Cap-and-trade, crowding out, and the implications for municipal climate policy motivations

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Abstract

Cities have emerged as important actors in climate change policy, implementing measures to reduce emissions from transportation, buildings and waste. More recently, states such as California have implemented cap-and-trade programs to control greenhouse gases. However, a state-level cap handcuffs cities: by fixing emissions at the level of the cap, it precludes local governments from further reducing aggregate emissions. In this paper, we examine whether cities respond to the changed incentives presented by state-level programs. We find no evidence for crowding out: cities plan their emission reductions in similar ways regardless of state-level cap-and-trade programs. Our results suggest that cities likely have a range of motivations for their climate policy efforts, not simply a pure altruistic desire to improve the global environment.

Introduction

Why do cities take costly actions to improve the global environment? It may seem irrational for cities to invest in renewable energy, install methane capture systems for landfill sites, or take other measures to reduce greenhouse gas emissions. The city bears (in most cases) the entire cost, but only captures a tiny share of the global environmental benefit. Such a collective action problem has stymied progress on negotiating an international climate agreement, and one would expect the challenge to be even greater at smaller scales such as the city.

Despite this, much of the action on climate change mitigation has taken place at the local level. Cities have been said to lead the way on climate (Bulkeley and Betsill, 2003; Kousky and Schneider, 2003), and scholars have observed the "rescaling of environmental governance" (Bulkeley, 2005; Trisolini, 2010) as local governments and non-state actors shape policy environments on issues that might be considered the natural preserve of the nation state. Environmental preferences may partly explain city behavior, if city leaders and the electorate are altruistic or benefit politically from the "warm glow"[1] of their environmental actions. Indeed, environmentally progressive cities are more likely to adopt greenhouse gas (GHG) reduction plans, and to implement specific emission reduction measures such as public transport improvements and energy-efficiency building regulations (Millard-Ball, 2012; Wang, 2013; Zahran et al., 2008).

An explanation that relies on environmental preferences, however, is puzzling in the presence of "handcuffing" – that is, when binding policies from higher tiers of government preempt action at the city level. Cap-and-trade provides a particularly striking example. Because aggregate emissions are fixed at the level of the cap, any additional emission reduction in capped sectors will normally not provide a global environmental benefit. Rather, the reduction simply frees up emission permits for use by other sources, and so emissions elsewhere will rebound to the level of the cap. In capped sectors, cities can have no real impact on aggregate GHG emissions – making costly abatement action seem

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[1] The concept of "warm glow" or impure altruism refers to the psychological reward to the donor from the act of giving, regardless of the impact on the intended beneficiary (in this case, the global climate) (Andreoni, 1990).

irrational, even in the presence of strong environmental preferences (Shobe and Burtraw, 2012; Twomey et al., 2012).

The elimination of the potential for lower-level jurisdictions to achieve emission reductions has significant implications for the cost-effectiveness of cap-and-trade (Goulder, 2013, page 92). It also has implications for the broader study of urban politics, where an important recent theme has been the relationships between cities and other tiers of government (Hooghe and Marks, 2003; Kübler and Pagano, 2012). There is ample research on how cities have helped to fill a policy void through enacting GHG reduction policies (Betsill and Bulkeley, 2007). But there is almost no work on how incentives might flow in the other direction – i.e., how closing a state or national policy void might reduce municipal efforts.

In this paper, we present the first empirical evidence on the extent to which municipal governments respond to handcuffing. We ask whether cities in regions regulated by cap-and-trade plan their mitigation efforts differently than cities in other regions. We compare cities in California, where a cap-and-trade program began in 2013, to cities located in states without cap-and-trade.

We take advantage of the fact that cap-and-trade systems to date only provide partial caps on GHG emissions, covering only electricity generation, large industrial users, and in some cases transportation, while omitting emissions from other sectors such as waste. Thus, we examine whether cities under cap-and-trade allocate less effort to action in capped sectors, and/or more effort in non-capped sectors. Such a course of action, up to the point of abandoning effort in capped sectors altogether, would be rational from the point of view of a city that wishes to contribute to global climate mitigation.

