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A tragedy of the anticommons: local option taxation and cell phone tax bills

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Abstract When multiple taxing jurisdictions overlap and fail to account for one another's actions, they over-tax the common base. This is a prediction of the anti-commons model, in which numerous parties have authority to exclude others from using a resource. This model further predicts that when governments over-tax the base, private parties will underutilize the resource, and underutilization will be greater as the number of parties with exclusion rights rises. We test these predictions by studying cell phone taxation and local option tax authority, which allows some cities, counties, and special-purpose districts to levy taxes on cell phone use. Consistent with theory, we find that the tax rate on cell phone service is higher when local governments have the option to tax. Further, the percentage of households owning cell phones is lower when there is the local option to tax, and ownership rates fall with the number of taxes levied.

Keywords Anticommons · Overlapping jurisdictions · State taxation · Vertical externalities · Fiscal federalism

JEL Classification H1 · H3 · H7

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1 Introduction

Beginning with Cassing and Hillman (1982), a number of authors have identified spillovers or externalities when multiple levels of government possess the authority to tax the same base. If each government level fails to account for the taxes that others levy, economic theory predicts that the total tax rate will exceed that which would be imposed by a unified government.

We suggest that this situation is an application of what has come to be known as the tragedy of the anticommons. The latter arises when multiple parties have the authority to block access to a resource, resulting in under-utilization of that resource. Michael Heller (1998), whose work spawned the anticommons literature, has noted that though "anti-commons theory is now well established…empirical studies have yet to catch up" (Heller 2012, p. 68). Viewing the overlapping tax jurisdiction as an application of the anticommons offers an environment in which to test the theory.

We test the anticommons model using institutional variation in local option taxing authority across US city governments. We focus on cross-city variation in local (that is, county, city, and special-purpose district) authority to tax goods and services. This local taxing authority, referred to as the local option to tax, is granted in statutes of 37 states.

We test the model's predictions by focusing on the market for mobile (cellular) telephone services, which supplies an ideal empirical setting. First, this market is somewhat unusual in that multiple overlapping jurisdictions have the authority to levy taxes on the use of this service. Second, in most cases the local authority to tax, which permits taxation by multiple levels of government, was included in state statutes long before the adoption of cell phone technology, minimizing concerns of reverse-causality. Third, the relatively high tax rates that apply to mobile phone service are not easily justified on normative grounds since this service has no obvious negative externality characteristics, and the demand for cell phone services is relatively elastic (Ward and Woroch 2010).

First, we ask whether the combined state and local tax rate on cell phone service is higher in cities where local governments have the option to tax. Second, we test whether the "tragedy of the anticommons" leads to less resource use. Here, we study whether household cell phone ownership is lower in cities where city governments and other local authorities have the option to tax. Third, we analyze whether household cell ownership falls with the number of taxes levied on cell phone use.

Our empirical analysis supports the anticommons model's prediction that the combined tax rate is higher when local governments have the option to levy taxes. This finding suggests that when the institution of local option taxation is present, the tax base becomes an anticommons. Further, our results show that cell phone adoption is lower in cities with local taxing authority, and that cell phone ownership rates fall with the number of taxes levied. These findings show that an anticommons leads to underutilization of a resource.

Our findings contribute an explanation for the puzzling observation that cell phone services are subject to higher taxation than other services. For example, while in 2010 the combined average state and local sales tax was 7.33 %, the combined federal, state, and local tax rate on mobile service averaged 16.26 % and the combined state and local tax on these services averaged 11.21 % (Mackey 2011). Moreover, the average cell phone tax rate exceeds the average tax rate on alcohol, the latter being a product with perhaps more

apparent negative externality characteristics than mobile phone services. For example, the average tax rate applied to beer is 9.2 %.[1]

In the next section we discuss how the literature on vertical tax externalities in federal systems of government can be viewed as an application of the anticommons model. In Sect. 3 we provide background on cell phone taxation, and in Sect. 4 we offer a more detailed description of cell phone taxes in New York city and Albany, New York. Section 5 describes the local option institution and presents our testable hypotheses. Section 6 contains our data analysis. Section 7 offers concluding remarks.

2 The tragedy of the anticommons and vertical tax externalities

The tragedy of the commons refers to instances in which multiple parties have access to a common resource (Hardin 1968). Each party fails to account for the fact that his use diminishes the amount available to other users, causing the resource to be over-utilized. Commercial fishing in the open sea is a classic example. No single fisherman has an incentive to take full account of the consequences of his actions, so a fleet of independent commercial fishermen will tend to overfish, sometimes driving species to the brink of extinction.

In contrast, a tragedy of the anticommons arises when multiple parties can—through taxation, regulation, veto power, or other means—exclude others from the use of a resource. The mirror image of the tragedy of the commons, a tragedy of the anticommons leads to over-exclusion and therefore underutilization of the resource.[2] Originally developed by Heller (1998), the anticommons concept was modeled formally by Buchanan and Yoon (2000) and Yoon and Shughart (2013). Recent work by Heller (2010) illustrates the importance of the anticommons by providing multiple examples. To date, most anticommons research has been primarily theoretical rather than empirical (Heller 2012).

Though the term "anticommons" is relatively new, the phenomenon described by this term dates back to antiquity. The Rhine River during the middle ages provides a classic example (Gardner et al. 2002). Under the Holy Roman Empire, river taxation was modest and trade, protected by the Treaty of Westphalia, flourished along the Rhine (Gross 1948). At this point there was no underuse because only one entity—the Empire—had the authority to tax trade along the river. With costs and benefits internalized, the Empire had no incentive to over-tax the base to the point that revenue began to decline. Once the Empire fell, however, local barons erected a series of castles along the river and began exacting their own tolls. Acting independently, each baron failed to account for the fact that his taxes diminished the base on which other (down-river) barons collected tolls. As a whole, the barons overtaxed trade along the Rhine, and the river was underutilized as a trade route by private parties. According to Heller (2010, p. 3), "the growing gauntlet of 'robber baron' tollbooths made shipping impracticable. The river continued to flow, but boatmen would no longer bother making the journey… For hundreds of years, everyone suffered—even the barons. The European economic pie shrank. Wealth disappeared. Too many tolls meant too little trade."

