, $M^L + M^H$, and let D represent their demand $(M^L + zM^H)$. Using equations (2.36) for W_H^f and (2.32) for W_H^t the change in welfare for an H-type is

$$
\begin{aligned}
W_H^f - W_H^t &= z\left[\left(\frac{MF}{D}\right)^{1/2} - \left(\frac{M(F+Ms)}{D}\right)^{1/2}\right] \\
&\quad + \frac{M}{4}\left[\left(\frac{F}{MD}\right)^{1/2} - \left(\frac{F+Ms}{MD}\right)^{1/2}\right] + \left(\frac{MD}{F}\right)^{1/2}s \\
&= \left(\frac{M}{D}\right)^{1/2}\left[z[F^{1/2} - (F+Ms)^{1/2}] + \frac{1}{4}[F^{1/2} - (F+Ms)^{1/2}] + \left(\frac{D}{F^{1/2}}\right)s\right] \\
&= \left(\frac{M}{D}\right)^{1/2}\left[(z + \frac{1}{4})(F^{1/2} - (F+Ms)^{1/2}) + \left(\frac{D}{F^{1/2}}\right)s\right].
\end{aligned}
$$

Using the same process for L-types and using equations (2.31) and (2.35) we find the gain from using to fees to be

$$
W_L^f - W_L^t = \left(\frac{MF}{D}\right)^{1/2} - \left[\frac{M(F+Ms)}{D}\right]^{1/2} + \frac{M}{4}\left[\left(\frac{F}{MD}\right)^{1/2} - \left(\frac{F+Ms}{MD}\right)^{1/2}\right]
$$

$$
+ \left(\frac{MD}{F}\right)^{1/2} s
$$

$$
= \left(\frac{M}{D}\right)^{1/2}[F^{1/2} - (F+Ms)^{1/2}] + \left(\frac{M}{D}\right)^{1/2}\frac{1}{4}[f^{1/2} - (F+Ms)^{1/2}]
$$

$$
+ \left(\frac{M}{D}\right)^{1/2}\frac{D}{F^{1/2}}s
$$

$$
= \left(\frac{M}{D}\right)^{1/2}\left[\frac{5}{4}F + Ds - \frac{5}{4}(F^2 + FMs)^{1/2}\right].
$$

Combining the changes in welfare for both H-types and L-types we find that the total change in utility for the jurisdiction, $W_j^f - W_j^t$, is equal to

$$
W_j^f - W_j^t = M^H\left(\frac{M}{D}\right)^{1/2}\left[(z+\frac{1}{4})(F^{1/2} - (F+Ms)^{1/2}) + \left(\frac{D}{F^{1/2}}\right)s\right]
$$

$$
+ M^L\left(\frac{M}{D}\right)^{1/2}\left[\frac{5}{4}F + Ds - \frac{5}{4}(F^2 + FMs)^{1/2}\right]
$$

$$
= \left(\frac{M}{D}\right)^{1/2}\left[\left(M^H\left(z+\frac{1}{4}\right) + \frac{5}{4}M^L\right)(F^{1/2} - (F+Ms)^{1/2})\right.
$$

$$
\left. + (M^H + M^L)\frac{D}{F^{1/2}}s\right].
$$

In order for the previous equation to be positive the term inside the brackets must be positive. After distributing, rearranging and multiplying through by $F^{1/2}$ we find the term to be positive because

$$
\left[M^H\left(z+\frac{1}{4}\right) + \frac{5}{4}M^L\right]F + (M^L + M^H)(M^L + zM^H)s
$$

$$
> \left[M^H\left(z+\frac{1}{4}\right) + \frac{5}{4}M^L\right][F^2 + F(M^L + M^H)s]^{1/2}.
$$

APPENDIX B

TABLE FOR CHAPTER 2

Table B.1: States with Impact Fee-Enabling Acts

State	Year
Arizona	1988
Arkansas	2003
California	1989
Colorado	2001
Florida	2006
Georgia	1990
Hawaii	1992
Idaho	1992
Illinois	1987
Indiana	1991
Maine	1988
Montana	2005
Nevada	1989
New Hampshire	1991
New Jersey	1989
New Mexico	1993
Oregon	1991
Pennsylvania	1990
Rhode Island	2000
South Carolina	1999
Texas	1987
Utah	1995
Vermont	1989
Virginia	1990
Washington	1991
West Virginia	1990
Wisconsin	1993

Source: impactfees.com, 2008

Derivation of U^t:

Substituting $1/4n^t$ into (3.10) yields

$$U^t = B - \left[p + \frac{M}{4n^t} + n^t s \right].$$ (C.1)