We find, however, no significant difference between the two groups of cities in how they assign mitigation efforts between capped and non-capped sectors, and a qualitative review of selected climate action plans provides further support for the conclusion that cities are not changing their behavior in response to the handcuffing effect of cap-and-trade. In this instance, a finding of "no effect" is surprising and noteworthy, as it challenges the presumption, implicit or explicit, that municipal mitigation efforts reflect an altruistic

desire to contribute to a global public good. In turn, our findings trigger important questions concerning cities' other motivations for elaborating climate action plans. We suggest that for multiple reasons – the "warm glow" from enacting mitigation policies, demonstrating political leadership, or taking advantage of local co-benefits – cities may care more about reducing local emissions than emissions in aggregate.

We begin with an overview of the literature on the recent surge in local climate action planning, and its interaction with state policies. We then present our quantitative methodology and results, followed by a qualitative analysis, which helps validate our quantitative findings by searching for signals of handcuffing in the cities where it is most likely to occur. Finally, we discuss the implications of our findings in terms of a broader understanding of the process of handcuffing.

Scale, Urban Politics and Climate Mitigation

One of the most challenging issues in environmental governance is to determine the appropriate scale of action (Lemos and Agrawal, 2006; Meadowcroft, 2002). One influential theory is the matching principle, which holds that the correct tier of government to address an environmental problem is that one that most closely matches the size of the geographic area affected (Butler and Macey, 1996). This implies that the international, or failing that, the national level is best suited to address climate change mitigation (for a critical discussion, see Trisolini, 2010). Similar ideas can be found in the urban politics literature. For example, Hooghe and Marks (2003, page 235) suggest that the spatial extent of the externality, along with considerations such as heterogeneity in preferences across a region and the potential for economies of scale, dictates the most efficient level of government to address a policy. Thus, garbage collection might be a local matter, but climate change something to be decided at the national or international level.

However, sufficient action at the national level to avoid dangerous climate change is not happening. Moreover, the urban scale is sometimes ideal to implement climate change mitigation. As argued by Dodman (2009) and Lefèvre (2012), cities often have responsibility over land-use planning, public transportation, industrial regulations, and energy consumption in transportation and buildings – all major sources of GHG emissions.

Secondly, the density of cities allows mitigation measures such as mass transit to be more effective than they would in non-dense areas.

A Wave of City Climate Change Policy

Mitigation action at the local level has mushroomed since the early efforts in the 1990s (Lutsey and Sperling, 2008; Trisolini, 2010; Wheeler, 2008). California cities have shown particularly strong commitments to GHG mitigation (Kwon et al., 2014).

Many cities coordinate their mitigation efforts under the umbrella of a climate action plan (CAP), which typically includes an emissions inventory, an emission reduction target, and a list of measures designed to achieve that target. Typical measures relate to building efficiency, renewable energy, public transportation, walkability, bike-friendliness, efficient land-use, waste reduction, recycling, and composting, as well as measures to increase urban greenery, encourage local foods, and educate the public.

The causal role of a CAP in spurring the implementation of new policies is questionable, as the plans appear to be mainly serving to catalogue what cities are already doing (Millard-Ball, 2012, 2013). Some authors have also questioned the quality of the plans or called for more ambitious targets (Stone et al., 2012; Tang et al., 2010; Wheeler, 2008).

Regardless, however, CAPs are a useful measure of the scale of municipal ambitions. By 2007, emission reduction targets had been set by 684 U.S. cities, which if achieved would amount to 7% of total U.S. emissions (Lutsey and Sperling, 2008). A survey by Krause (2011a) found that 15% of medium- to large-size cities had adopted a GHG reduction plan by 2010. As of August 2012, 177 cities (of all sizes) in the U.S. had developed complete CAPs, and more than 200 were in the process of drafting one (Boswell and Greve, 2012).

The Local-State Policy Interaction

Cities are far from the only tier of government that is addressing climate change in North America. At the state level, mitigation plans encompass measures from renewable energy mandates to fuel economy standards and the promotion of green buildings (Wheeler, 2008).