Buchanan and Yoon (2000) formalize the anticommons model. They assume that two parties have the authority to exclude access to a resource, using the example of a parking lot. Imagine that the two parties independently can tax those who use the parking lot.

[1] For the state and local sales tax rate, see Mackey (2011). For the beer tax, see Rothschild (2011).

[2] For a recent treatment of a related concept, the fiscal commons, see Wagner (2012).

Buchanan and Yoon assume an absence of trust between the two parties, so "explicit collusion," which would "allow for attainment of the efficient solution," is impossible (Buchanan and Yoon 2000, p. 8). The demand for the parking lot is a linear function of the combined tax charged by the two parties, $T = T_1 + T_2 = a - bQ$ where T is the sum of the tax levied by the first party, T_1, and the tax levied by the second party, T_2, and Q is the total number of parking spaces utilized. A symmetric Nash equilibrium exists in which each tax authority sets its own tax to maximize revenue. In this equilibrium, the combined tax is set higher than the optimal tax ($T = 2a/3$ rather than $T = a/2$) and the parking lot is underutilized ($Q = a/3b$ rather than $Q = a/2b$). Extending the model to multiple excluders (n), Eq. (1) shows the equilibrium tax, T^*, and Eq. (2) the equilibrium quantity, $Q^*(n)$.

$$T^* = \frac{na}{n+1} \tag{1}$$

$$Q^*(n) = \frac{a}{b(n+1)} \tag{2}$$

These equilibrium solutions show that as the number of excluders, n, increases, the combined tax, T^*, rises and the quantity, $Q^*(n)$, falls. The model therefore offers three testable hypotheses. First, the combined tax is higher when multiple parties have the right to exclude. Second, the resource is underutilized when multiple parties possess exclusion rights. And third, resource utilization falls as the number of excluders rises.

In a separate literature, beginning with Cassing and Hillman (1982), a number of authors identified a potential externality problem in federal systems in which overlapping jurisdictions tax the same base. Examples of this work include Flowers (1988), Johnson (1988), Shughart and Tollison (1991), Dahlby (1996), Boadway and Keen (1996), Migué (1997), Sobel (1997), Boadway et al. (1998), Keen (1998), Besley and Rosen (1998), Wrede (1999), Hoyt (2001), Esteller-Moré and Solé-Ollé (2001), Hayashi and Boadway (2001) and Keen and Kotsogiannis (2002). These studies of overlapping tax bases focus on "vertical" externalities between the national and state governments (or between state and local governments). They differ from other fiscal federalism studies, which traditionally have focused on "horizontal" externalities between states in a federation.[3] Horizontal externality models predict that competition between states will reduce tax rates when the tax base is mobile. Brennan and Buchanan (1980) argue that this horizontal competition is efficiency-enhancing, while Zodrow and Mieszkowski (1986) argue that it leads to an under-provision of public goods.[4] In contrast, the vertical externality model predicts that when the federal and state governments have the authority to levy taxes on the same base, the combined tax rate is higher than it otherwise would be.

Although the vertical externality literature uses a different terminology than the anti-commons literature, it is useful to think of a vertical tax externality as an example of the tragedy of the anticommons. This point has implicitly been made by Keen and Kotsogiannis (2002, p. 363), who write that "shared tax bases create a common pool problem, with the tax decisions of each level of government inducing decisions by the private sector that affect the shared tax base." The authors suggest further that vertical externalities "are

[3] According to Keen (1998, p. 455), "The analytical focus of writing on fiscal federalism has traditionally and typically (with rare exceptions) been on horizontal relationships between the states, and possible fiscal externalities between them."

[4] See Wilson and Wildasin (2004) for an overview.

likely to leave state taxes too high: each state unduly discounts the pressure on federal spending it creates by raising its own tax rate (so setting off incentive effects that shrink the federal tax base)" (Keen and Kotsogiannis 2002, p. 363).

The early papers of the vertical externality literature model how vertical externalities lead to higher than optimal taxation given a set of assumptions about government behavior (see, for example, Cassing and Hillman 1982; Flowers 1988; Johnson 1988; Migué 1997; Sobel 1997). Keen (1998), however, shows that under a different set of assumptions this prediction is incorrect. For example, if the federal government plays a game of Stackelberg instead of a game of Nash, thus anticipating state government reaction to its behavior, and if the federal government transfers resources to states, then the federal government will set a rate that ensures an optimal combined rate (Keen 1998, p. 468). This result is consistent with a point made by Buchanan and Yoon (2000). They note that coordination between those with authority to exclude leads to an efficient solution. However, the predictions derived from their anticommons model are based on the assumption of an absence of trust that would permit such coordination. In this sense, empirical tests of the anticommons model such as those that we undertake here can be considered as tests of the validity of Buchanan and Yoon's assumption.

Over the last decade scholars have tested the predictions of the vertical externality literature. Here, the research focus has been on whether one level of government adjusts its taxation in response to tax changes at another level. Importantly, that scholarly work does not focus on variations in institutions that would give rise to an anticommons effect. Examples of this work include Besley and Rosen (1998), who find that when the U.S. federal government increases its tax on gasoline, then states also increase gas taxes. Esteller-Moré and Solé-Ollé (2001) come to a similar conclusion, finding that states increase income taxes and general sales taxes following an increase in federal taxes. Goodspeed (2000) studies a panel of OECD countries and, in contrast to some of the other studies, finds that when national income tax rates are higher, local income rates are lower. Hayashi and Boadway (2001) use data from Canadian provinces and also reach the conclusion that tax rates in lower levels of government fall when the federal tax rate increases. Shughart and Tollison (1991) find that governments with overlapping tax bases end up on the downward-sloping portion of the Laffer curve.

While empirical studies of vertical externalities have careful research designs, they largely ignore institutional variation. By contrast, our empirical strategy is guided by the theoretical predictions of the anticommons literature, and is based on cross-city differences in the institutional environment. These institutional differences arose before taxes were imposed on cell phone service, simply because such telecomm services were not yet available. We believe that this institutional feature addresses some endogeneity concerns.

