Optimal Energy Taxation in Cities

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Cities: Sustainability Lecture
April 25, 2022

Overview

Driving in cities creates greenhouse gases (GHG) as well as local pollution.

But so does heating and cooling of buildings:

US POLLUTION SHARES

- Residential: 16.9%
- Commercial: 16.9%
- Transportation: 27.1%
- Industry: 30.0%

Taxing GHG from urban commuting along with local emissions can be done via gas tax.

Gas Tax

Using \$40/metric ton damage from GHG, required tax is \$0.71/gallon, assuming 20 mpg average fuel economy.

Current average state + federal tax is about \$0.49 per gallon, so bigger tax needed.

By raising commuting costs, higher gas tax will give incentive for shorter commutes, making cities more compact.

Building Taxes

Energy use for heating and cooling of buildings depends on a building's surface area.

Surface area and interior space are related.

Surface area increases less rapidly than interior space as a building gets taller.

$\Longrightarrow$ Energy cost per square foot of space falls with building height.

$\Longrightarrow$ Energy efficiencies from tall buildings.

Building taxes

Requires two taxes: a floor-space tax, and a building-footprint tax (land tax)

Under our calibration, floor-space tax is \$0.066/sq ft and the footprint tax is \$0.024/sq ft.

Urban spatial equilibrium

Urban residents consume housing space (q square feet per dwelling) at a price of p per square foot.

Housing developers use land and building materials to produce floor space, paying land rent r.

Consumers need to be compensated for long suburban commutes to the CBD, so the price p falls (and q increases) with distance.

Land rent r follows same pattern, causing building heights and population density to also fall with distance.

Edge of city is where land rent r equals agricultural rent r_A.

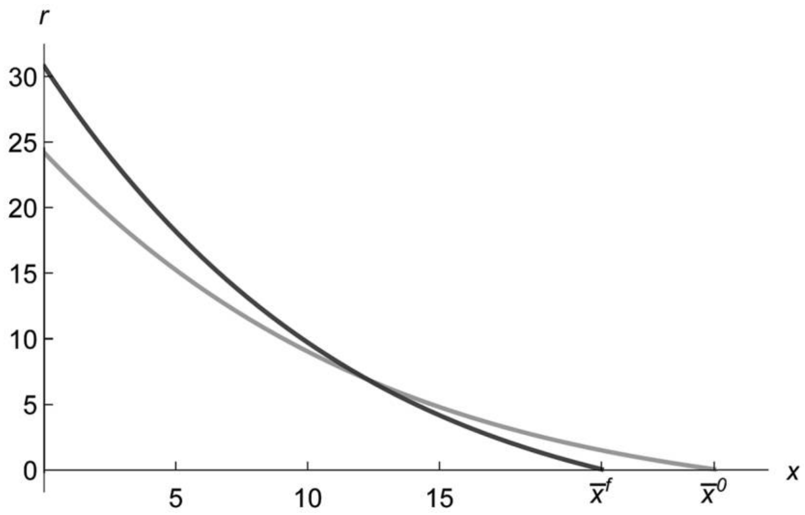
Effect of taxes

Taxes on commuting, floor space, and the building footprint alter the urban equilibrium.

Commuting tax makes the city more compact.

Residential taxes reduce dwelling sizes and make buildings taller, reinforcing densification.

Result is a reduction in the city's GHG emissions.



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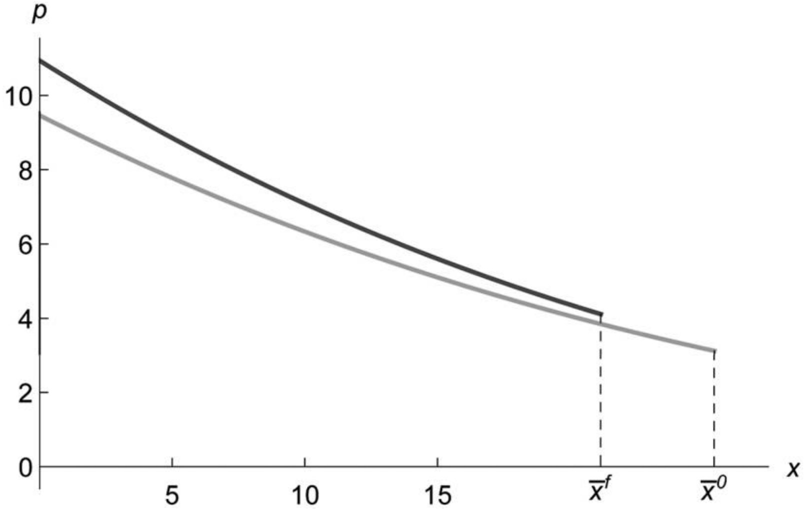