More importantly in the context of this paper, several states and provinces have implemented cap-and-trade programs. California's program, which is the empirical focus of this paper, is discussed in detail below. Other state- or provincial-level cap-and-trade programs in North America include Quebec, linked to the California scheme, and a consortium of states in the northeastern US under the Regional Greenhouse Gas Initiative (RGGI).

A properly designed cap-and-trade system provides certainty regarding an emissions reduction target, at least within the sectors that are capped, and in principle allows a given target to be achieved at the lowest cost (Goulder, 2013). A feature of cap and trade that has only recently drawn attention, however, is that the *cap* also serves as an emissions *floor* (Twomey et al., 2012). Assuming the cap is binding[2], no entity can have an impact on aggregate emissions within the scope of the cap, because total emissions will equal the level of the cap. Emissions reductions by an individual or firm will free up permits, reduce the permit price, and allow emissions elsewhere to rise by an equivalent amount. Lower-level jurisdictions, individuals and firms are "handcuffed" – they have no ability to reduce aggregate emissions. In Australia, subnational governments have sometimes been advised to reconsider planned mitigation policies for precisely this reason (Twomey et al., 2012). In Europe, analysts have expressed concern that unilateral policies implemented by individual countries, such as subsidies for renewables, are not effective in the presence of the Europe-wide cap-and-trade scheme (Euro-CASE, 2014).

Therefore, cap-and-trade replaces the environmental benefit of local mitigation (global CO_2 reduction) with an economic benefit (lower compliance costs elsewhere in the economy). If cities care about the environmental benefits but not the economic ones (Millard-Ball 2009), then a reduction or cessation of low-cost municipal mitigation efforts would compromise the efficiency of cap-and-trade. The same is true of altruistic CO_2 reductions by individuals and firms (Twomey et al., 2012). Theoretical (Perino, 2013) and experimental (Braaten, 2014; Noussair and van Soest, 2014) studies suggest that cap-and-

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[2] Note that not all cap-and-trade programs bind. Emissions can be lower than the cap, as in the case of RGGI, suggesting that the cap was set too high.

trade leads individuals to scale back their voluntary measures to reduce emissions. Cities, then, might be expected to respond in the same way.

Handcuffing can be seen as an extreme example of a more general phenomenon of crowding out. Any policy action by one entity may reduce the motivation of others to implement their own policies. Crowding out of policy action by lower tiers of government has been suggested or demonstrated in arenas such as highway spending (Knight, 2002) and wetlands protection (Adler, 2007). In the case of cap-and-trade, however, crowding out is inherent in the design.

Empirical Implications

A theoretical model where a city cares about aggregate emission reductions (environmental outcomes) but not about the mitigation costs borne by those outside the city has clear empirical implications. One would expect cities to reduce or cease mitigation activity within capped sectors. They might reduce their overall emission reduction ambitions, and/or redirect their energies to addressing uncapped sources and sinks of greenhouse gases, such as methane from landfills and urban forestry.

Several other possibilities are also theoretically plausible, and are not considered in the simple handcuffing model of Twomey et al. We consider four broad groups of explanations here: knowledge, alternative motivations, strategy, and cap-and-trade design.

The first, knowledge, is the simplest. Cities could simply be unaware of the handcuffing implications of cap-and-trade, or have committed to their own climate change policies before cap-and-trade was planned.

The second category considers that cities may have other motivations for mitigation policies. In one scenario, a city may have preferences over its *own* mitigation policies, rather than atmospheric CO_2 concentrations. In other words, a city's own contribution to a global public good is more important than the end result – this is the "warm glow" effect noted above. Alternatively, the primary motivation may be the local co-benefits from mitigation policies, such as energy savings, cleaner air, reduced traffic, or the opportunities for local elected officials to demonstrate policy entrepreneurship (Krause, 2011b). Rather

than overcoming a global collective action problem, municipal governments are in fact incurring considerable local benefits by reducing emissions (Bulkeley and Betsill, 2003; Kousky and Schneider, 2003). Further, to the extent that cap-and-trade increases energy and gasoline prices, new investments in energy efficiency or public transportation may become cost effective.[3]