3 Taxes and fees on cellular telephone services

Levies on cell phone services include state and federal Universal Service Fund fees and state sales taxes. These levies also can include other state and local taxes, such as 9-1-1 emergency service fees, poison control fees, police protection fees, fire protection fees, deaf relay service fees, telecommunications relay service fees, utility taxes, school district taxes, and other mobile phone-specific taxes (Mackey 2011). Some of these levies, such as those for 9-1-1 service, are dedicated to particular uses, while others, such as sales and gross receipts taxes, support general funds. While each of these levies tends to be relatively

small, in 2010 the combined average tax rate on cell phone services at the federal, state, and local levels exceeded 16 % of a customer's gross monthly bill.

Scholarly work on taxation of mobile phone services documents that cell phone service taxes are welfare reducing (Hausman 2000, p. 733). Using data from around the time cell phone use became more common, Hausman (1997) finds that the own-price elasticity of demand for mobile phone service is −0.51, and notes in another paper that the price elasticity of demand is "relatively high for telecommunications services" (Hausman 1999, p. 7). Using more recent data, Hausman (2000) updates his elasticity estimate and finds that it rose to −0.71, although the new estimate is not statistically significantly different from the earlier estimate. Among other more recent calculations, Ward and Woroch (2010, p. 27) find the elasticity of demand for mobile phone services to be between −0.75 and −0.81, while Ingraham and Sidak (2004, p. 257) report a range between −1.12 and −1.29.

The balance of these studies suggests that the demand for mobile service is relatively elastic for telecommunications services, and that this elasticity of demand has grown over time.[5] These estimates do not seem to suggest that mobile phone service use is a promising candidate for above-average taxation based on the Ramsey rule (Ramsey 1927), under which higher tax rates on goods with inelastic demands are "efficient" because the excess burden is comparatively small.[6] Instead, these studies indicate that cell phone service taxes are costly from a welfare perspective because the demand for this service is relatively elastic and the excess burden correspondingly large.

Little or no normative justification is apparent for setting tax rates for cell phone services higher than those on other goods. For example, cell phones do not have obvious negative externality characteristics.[7] Further, because mobile devices are increasingly popular as a means of accessing broadband, taxation of cell services runs counter to the policy goal of Congress to make access to broadband widely available (Federal Communications Commission 2011). There also seems to be no obvious reason to levy cell phone taxes for the purpose of redistributing income, since Congress has explicitly made low-income cell service a priority through the "Lifeline" program and since poor households are almost twice as likely as others to rely exclusively on mobile phones for telecommunication (Blumberg and Luke 2010). Cell phones might even have positive externalities. For example, Klick et al. (2012) show that cell phone use is associated with less crime.

4 Cell phone taxes in New York city and Albany, NY

In 2010, the cumulative state and local tax rate on mobile phone services ranged from a low of 1.8 % in Salem, Oregon, to a high of 18.7 % in Omaha, Nebraska. The mobile phone service tax bills of New York residents are illustrative. Panel A of Table 1 shows the 11 different tax rates New York City residents pay for cellular service. The table also

[5] Because early adopters tend to place higher value on the use of a new product or service, they tend to be less price sensitive than later adopters. This might explain why successive estimates have found increasingly higher elasticities.

[6] See Brennan and Buchanan (1980) for an alternative view.

[7] One negative externality argument with respect to cell phone use may be that distracted drivers impose a cost on others when they talk on their mobile phones. In this case, though, a more direct way to internalize the externality is to fine those who use their phones while driving, rather than to tax cell phone service in general. In fact, many states do fine drivers when they talk on their cell phone without a hands-free device.

Table 1 Mobile phone tax bills in 2010

Taxing authority	Recipient of cell phone tax revenues	Description	Rate as share of average monthly bill (%)
Panel A: New York city			
Federal government	Federal government	USF fee	5.05
New York state	New York state	Sales tax	4.00
New York state	New York state	Excise tax	2.50
New York state	New York state	Franchise tax	0.38
New York state	New York state	Wireless 9-1-1 fee	2.49
New York city	New York city	Wireless 9-1-1 fee	0.62
New York city	New York city	Utility gross receipts tax	1.97
New York city	New York city	Sales tax	4.50
New York state	New York city metropolitan commuter transportation district	Sales tax	0.38
New York state	New York city metropolitan commuter transportation district	Excise tax	0.60
New York state	New York city metropolitan commuter transportation district	Surcharge	0.13
New York city total			22.62
Panel B: Albany			
Federal government	Federal government	USF fee	5.05
New York state	New York state	Sales tax	4.00
New York state	New York state	Excise tax	2.50
New York state	New York state	Franchise tax	0.38
New York state	New York state	Wireless 9-1-1 fee	2.49
Albany	Albany	Utility gross receipts tax	1.00
Albany	Albany	Sales tax	4.00
School district	School district	Utility tax	3.00
Albany total			22.42

indicates the taxing authority, the disposition of the revenue collected, and the name of each tax.

Taxation of mobile phone services differs from other taxation, such as that on income, property, or general sales. The latter are typically taxed at only one or two levels of

government, while mobile phone services are often taxed by four or more levels of government. Table 1, Panel A shows that taxes levied on a New York city resident's cell service fund several different levels of government. The federal, state, and city governments as well as local districts all derive revenue from cell phone taxes. For example, the State of New York levies four separate taxes that fund state projects and three additional taxes that fund the metropolitan commuter transportation district. At the same time, the city levies three taxes of its own. In 2010, New York City's tax rates on mobile phone services ranged from a low of 0.13 %, a surcharge levied for the benefit of the New York city metropolitan commuter transportation district, to a high of 5.05 %, the universal service fee (USF) levied by the US federal government. The sum of all of these small mobile phone service taxes and fees adds up to a cumulative tax rate of more than 22 %. While this cumulative tax rate applies to 2010, by 2012 it had risen to 23.5 % (Mackey 2012).