Using the equation (3.8) for n^t and (3.9) for p^t in (C.1) we find

$$U^t = B - \left[F^{1/2} + c + \frac{M}{4MF^{-1/2}} + MsF^{-1/2} \right]$$ (C.2)

which simplifies to our equation for the average household's welfare under taxes

$$U^t = B - \left[\frac{5}{4} F^{1/2} + c + MsF^{-1/2} \right].$$ (C.3)

Derivation of W^g:

Substituting (3.26), (3.24), and using the location of the average household, $1/(4n^g)$, for x in (3.12) yields

$$U^g = B - \left[\left(1 + \frac{4Ms}{F - 4Ms} \right)^{1/2} F^{1/2} + c + \frac{\left(1 + \frac{4Ms}{F - 4Ms} \right) M}{4n^g} \right].$$ (C.4)

Substituting (3.25) for n^g and simplifying the last term yields

$$U^g = B - \left[\left(1 + \frac{4Ms}{F - 4Ms} \right)^{1/2} F^{1/2} + c + \frac{1}{4} \left(1 + \frac{4Ms}{F - 4Ms} \right) F^{1/2} \right]$$ (C.5)

and simplifies to

$$W^g = B - \left[\frac{5}{4} \left(1 + \frac{4Ms}{F - 4Ms} \right)^{1/2} F^{1/2} + c \right].$$ (C.6)

Proof of $W^t - W^g > 0$:

Subtracting equation, (3.27) for W^g from (3.11) for W^t, we obtain

$$W^t - W^g = B - \left[\frac{5}{4}F^{1/2} + c + MsF^{-1/2}\right] - B + \left[\frac{5}{4}(1 + \frac{4Ms}{F - 4Ms})^{1/2}F^{1/2} + c\right] \quad \text{(C.7)}$$

which after collecting terms simplifies to

$$W^t - W^g = \frac{5}{4}\left(1 + \frac{4Ms}{F - 4Ms}\right)^{1/2}F^{1/2} - \frac{5}{4}F^{1/2} - MsF^{-1/2}. \quad \text{(C.8)}$$

After factoring out $F^{-1/2}$ we are left with (3.35)

$$W^t - W^g = F^{-1/2}\left[\frac{5}{4}\left(1 + \frac{4Ms}{F - 4Ms}\right)^{1/2}F - \frac{5}{4}F - Ms\right]. \quad \text{(C.9)}$$

To see that this equation is positive we can compare the first term in the bracket to the sum of the latter two and see that

$$\frac{5}{4}\left(F^2 + \frac{4MsF^2}{F - 4Ms}\right)^{1/2} > \frac{5}{4}F + Ms. \quad \text{(C.10)}$$

After squaring both sides we see

$$\frac{25}{16}F^2 + \frac{25}{4}\frac{MsF^2}{F - 4Ms} > \frac{25}{16}F^2 + \frac{5}{2}FMs + (Ms)^2. \quad \text{(C.11)}$$

which after canceling and multiplying both sides by $(F - 4Ms)$, which must be positive because the gas tax must be strictly positive to generate revenue to build infrastructure, $r = (4Ms)/(F - 4Ms) > 0$, we see

$$25MsF^2 > (4F - 16Ms)\left(\frac{5}{2}FMs + (Ms)^2\right). \quad \text{(C.12)}$$

Carrying out the multiplication yields

$$25MsF^2 > 10F^2Ms + 4F(Ms)^2 - 40F(Ms)^2 - 16(Ms)^3 \quad \text{(C.13)}$$

which we can clearly see is positive when all the terms are collected on the left-hand-side

$$15MsF^2 + 36F(Ms)^2 + 16(Ms)^3 > 0. \quad \text{(C.14)}$$

Intuition for Proposition 1 The intuition for *Proposition 1* is that the costs to the household increase under a gas tax by more than the taxes paid under a financing regime. To see this I compare the increase in price net of a reduction in transport costs, to the taxes paid in a property tax regime.

$$p^g - p^t + \frac{M}{4}\left[\frac{(1+r)^{1/2}}{n^g} - \frac{1}{n^t}\right] > n^t s \tag{C.15}$$