Third, a city may pursue climate policies for strategic reasons related to the indirect effects of mitigation action. The strategy may be explicitly political, and designed to exert pressure on higher tiers of government, perhaps shaming them into action (Moser, 2007), or representing a symbolic statement in solidarity against global warming (Kwon et al., 2014). Alternatively, a city may want to influence longer-term decisions on the level of the cap: to the extent that a city's mitigation action in capped sectors lowers the carbon price or creates the perception that reducing emissions is easy and cheap, it may influence aggregate emissions through the future level of the cap. Thus, a city may recognize that legislators could tighten, loosen, or even abandon the cap in years to come.

The fourth explanation relates to cap-and-trade design elements that allow emissions to fluctuate above or below the cap, notably through a price floor or price ceiling (Dinan and Stocking, 2012). By setting a reserve price for the auctioning of allowances, a price floor essentially converts cap-and-trade to a carbon tax, if the market price of allowances would otherwise fall below the floor. Emissions could then fall below the level of the cap, if some allowances remained unsold at the floor price. The opposite would happen if a price ceiling were to be reached, and unlimited allowances sold at the ceiling price. In these cases, crowding out may be incomplete, but cap-and-trade should still influence city behaviour, unless there are no potential mitigation projects in non-capped sectors in the relevant price range. In effect, cap-and-trade increases a city's abatement costs within capped sectors, encouraging it to reduce its climate policy efforts or redirect them to non-capped sectors.[4]

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[3] We thank one of the anonymous reviewers for this suggestion.

[4] To see this, suppose that a cap-and-trade system binds with probability p. The expected emission reductions from a given mitigation action within a capped sector fall from Q_0 to $(1-p)Q_0$, and the cost per ton increases from c_0 to $c_0/(1-p)$. This probabilistic framework also allows the model to capture the possibility that the cap or price floor will change in future years.

Thus, while a simple model suggests that complete crowding out would occur, with cities abandoning mitigation efforts in capped sectors, a more careful consideration implies a more limited effect. Crowding out may not be complete, or need not occur at all.

To date, however, there is no empirical evidence about how cities respond to the introduction of cap-and-trade by higher tiers of government. While this paper focuses on city governments, the implications are much broader, and can be useful for state-to-national, or national-to-supranational interactions (e.g. European Union).

Cap-and-Trade in California

Given that our empirical focus is on cap-and-trade in California, we discuss in more detail here the specifics of the program, and the extent to which handcuffing might be expected. Cap-and-trade in California was authorized (although not mandated) by the state Global Warming Solutions Act of 2006, commonly known as AB32. Decisions on cap-and-trade implementation, and program design decisions such as sectoral coverage and permit allocation, were subsequently taken by the California Air Resources Board (CARB). While the final cap-and-trade regulation was only adopted by CARB in 2011, it was fairly clear long before that cap-and-trade was likely to be implemented, not least because it formed a central part of CARB's 2008 Scoping Plan.

California's cap, which came into force in 2013, applies to large electric power plants and industrial plants emitting 25,000 $mtCO_2$-e/year or more. In January 2015, the program expanded to apply to fuel distributors – thus effectively covering all heating and transportation emissions as well. The scheme covers about 85% of emissions in the state, and is designed to reduce emissions to 1990 levels by 2020.

One particular feature of cap-and-trade in California is the price floor, which started at $10 per metric ton in 2012 and rises annually by 5% plus the rate of inflation. In practice, auction prices have averaged 8.5% *above* the floor,[5] meaning that the price floor has not

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[5] Data for the first ten auctions (November 2012 through May 2015) from California Air Resources Board (2015). The price data refer to the auction of current vintages, rather than advance auctions, because any unsold advance allowances would simply be re-auctioned in the future.

affected aggregate emissions, at least directly. (In contrast, prices in the RGGI cap-and-trade program have often been at the floor.)