The interest groups that support New York state's excise tax likely are distinct from the groups that support the state's 9-1-1 service tax. However, because those interest groups draw resources from the same common tax base, neither has an incentive to account for the loss in revenue that the other group experiences as a result of additional taxes. That is, an interest group supporting the excise tax fails to account for the fact that the excise tax shrinks the 9-1-1-service tax base, and vice versa. Similarly, interest groups lobbying for additional mobile phone taxes in the city of New York are unlikely to account for any effect that their taxes might have in reducing the federal USF tax base and vice versa.

Table 1, Panel B, shows the cell phone taxes paid by the average resident of Albany, New York, the state's capitol. There, the service is subject to eight separate taxes that fund four separate levels of government: the federal government, the state government, the city government, and the local school district. These taxes range from a low of 1 %, levied by the city of Albany, to a high of 5.05 %, levied by the Federal Government. In Albany, these small taxes add up to a cumulative rate exceeding 22 %.

New York is not unique with respect to levying several taxes on cell phone services. In 2010, residents of Salt Lake City, Utah, faced eight separate taxes at the federal, state, and local level, and in Sioux Falls, South Dakota, residents faced seven separate taxes (Mackey 2011). In other cities, such as Portland, Oregon—a city that lacks a local option taxing authority—city residents face only three taxes: the federal USF fee and two state levies.

5 Local option taxes and empirical predictions

State law determines whether counties, cities, and local special-purpose districts possess the authority to levy local option taxes at the point of sale. Massachusetts, for example, does not grant its local governments the option to levy a sales tax, while the state of New York does. In some states, the local authority to tax varies on a city-by-city or county-by-county basis. The State of Illinois, for example, gives only "home rule" counties the authority to levy their own local option tax. Since Cook County (where Chicago is located) is the sole home rule county in Illinois, it alone enjoys local option taxing rights.[8]

In addition to granting general sales tax authority, states often permit local governments to tax cell phone service with more targeted taxes, such as telecommunications taxes or utility taxes. In most cases, these targeted taxing powers are granted only when local governments have already been given the authority to levy local option sales taxes. In our

[8] Such examples are rare, however, and because of data limitations, none appear in our dataset.

sample, we found just two cities—Baltimore, Maryland, and Springfield, Illinois—that possess authority to levy targeted taxes on cell phones without having the broader authority to tax general sales. This makes local option taxing authority an important measure of the taxing powers of local governments.

We test several predictions of the anticommons model (Buchanan and Yoon 2000). First, the model predicts higher tax rates on mobile services if the tax base can be characterized as an anticommons. That is, when multiple parties possess the authority to levy taxes, excluding others from a tax base, the combined tax rate will be higher than otherwise. We test this hypothesis by regressing the combined state and local tax rate on an indicator for whether the local governments possess the authority to levy local option sales taxes. The anticommons model predicts a positive coefficient on the local option indicator. Finding a positive coefficient is consistent with the hypothesis that governments will not take account of the taxing authority of overlapping jurisdictions, and that the combined tax rate therefore will be higher in those cities where local governments have the option to tax.

Second, the anticommons model predicts less cell phone ownership when multiple authorities have the right to levy taxes on cell phone use: In an anticommons setting, parties with the authority to exclude will over-exclude, and the resource thus will be underutilized.[9] We test this prediction by examining whether cell phone adoption by households is lower in cities where local governments possess the authority to levy local option taxes.

Third, the anticommons model predicts that cell phone ownership falls as the number of taxing authorities increases. That is, resource use is lower as the number of authorities with taxing power rises. We test this hypothesis by studying whether cell phone adoption falls with the number of separate taxes applied to cell phone service. Table 2 summarizes these theoretical predictions and the corresponding empirical tests, which we describe in the next section.

6 Empirical models and estimation results

6.1 Models and data descriptions

Scott Mackey (2008, 2011) has published cell phone service tax data for several cities in 2007 and 2010.[10] Cell phone service tax data for 2005, 2006, 2008, and 2009 have not been published, but have been provided to us by Mackey. This allows us to build a unique database of cell phone tax data spanning 52 cities from 2005 through 2010. We merge this dataset with information on local option taxing authority, which we obtain by consulting state statutes. We also collect socio-economic variables from publicly available US Census data, the US Department of Justice and Berry et al. (1998). Finally, the Census Survey of Income and Program Participation, conducted every four years, includes a question about

[9] In our paper, data availability compelled us to focus on the extensive margin, cell phone ownership. It is equally plausible that an anticommons will induce behavioral changes along an intensive margin, affecting monthly cell phone use on plans that limit calls geographically or restrict data sharing.

[10] His data cover the largest cities as well as the capital cities in each state. Sometimes these are one and the same. Though his dataset spans only 52 cities, it is the most comprehensive cell phone tax data available.

Table 2 Summary of tests

Theoretical prediction from Buchanan and Yoon	Empirical tests performed
The combined tax will be higher when multiple parties have the authority to exclude	Equation (3): estimate the combined tax rate as a function of local option taxing authority
The resource will be underutilized when multiple parties have the authority to exclude	Equation (4): estimate ownership as a function of local option taxing authority
Resource utilization will fall as the number of excluders rises	Equation (5): estimate ownership as a function of the number of taxes imposed

household cell phone ownership.[11] These data are available for 2 years in our sample, 2005 and 2009. Table 7 in the Appendix lists the cities and the sample means of the variables included in our dataset. Table 8 in the Appendix lists the differences in these sample means between cities with and without the local option to tax.

Table 3 describes each variable and reports descriptive statistics. Household cell phone ownership averages 82 % across the sample; it ranges from a low of 52 % in Augusta, Georgia, to a high of nearly 99 % in Honolulu, Hawaii. On average, government authorities levy four separate state and local taxes on cell service, making the average cumulative state and local tax rate (i.e., excluding the federal tax) approximately 10 %. There is significant variation in cell phone service taxation. The combined state and local tax rate ranges from a low of 1.1 % in Las Vegas, Nevada, in 2005, to a high of nearly 19 % in Omaha, Nebraska, in 2010.