Substituting for equations 3.26, 3.9, 3.25, 3.8 for p^g, P^t, n^g, and n^t respectively yields

$$(1+r)^{1/2}F^{1/2} + c - F^{1/2} - c + \frac{M}{4}\left[\frac{(1+r)F^{1/2}}{M(1+r)^{1/2}} - \frac{F^{1/2}}{M}\right] > MsF^{-1/2} \tag{C.16}$$

and after collecting terms, canceling, and multiplying through by $1/F^{1/2}$ yields

$$\frac{5Ms}{F - 4Ms} > \frac{Ms}{F}. \tag{C.17}$$

Derivation of W^f

Similar to the property tax regime, under a system of fees the consumer is indifferent to purchasing from a firm in the clockwise or counterclockwise direction if the total cost of the good is the same, (3.1), thus the firm's demand is the same as it is under taxes, (3.3). However, because the firm must now pay an impact fee, F, the profit function includes the fee as an additional fixed cost

$$(p_i - c)(p + \frac{M}{n} - p_i) - F - Ms \tag{C.18}$$

but yields the same first order condition (3.5). Because there are not barriers to entry, other than fixed cost F and the impact fee Ms, the identical firms all charge the same price, $p_i = p$. Thus

$$p^f = \frac{m}{n^f} + c. \tag{C.19}$$

Firms also face a zero profit condition of

$$(p^f - c)(\frac{M}{n^t} - F - Ms = 0. \tag{C.20}$$

Combining (C.19) and (C.20) we can solve for the equilibrium number of firms

$$n^t = \left(\frac{M^2}{F + Ms}\right)^{1/2} = M(F + Ms)^{-1/2}. \tag{C.21}$$

Substituting (C.21) into (C.20) yields the per-unit price under fees

$$p^f = (F + Ms)^{1/2} + c. \tag{C.22}$$

We can solve for the average household's welfare using the equation for price, (C.22), the average consumer's travel distance of $1/4n^t$, and a welfare equation similar to that of the household under taxes, (3.11), but without the tax costs, ns. Thus, the welfare for the average household under an impact-fee regime is

$$W^f = B - \left[\frac{5}{4}(F + Ms)^{1/2} + c\right] \tag{C.23}$$

the same as asserted in equation (3.34). **Proof of $W^f - W^g > 0$:**

Subtracting equation (3.27) for W^g from (3.34) for W^f we find

$$W^f - W^g = B - \left[\frac{5}{4}(F + Ms)^{1/2} + c\right] - B + \left[\frac{5}{4}\left(1 + \frac{4Ms}{F - 4Ms}\right)^{1/2} F^{1/2} + c\right] \tag{C.24}$$

which simplifies to

$$W^f - W^g = \frac{5}{4}\left(1 + \frac{4Ms}{F - 4Ms}\right)^{1/2} - \frac{5}{4}(F + Ms)^{1/2}. \tag{C.25}$$

Factoring out $(5/4)F^{-1/2}$ we see

$$W^f - W^g = \frac{5}{4}F^{-1/2}\left[\left(F^2 + \frac{4MsF^2}{F - 4Ms}\right)^{1/2} - (F^2 + MsF)^{1/2}\right]. \tag{C.26}$$

To see the last equation is positive, notice that the term in brackets is greater than zero. To see this, we square both terms to find

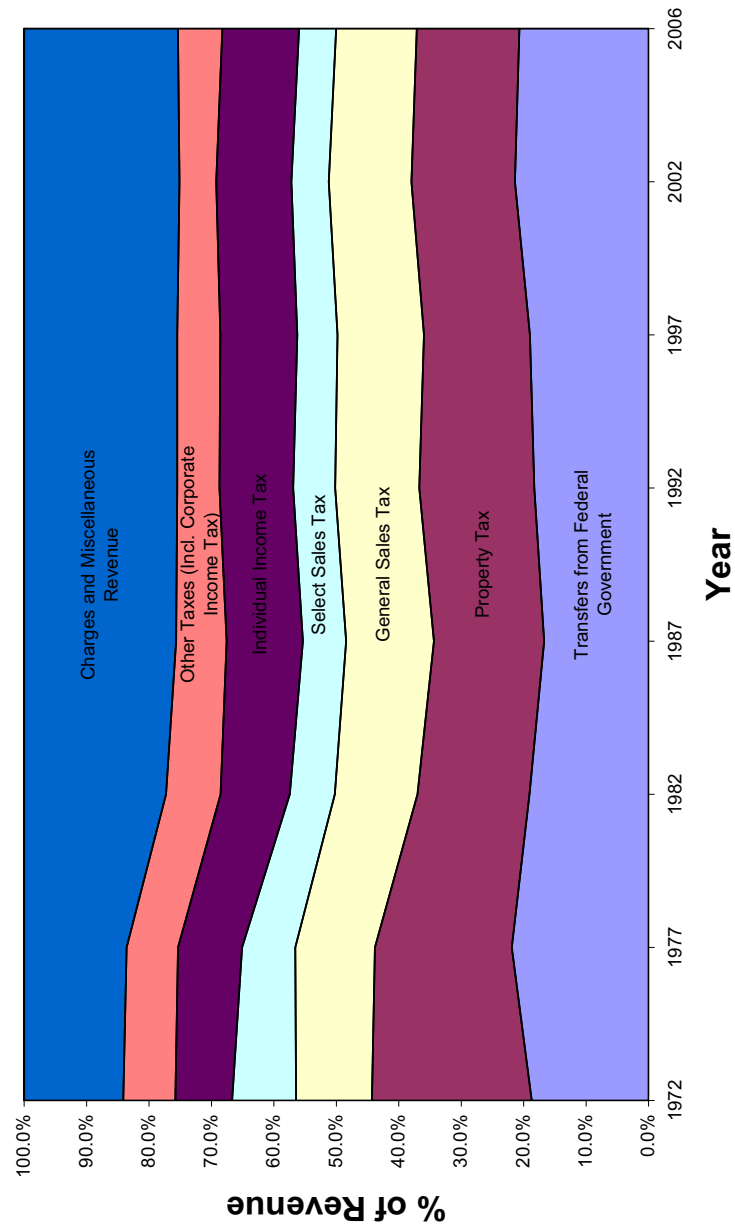$$F^2 + \frac{4MsF^2}{F - 4Ms} > F^2 + MsF \tag{C.27}$$