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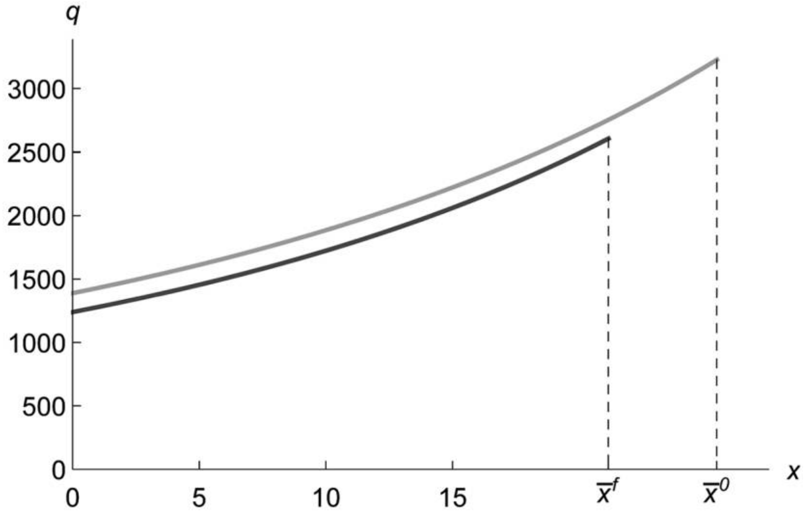

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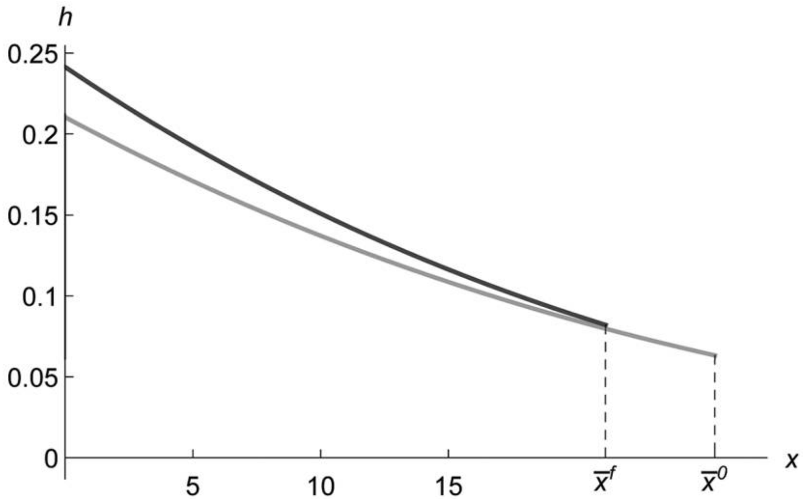
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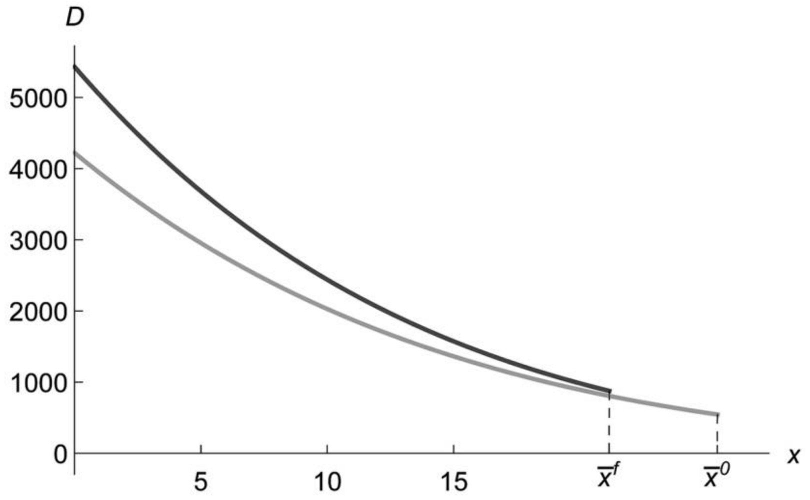
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Table 3. City Characteristics

	No Tax	First Best $\mu = \$.04$	First Best $\mu = \$.10$	Second Best $\tau_\ell = \tau_q = 0$
City border $\bar{x}$ (miles)	25.43	23.40	21.15	24.09
Emissions per capita (kg per year)	24,164.60	21,422.00	18,521.50	22,076.90
Building height index $h(S)$, housing sq ft/land area (sq ft/sq ft)	.21	.22	.24	.23
Central density D (households/sq mi)	4,224.24	4,680.74	5,431.69	4,936.37
Central land rent r (million \$/sq mi per yr)	24.2	26.7	30.7	29.6
Central housing price p (\$/sq ft per yr)	9.47	10.05	10.94	10.34
Central dwelling size q (sq ft)	1,389.14	1,326.97	1,239.13	1,305.33
Commuting tax τ_t (\$/mi per yr)	0	22.18 (4.40%)	55.44 (11.01%)	79.68 (15.82%)
Housing tax τ_q (\$/sq ft per yr)	0	.066 (1.17%)*	.160 (2.61%)*	0
Land tax τ_ℓ (\$/sq ft per yr)	0	.024 (12.93%)*	.060 (27.14%)*	0
Equivalent variation (% of income)	. . .	.09%	.5%	.06%

* Average ad valorem tax rates.

Conclusion

Imposing optimal energy taxes doesn't produce a dramatic reduction in a city's GHG emissions

Reduction is 11% under \$40/metric-ton damage valuation.

But reduction is 23% under a larger \$100/metric-ton value.

Welfare gains are not dramatic either: 0.09% of income in first case, 0.5% in second case.

Nevertheless, such taxation is good environmental policy.