The *Local Option* variable, which is based on state statutes, indicates whether or not local authorities—which include authorities such as the city itself, any surrounding counties, and any special taxing districts in or around the city—are permitted to levy a tax at the point of sale of a product or service. We found one instance (Jackson, Mississippi) in which this authority varies across time. In all other cases, institutional variation in this local taxing authority is time-wise invariant and predates by several decades the widespread adoption of cell phones, which began in the 1990s. This suggests that the variable likely is exogenous to cell phone ownership. We drop observations drawn from Jackson, Mississippi, in which this authority changes over time. However, the estimation results we report are not sensitive to the omission of this observation. Seventy-nine percent of cities in our sample possess the authority to levy local option sales taxes.

The Buchanan and Yoon (2000) model predicts a higher combined tax rate in the presence of an anticommons. Therefore, we test whether the combined state and local tax rate will be higher in those cities where local governments possess the authority to levy local option sales taxes. To do so, we estimate a regression model explaining the tax rate in city c in year t with whether the city government and other authorities in the city are given the local option to tax, *Local Option*.

The regression model is

$$Mobile\ Tax\ Rate_{c,t} = \beta Local\ Option + \mathbf{X_{c,t}\Gamma} + \boldsymbol{\gamma_R} + \boldsymbol{\Phi_T} + \varepsilon_{c,t} \quad (3)$$

where $\varepsilon_{c,t}$ is a random disturbance term.

[11] The US Census has not released cell phone ownership data at the city level to the public. The Census retained control of this information and all ownership regressions (Eqs. 4 and 5) were run by the Census. Because it does not include ownership data, we test Eq. 3 ourselves, and will make those data available to others interested in replicating our results. We exclude the District of Columbia from our analysis because for the District there is no meaningful distinction between the state and city governments.

Table 3 Descriptive statistics

Variable	Description	Years available	Obs.	Mean	SD	Min	Max
Pct. cell ownership	The share of households that own cell phones	2005, 2009	97	0.82	0.09	0.52	0.99
Mobile tax rate	Combined state county, city and special district mobile phone service tax rate	2005–2010	312	0.10	0.04	0.01	0.19
No. of taxes	Count of individual taxes levied on cell phones	2005–2010	312	4.05	1.76	2	10
Local option	A dummy variable equal to 1 if counties, cities and special districts have the authority to impose a sales tax and 0 otherwise	2005–2010	312	0.79	0.41	0	1
log(Population)	Log of the population	2005–2010	269	12.76	0.98	10.98	15.94
Pct. 65 and over	The share of the population aged 65 or older	2005–2010	269	0.11	0.02	0.05	0.15
Citizen ideology	Citizen ideology score. Higher numbers indicate more liberal ideology	2005–2010	312	51.80	14.93	18.07	94.14
Violent crime rate	Violent crime rate per 100,000 inhabitants	2005–2010	282	488.98	186.98	76.30	905.50

Sources Tax rates: Mackey. Local option: state statutes. Percent cell ownership, 65 % and over, and population: US Census Bureau

To control for other factors that might explain variation in mobile tax rates, we include a vector of city- and year-specific socioeconomic variables, $\mathbf{X}_{c,t}$. This vector contains the share of the population aged 65 and older, the log of the city population, a measure of citizen ideology to proxy the demand for public services, and the violent crime rate to account for political pressure for higher or lower cell phone taxes. The violent crime rate is a proxy for pressure to raise revenue to support 9-1-1 service fees and other emergency fees, which are a common component of cell phone taxation.

To account for geography-specific effects, we also add a vector of regional indicators, $\boldsymbol{\gamma}_{\boldsymbol{R}}$. Our regions, as defined by the US Census, are the East, West, South and Central, with the Central region serving as the reference group. To account for time effects, we also include year indicators, $\boldsymbol{\Phi}_{\boldsymbol{T}}$.

We estimate model (3) as a repeated cross section. We cannot include city indicators in this regression because there is no variation in the local option to tax within a city over time. To account for the likelihood that the city-level observations are not independent over time, we cluster the standard errors in all panel regressions at that level. We suggest some caution in interpreting the meaning of the estimated coefficient on *Local Option* in Eq. (3). While the local option institution preceded the adoption of cell phones, this doesn't necessarily mean that causation runs from the local option institution to cell phone tax rates. It is possible that citizens favoring a mix of higher taxation and more government

services have sorted themselves (Tiebout 1956) into particular states and have demanded higher cell phone tax rates *and* local option taxation in those locales.[12]

The anticommons model also predicts that a resource's use falls when there are many parties who can block access to it. To test this hypothesis, we estimate the effect of the local option to tax on household cell phone adoption. Equation (4) shows this regression.

$$Percentage\ Cell\ Ownership_c = \gamma Local\ Option_c + \lambda Lag\ Ownership_c + \mathbf{\Theta_c H} + \boldsymbol{\gamma_R} + \varepsilon_c \tag{4}$$

For regression model (4), we estimate a series of alternative specifications with the share of households that own cell phones as the dependent variable. The anticommons model predicts a negative sign on *Local Option*. The Census Survey of Income and Program Participation asked respondents about cell phone ownership in 2005 and 2009. To allow for the baseline cell phone ownership level, we estimate model (4) with the 2009 cross section and include the lagged 2005 value of cell phone ownership. We also include a vector of city-specific control variables, $\mathbf{\Theta_c}$, which includes the log of the population and the share of the population over 65 years of age. Since this model pertains to 2009 only, it does not include year indicators. We estimate the model using both Ordinary Least Squares (OLS) and Weighted Least Squares (WLS). Our WLS estimates weight more heavily those cities in which the Census survey sample was larger. Because the variance is larger for observations derived from small samples, we expect the WLS estimates to be more precise.

The third prediction of the anticommons model is that resource utilization declines with the addition of more entities having exclusion rights. We test this hypothesis by modeling household cell ownership as a function of the number of distinct taxes levied on cell phone services. Each tax funds a separate interest group and often a separate level of government. In our regressions we explain *Percentage Cell Ownership* using the same control variables on the right-hand side as were used in the previous regression model.

$$Percentage\ Cell\ Ownership_c = \delta Number\ of\ Taxes_c + \lambda Lag\ Ownership_c + \boldsymbol{\Theta_c H} + \boldsymbol{\gamma_R} + \varepsilon_c \tag{5}$$

Specification (5) differs from specification (4) in that we now use the *Number of Taxes* as the key explanatory variable instead of *Local Option*.[13] As with model (4), we estimate this model with both OLS and WLS. Our model predicts a negative sign on the number of taxes.