which after canceling out the F^2 terms and multiplying through by $(F - 4Ms)$, which must be positive if $r > 0$, and simplifying yields

$$4MsF^2 > MsF^2 - 4(Ms)^2F. \tag{C.28}$$

APPENDIX D

FIGURES FOR CHAPTER 4

Figure D.1: State and Local General Revenue by Source

Appendix E

Tables for Chapter 4

Table E.1: Summary Statistics

	With Fees			Without Fees			All Counties		
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
Capital Exp. Per Capita									
Transportation	26	52.88	24.13	38	80.64	85.87	64	69.36	68.92
Recreation	15	29.68	29.35	49	26.71	53.92	64	27.41	49.07
Public Safety	26	27.83	20.19	38	23.64	15.60	64	25.34	17.57
Total	34	119.07	92.74	30	125.56	90.38	64	122.12	90.97
Impact Fee Rev. Per Capita									
Transportation	26	18.52	13.04						
Recreation	15	4.97	4.60						
Public Safety	26	8.28	14.97						
Total	34	22.69	18.21						
Public Sector Wage									
Transportation	26	2615.15	423.14	38	2172.23	334.78	64	2352.17	430.05
Recreation	15	2198.55	224.75	48	1958.40	338.66	63	2015.58	330.12
Public Safety	26	3481.93	676.64	37	2953.93	660.32	63	3171.84	711.65
Total	34	3017.90	594.80	30	2505.32	402.86	64	2777.63	571.39
Per Capita Income	26	37986.58	5436.42	38	31930.32	5995.88	64	34390.67	6467.57
Population	26	425287	549750	38	103983.4	207191.1	64	234513	412843
Per. Owner Occ. Housing	26	0.754	0.09	38	0.774	0.059	64	0.767	0.073
Debt to Revenue Ratio	26	.446	.317	37	.256	.210	63	.335	.274
Population Growth Rate	26	0.025	0.017	38	0.01	0.032	64	0.016	0.028
State Grant Per Capita									
Transportation	26	3.75	5.33	38	40.94	92.41	64	25.83	73.25
Recreation	15	4.75	5.33	49	7.30	10.92	64	6.70	9.92
Public Safety	26	8.53	12.65	38	7.02	8.23	64	7.63	10.19
Total	34	27.22	70.77	30	54.82	94.59	64	40.16	83.28

Table E.2: Capital as a Percentage of Total Expenditure

	(1)	(2)	(3)	(4)
Sector	All Counties	With Fees	Without Fees	
	N	N	N	
Total Exp.	.09	.08	.10	
	N=66	N=36	N=30	
Transportation	.37	.39	.36	
	N=66	N=28	N=38	
Public Safety	.08	.08	.09	
	N=66	N=28	N=38	
Recreation	.33	.27	.35	
	N=66	N=17	N=49	