6.2 Empirical results

Table 4 reports the estimates of regression Eq. (3). The table presents five specifications for which the dependent variable is the combined state and local mobile phone tax rate in a

[12] In an attempt to mitigate these endogeneity concerns we implemented a two-stage test, first estimating the fixed effects of cities on tax rates and then, in a second stage, estimating the effects of *Local Option* on the city coefficients estimated from the first stage. The second stage tests employed weighted least squares (WLS), with observations weighted by the inverse of the estimated standard errors from the first stage. This procedure gives greater weight to those coefficients that were estimated with smaller standard errors. In all second-stage tests, the estimated coefficient on *Local Option* was positive and, depending on the covariates included, often statistically significant.

[13] Compared with the local option, there is a weaker case to make for the idea that the number of taxes is exogenous. A high demand for cell phones may induce greater political pressure to reduce cell phone taxation and our regression may be picking up some of this effect.

Table 4 Determinants of cell phone tax rates

Independent variables	(1)	(2)	(3)	(4)	(5)
Local option	0.0428***	0.0391**	0.0363**	0.0480***	0.0360**
	(0.0108)	(0.0162)	(0.0173)	(0.0162)	(0.0169)
log(Population)		0.00944**	0.00930**	0.00792*	0.00957**
		(0.00434)	(0.00433)	(0.00414)	(0.00452)
Pct. 65 and over			−0.290	−0.260	−0.294
			(0.208)	(0.249)	(0.245)
Citizen ideology		−0.000862*	−0.000914*		−0.00102**
		(0.000507)	(0.000479)		(0.000490)
Violent crime rate				−3.65e−06	3.93e−06
				(3.69e−05)	(3.57e−05)
Constant	0.0611***	−0.0145	0.0252	−0.0148	0.0266
	(0.0143)	(0.0520)	(0.0608)	(0.0579)	(0.0607)
Regional controls	Yes	Yes	Yes	Yes	Yes
Year controls	Yes	Yes	Yes	Yes	Yes
Observations	312	269	269	244	244
R^2	0.28	0.32	0.34	0.31	0.36
Years included	2005–2010	2005–2010	2005–2010	2005–2010	2005–2010

Dependent variable: mobile tax rate

Clustered standard errors are in parentheses

* Significance at the 10 % level for a two-tailed test. ** Significance at the 5 % level. *** Significance at the 1 % level

city. The regressions include all years from 2005 to 2010. The regression in column 1 includes only the variable of interest, the local option to tax, and employs the full dataset. The regression in column 2 adds the log of the population and Berry, et al.'s (1998) measure of citizen ideology to account for ideological differences that might explain cell phone tax rates. Owing to missing observations, including these covariates reduces the sample size to 269 observations. Column 3 shows the effect of adding the share of the population over 65 years of age. Columns 4 and 5 include the violent crime rate to control for 9-1-1 service fees and other emergency services, which are a common component of mobile phone tax bills. The inclusion of this variable reduces the sample to 244 observations.

In each specification in Table 4, the estimated coefficient on *Local Option* is positive and statistically significant. This finding is consistent with the cell phone tax base being an anticommons, because the anticommons model predicts that the combined tax rate is higher when counties, cities, and special districts possess the authority to tax mobile phones.[14] Our estimated effect of the *Local Option* also is quantitatively significant. The point estimates on that variable indicate that the local option increases the tax rate by between three and five percentage points. Given that the mean tax rate is ten percent, the

[14] A zero effect would have been consistent with the hypothesis that jurisdictions strategically account for the externality that occurs when overlapping jurisdictions independently set tax rates. This finding would have invalidated Buchanan and Yoon's (2000) assumption that parties cannot explicitly collude.

Table 5 Determinants of cell phone ownership in 2009, the local option effect

Independent variables	No weighting			Sample weighting		
	(1)	(2)	(3)	(4)	(5)	(6)
Local option	−0.0431*	−0.0384*	−0.0444**	−0.0198***	−0.0174***	−0.0194***
	(0.0214)	(0.0210)	(0.0212)	(0.00136)	(0.00123)	(0.00149)
Pct. cell ownership in 2005	0.428***	0.427***	0.476***	0.389***	0.389***	0.411***
	(0.154)	(0.156)	(0.159)	(0.00966)	(0.00973)	(0.0109)
log(Population)	0.0125**	0.0141**		0.0132***	0.0143***	
	(0.00581)	(0.00628)		(0.000461)	(0.000514)	
Pct. 65 and over	−0.283		−0.379	−0.120***		−0.278***
	(0.248)		(0.272)	(0.0158)		(0.0203)
Constant	0.469***	0.412**	0.603***	0.452***	0.424***	0.623***
	(0.143)	(0.153)	(0.121)	(0.0109)	(0.0118)	(0.00816)
Regional controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	41	41	41	41	41	41
R^2	0.46	0.45	0.43	0.46	0.46	0.40

Dependent variable: percent cell ownership in 2009

Robust standard errors are in parentheses. In columns 4–6 the observations are weighted by Census survey sample size

* Significance at the 10 % level for a two-tailed test. ** Significance at the 5 % level. *** Significance at the 1 % level

effect of the local option is to raise the combined tax rate by about 50 % of the average tax rate. To put it another way, the local option increases the mobile tax rate by one tax rate standard deviation.

Table 4 shows that the estimated coefficients on the log of the city population are positive and statistically significant, though small in magnitude. Estimated coefficients on the share of the population aged 65 and older are negative in all specifications, although the point estimates are not statistically significant. In all specifications, we find a negative and statistically significant effect of citizen ideology on cell phone tax rates. Because larger numbers on Berry et al.'s citizen ideology score indicate a more liberal populace, the relationship suggests that more liberal cities have lower taxes on cell phones. This finding is consistent with recent work by Johnson et al. (2014), who found that though Democratic governments tend to have higher levels of government spending, they also finance that spending with higher income and corporate taxes, while keeping sales taxes low.

Table 5 reports the results from estimating Eq. (4), modeling the effect of the local option to tax on cell phone ownership rates. Since cell phone ownership rates are available for only 2005 and 2009, we estimate these regressions using the 2009 ownership rate as the dependent variable with the 2005 ownership rate as one of the explanatory variables. This lagged dependent variable accounts for a baseline ownership level.

Table 5, column 1, shows the results of a regression that includes all of the explanatory variables in Eq. (4). Column 2 reports the results when we omit the share of the city population aged 65 and older. Column 3 shows the results when we omit the log of the city population. In columns 4 through 6, we estimate the regressions with the Census sampling

weight for sample size. Here, we again present both the base specification as well as two specifications omitting, respectively, the city population aged 65 years and older, and the log of the city population. These WLS estimates are our preferred estimates given that they give greater weight to observations drawn from larger survey samples.

In all specifications, the estimated coefficient on *Local Option* is negative and statistically significant, indicating that the local option to tax is associated with reduced cell phone ownership rates. This finding is consistent with the predictions from a tragedy of the anticommons model. That is, when numerous overlapping jurisdictions are permitted to impose levies on the cell phone tax base, resource use falls. The point estimates on the local option variable also are economically significant. We find that the local option to levy taxes reduces the rate of cell phone ownership by between two and four percentage points.

The results in Table 5 further show, as one may expect, that households in cities with high rates of cell phone ownership in 2005 were also likely to have high rates of cell phone ownership in 2009.[15] The results also indicate that households in larger cities are more likely to own cell phones. Households in cities with older populations are less likely to own cell phones, although the coefficients are not statistically significant in the OLS regressions.

Table 6 reports the results from estimating Eq. (5). The relationship of interest is the effect of the number of cell phone taxes on household cell phone ownership rates. As in Table 5, we estimate these specifications for a cross section, where the 2009 cell phone ownership rate is the dependent variable and the 2005 cell phone ownership rate is one of the explanatory variables.

Table 6, columns 1 through 3 report the results using equal weighting for all cities and columns 4 through 6 use weighted least squares, giving greater weight to those cities in which the Census survey sample is larger. As in the previous specifications, we have more confidence in the WLS specifications.

In all of our specifications in Table 6, the estimated coefficient on the number of taxes on cell phone ownership rates is negative and statistically significant at the 5 or 1 % level. The estimated coefficients indicate that a one standard deviation increase in the number of taxes reduces cell ownership by about 1.1 percentage points.

As in our regression results in Table 5, we find that higher cell phone ownership rates in 2005 are associated with higher ownership rates in 2009. Furthermore, we consistently find that cities with larger populations are associated with greater household cell phone adoption rates and that this effect is statistically significant. An older population is associated with lower household cell phone adoption rates, although in the OLS tests these point estimates are not statistically significant.

7 Conclusion

In motivating his discussion of the tragedy of the anticommons, Heller (2010) points to the example of German barons who, after the fall of the Holy Roman Empire, erected a series of castles along the Rhine River in order to exact tolls from passersby. Users of mobile cell services might feel themselves in a similar situation as travelers who once encountered German 'robber barons' on the Rhine. While taxes on the Rhine brought river traffic to a standstill, cell phone taxes clearly have not eliminated cell phone use. Our research,

[15] We likely underestimate the effect of *Local Option* given that the lagged variable captures some of that effect.

Table 6 Determinants of cell phone ownership in 2009, the number of taxes effect

Independent variables	No weighting			Sample weighting		
	(1)	(2)	(3)	(4)	(5)	(6)
No. of taxes	−0.00873**	−0.00842**	−0.00867**	−0.00623***	−0.00603***	−0.00559***
	(0.00414)	(0.00388)	(0.00411)	(0.000307)	(0.000294)	(0.000305)
Pct. cell ownership in 2005	0.395**	0.396**	0.447**	0.391***	0.391***	0.415***
	(0.160)	(0.159)	(0.164)	(0.00955)	(0.00963)	(0.0106)
log(Population)	0.0133**	0.0144**		0.0142***	0.0150***	
	(0.00532)	(0.00572)		(0.000435)	(0.000488)	
Pct. 65 and over	−0.208		−0.305	−0.0951***		−0.259***
	(0.210)		(0.237)	(0.0125)		(0.0171)
Constant	0.467***	0.428***	0.608***	0.439***	0.418***	0.619***
	(0.148)	(0.156)	(0.127)	(0.0107)	(0.0116)	(0.00783)
Regional controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	41	41	41	41	41	41
R^2	0.47	0.46	0.43	0.49	0.49	0.42

Dependent variable: percent cell ownership in 2009

Robust standard errors are in parentheses. In columns 4–6 the observations are weighted by Census survey sample size

* Significance at the 10 % level for a two-tailed test. ** Significance at the 5 % level. *** Significance at the 1 % level

however, does provide evidence that these taxes are associated with lower rates of cell phone adoption.

Mobile phone services are subject to numerous taxes and fees from several distinct layers of government. Individually, each of these tax levies is relatively small, but together they can amount to a large bill, making cell phone service one of the most heavily taxed services in the country. Each of the various taxes supports a separate policy interest, such as rural telephone service, 9-1-1 emergency service, or general-fund spending.

Cell phone markets are an ideal setting in which to test the predictions of the anti-commons model. First, mobile phones are taxed by numerous overlapping jurisdictions. Second, there are no obvious reasons to single them out for high taxation. And third, cell phones already were in widespread use by the time taxing authorities were established. This sequence mitigates concerns of endogeneity of the local option variable in the cell phone ownership regression.[16]

We exploit cross-city variation in the local option to levy taxes in order to identify an anticommons. We find that when counties, cities, and special-purpose districts are granted the right to levy local sales taxes, the overall tax rate is higher. Furthermore, cell phone ownership is lower in the presence of a local option, which is consistent with a tragedy of the anticommons. We also document that cell phone ownership falls as more distinct taxes are levied, which suggests that the reason the local option to tax is associated with resource underutilization is that multiple taxing authorities lead to excessive exploitation of a tax base, higher tax rates than otherwise, which in turn lowers cell phone use.