Table E.3: OLS Estimation

	(1)	(2)	(3)	(4)	(5)	(6)
	ols4cat	ols4catm	ols3cat	ols3catm	ols2cat	ols2catm
ln_fee_per_capita	0.336***	0.295***	0.395***	0.334***	0.387**	0.280***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.031)	(0.002)
ln_med_inc	0.615	0.361	1.562*	0.588	0.874	0.0244
	(0.402)	(0.429)	(0.061)	(0.193)	(0.347)	(0.967)
ln_wage	0.898*	0.984***	1.215*	0.696**	1.219	1.422
	(0.078)	(0.003)	(0.057)	(0.042)	(0.362)	(0.138)
ln_tax_share	-0.529	-0.397	-0.286	-0.604	-1.631	-0.791
	(0.502)	(0.303)	(0.756)	(0.131)	(0.229)	(0.212)
ln_pop2002	-0.718	-0.530	-0.458	-0.734*	-1.702	-0.936
	(0.345)	(0.183)	(0.600)	(0.072)	(0.182)	(0.137)
ln_own_occ	-3.069	-1.402	-1.269	-1.342	-2.949	-1.534
	(0.118)	(0.201)	(0.504)	(0.219)	(0.202)	(0.306)
ln_debt_rev_ratio2002	0.0118	0.0462	-0.0306	0.0390	-0.0582	0.0426
	(0.797)	(0.288)	(0.429)	(0.423)	(0.229)	(0.532)
growth_rate	-3.557	-3.504*	-7.226	-3.958**	-0.626	-3.103
	(0.618)	(0.052)	(0.397)	(0.023)	(0.967)	(0.274)
ln_grant_per_capita	0.226***	0.315***	0.135*	0.178**	0.216**	0.176*
	(0.006)	(0.000)	(0.051)	(0.039)	(0.032)	(0.088)
recreation_x_fee	-0.164	-0.246*	-0.154	-0.242*	-0.200	-0.206*
	(0.244)	(0.070)	(0.344)	(0.089)	(0.264)	(0.213)
public_safety_x_fee	-0.381***	-0.489***	-0.401***	-0.401***		
	(0.000)	(0.000)	(0.000)	(0.000)		
total_x_fee	0.0742	0.210				
	(0.237)	(0.675)				
_cons	-8.802	-7.051	-21.23**	-6.948	-14.74	-6.267
	(0.335)	(0.177)	(0.049)	(0.165)	(0.307)	(0.481)
N	103	253	67	189	39	126
R^2	0.592	0.343	0.463	0.182	0.531	0.184

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Table E.4: IV Estimation

	(1)	(2)	(3)	(4)	(5)	(6)
	iv4cat	iv4catm	iv3cat	iv3catm	iv2cat	iv2catm
ln_fee_per_capita	0.355***	0.293***	0.393***	0.336***	0.265	0.284***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.202)	(0.007)
ln_med_inc	0.261	0.371	1.708*	0.561	-2.168	0.0260
	(0.774)	(0.394)	(0.098)	(0.202)	(0.493)	(0.963)
ln_wage	1.066*	0.995***	1.174*	0.686**	2.296	1.378
	(0.063)	(0.002)	(0.097)	(0.036)	(0.308)	(0.203)
ln_tax_share	-0.653	-0.405	-0.215	-0.578	-3.044*	-0.742
	(0.393)	(0.292)	(0.760)	(0.173)	(0.093)	(0.370)
ln_pop2002	-0.772	-0.549	-0.410	-0.689	-2.901*	-0.874
	(0.302)	(0.200)	(0.524)	(0.146)	(0.070)	(0.334)
ln_own_occ	-3.226*	-1.401	-1.122	-1.354	-5.710*	-1.529
	(0.059)	(0.181)	(0.416)	(0.184)	(0.081)	(0.283)
ln_debt_rev_ratio2002	0.0231	0.0466	-0.0354	0.0376	0.0525	0.0434
	(0.509)	(0.281)	(0.406)	(0.406)	(0.668)	(0.489)
growth_rate	-2.706	-3.691*	-7.606	-3.516*	11.80	-2.875
	(0.686)	(0.060)	(0.262)	(0.093)	(0.488)	(0.385)
ln_grant_per_capita	0.391	0.285	0.0800	0.253	0.898	0.221
	(0.225)	(0.218)	(0.852)	(0.413)	(0.175)	(0.632)
recreation_x_fee	-0.161	-0.241*	-0.153	-0.254*	-0.192	-0.214
	(0.186)	(0.080)	(0.300)	(0.079)	(0.184)	(0.242)
public_safety_x_fee	-0.395***	-0.488***	-0.399***	-0.410***		
	(0.000)	(0.000)	(0.000)	(0.000)		
total_x_fee	0.00358	0.0323				
	(0.980)	(0.741)				
_cons	-7.427	-7.051	-22.12**	-6.972	6.172	-6.201
	(0.406)	(0.155)	(0.011)	(0.151)	(0.819)	(0.471)
N	103	253	67	189	39	126
R^2	0.564	0.342	0.459	0.177	0.024	0.182

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$