Many authors have noted that taxes on wireless phone services are higher than average taxes, and that this is costly from a welfare perspective. This is consistent with the prediction that, when a resource is subject to an anticommons, welfare losses result. Woroch (2011) estimates that the taxation of wireless phone services costs consumers roughly $15.7 billion each year. From a welfare perspective, while some of this amount is offset by the revenue obtained from these taxes, Hausman (2000, p. 733) finds that wireless "taxes are a much greater drain on the economy than their direct costs."

Like other common-pool problems, successfully addressing the tragedy of the anti-commons likely requires an institutional solution. For example, states might consider enacting statutes prohibiting the imposition of multiple taxes on a single tax base. Federal legislation could be an additional or alternative solution. For example, federal legislation might prohibit federal taxation of goods that also are commonly taxed at the state and local level. Intergovernmental compacts are another potential way to address the anticommons problem. In the case of the robber barons, a series of treaties in 1831 eventually permitted free navigation of the Rhine (Heller 2010, p. 204). A similar solution for cellular telephone service might be worked out between the states and the federal government.

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Appendix

See Tables 7 and 8.

[16] See footnote 12 for more on this, however.

Table 7 Sample means

City	State	Local option	Percentage cell ownership in 2005	log(Population)	Pct. 65 and over	Citizen ideology	Violent crime rate
Baltimore	MD	0	0.74	13.35	0.12	68.77	770.10
Boise	ID	0	0.75	–	–	28.64	249.00
Boston	MA	0	–	13.30	0.10	83.95	576.06
Hartford	CT	0	0.76	11.69	0.10	79.89	298.52
Indianapolis	IN	0	0.70	–	–	48.98	607.92
Louisville	KY	0	0.78	–	–	44.57	406.67
Portland	OR	0	0.76	13.22	0.10	64.26	305.18
Providence	RI	0	0.70	12.04	0.09	83.63	371.83
Richmond	VA	0	0.78	12.19	0.14	52.11	343.65
Salem	OR	0	0.69	11.92	0.12	64.26	270.12
Va. Beach	VA	0	0.66	–	–	52.11	426.98
Albany	NY	1	0.70	11.41	0.13	73.99	337.40
Albuquerque	NM	1	0.76	13.15	0.12	63.47	747.64
Atlanta	GA	1	0.82	13.01	0.09	42.99	474.74
Augusta	GA	1	0.52	–	–	42.99	404.46
Austin	TX	1	0.81	13.53	0.07	45.56	344.18
Baton Rouge	LA	1	0.81	12.32	0.11	40.72	717.66
Cedar Rapids	IA	1	0.80	11.73	0.13	52.92	216.67
Charleston	SC	1	0.73	11.62	0.13	46.38	724.90
Cleveland	OH	1	0.73	12.92	0.12	55.77	435.15
Colorado Springs	CO	1	0.77	12.89	0.10	51.06	482.57
Columbia	SC	1	0.67	11.65	0.10	46.38	735.60
Columbus	OH	1	0.78	13.52	0.09	55.77	410.02
Denver	CO	1	0.78	13.28	0.10	51.06	380.08
Des Moines	IA	1	0.80	12.20	0.11	52.92	326.87
Fayetteville	AR	1	0.78	11.13	0.08	48.30	313.10
Honolulu	HI	1	0.80	–	–	77.97	284.00
Houston	TX	1	0.79	14.54	0.09	45.56	685.78
Jacksonville	FL	1	0.75	13.60	0.10	51.72	703.88
Kansas City	MO	1	0.79	13.01	0.11	51.79	551.95
Las Vegas	NV	1	0.79	13.25	0.12	54.22	808.97
Little Rock	AR	1	0.69	12.15	0.12	48.30	810.62
Los Angeles	CA	1	–	15.15	0.10	60.70	603.37
Milwaukee	WI	1	0.69	13.27	0.09	56.09	524.88
Minneapolis	MN	1	0.78	12.82	0.08	58.45	–
Montgomery	AL	1	0.72	12.21	0.12	37.14	415.58
Nashville	TN	1	0.74	–	–	42.98	775.38
New Orleans	LA	1	0.76	12.65	0.12	40.72	593.14
NYC	NY	1	–	15.93	0.12	73.99	413.10

Table 7 continued

City	State	Local option	Percentage cell ownership in 2005	log(Population)	Pct. 65 and over	Citizen ideology	Violent crime rate
Oklahoma City	OK	1	0.73	13.22	0.11	25.31	536.65
Omaha	NE	1	0.81	12.89	0.11	34.48	409.33
Phoenix	AZ	1	0.72	14.20	0.08	46.17	455.57
Provo	UT	1	0.61	11.66	0.05	30.57	89.70
Raleigh	NC	1	0.82	12.81	0.08	53.28	307.42
Sacramento	CA	1	0.80	13.03	0.11	60.70	541.77
Salt lake city	UT	1	0.68	12.13	0.10	30.57	350.23
Tallahassee	FL	1	0.86	12.00	0.08	51.72	822.28
Topeka	KS	1	0.71	11.72	0.14	41.01	398.85
Trenton	NJ	1	–	11.31	0.09	65.94	462.82
Tucson	AZ	1	0.76	13.17	0.12	46.17	524.58
Tulsa	OK	1	0.77	12.86	0.13	25.31	657.25
Wichita	KS	1	0.71	12.81	0.12	41.01	636.56

All data are averaged over the years 2005–2010

Table 8 Difference in sample means

Independent variables	Local option = 0	Local option = 1	Difference (p value)
log(Population)	12.53	12.81	−0.28 (0.09)
Pct. 65 and over	0.11	0.10	0.00 (0.18)
Citizen ideology	61.02	49.32	11.69 (0.00)
Violent crime rate	421.99	506.32	−84.33 (0.00)
Percent cell ownership in 2005	0.73	0.75	−0.02 (0.34)

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