While it is too early to evaluate the success of the program, initial indications are promising. As of February 2015, allowance prices were about $12 per ton of CO_2-equivalent, and environmental groups have praised the program's strong start (Hsia-Kiung and Morehouse, 2014). For more details of the California program design and rationale, the reader can consult Brown, Rodriquez, Nichols & Corey (2014) and Center for Climate and Energy Solutions (2014).

Empirical Approach

Our primary data consist of the greenhouse gas emission reduction targets set by U.S. cities. We also conduct a qualitative review of selected plans, the methods for which are discussed in a subsequent section. Emission reduction targets that are tied to a detailed mitigation plan provide the best available indication of the level of municipal climate policy ambitions. While cities may not ultimately achieve their targets, or may achieve them for reasons unrelated to their own mitigation efforts, for example by benefitting from spillovers from neighboring cities' efforts (DeShazo and Matute, 2012), the targets still provide the best available indication of the level of effort that cities plan to undertake. Indeed, most cities ignore the impact of exogenous changes such as state-level policies and secular trends when assessing the ability of their climate action plan to achieve a given target (Boswell et al., 2010), making the target a direct reflection of a city's policy ambition. In contrast, simply counting the number and types of policies that cities implement, which is a more typical approach in the literature (Bedsworth and Hanak, 2013; Castán Broto and Bulkeley, 2013; Stone et al., 2012), accounts for neither differences in the intensity of planned implementation, nor the varying efficacy of different policies.

We employ four screening criteria for a city to be included in our dataset.

1. The target is included in a Climate Action Plan (CAP) or a similar plan with climate change as the main topic. This criterion eliminates targets that are purely symbolic or aspirational, i.e. targets that are not coupled to a formal plan with specific GHG reduction

policies and projects. Thus, we exclude targets that are, for example, simply linked to a short discussion on a city webpage with no concrete mitigation actions. We also exclude targets that address only emissions from municipal operations.

2. The CAP includes a detailed quantitative breakdown, by policy or by sector, of the emissions reduction target. It has a thorough analysis of the policies to be implemented, and the associated GHG reduction expected from each action.

3. The target is set by a city, town, or civil township. We exclude counties and special districts, as their territorial boundaries often overlap with those of cities.

4. The status of state-level cap-and-trade was clear at the time the target or plan was adopted. We exclude cities in states that are (or were) part of the RGGI in the northeastern US, where the cap was set too high to provide a binding constraint on emissions. We also exclude certain plans in states that used to be members of the Western Climate Initiative.[6] In California, we only include plans adopted as of 2008 and later, by when it was clear that the state would implement cap-and-trade.[7]

These screening criteria led to more than 60 cities, mostly outside of California, being excluded from the sample, even though they had a CAP. Most commonly, the plan did not provide a quantitative breakdown of the target by policy, or only covered emissions from municipal operations.

Thus our final sample includes 103 cities, of which 72 are in California, and comprise the treatment group that is subject to cap-and-trade. The remaining 31 cities, in states with no existing or planned cap-and-trade programs, comprise the control group (see Figure 1). Thus, our sample frames are CAPs developed under California's cap-and-trade program, and CAPs developed in other states not under cap-and-trade. Cities were identified through Internet searches, using an ICLEI (Local Governments for Sustainability) database and

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[6] The Western Climate Initiative (WCI) brings together states and provinces interested in developing linked cap-and-trade programs. For cities in Arizona, Montana, New Mexico, Oregon, Utah and Washington, which withdrew from the WCI in 2011, we only consider plans published prior to the beginning of the WCI agreement, or after withdrawal.

[7] Our robustness checks described later in the paper show that similar results are obtained using different cut-off dates for the inclusion of plans from California cities.

annual report as starting points (ICLEI USA, 2009, 2010), which we supplemented with other sources (Boswell and Greve, 2012, OPR 2009, and Millard-Ball, 2011). The high degree of overlap between the different sources suggests that our sample includes the vast majority of cities with suitable climate action plans. However, given that there is no comprehensive database of climate action efforts, it is necessarily incomplete.
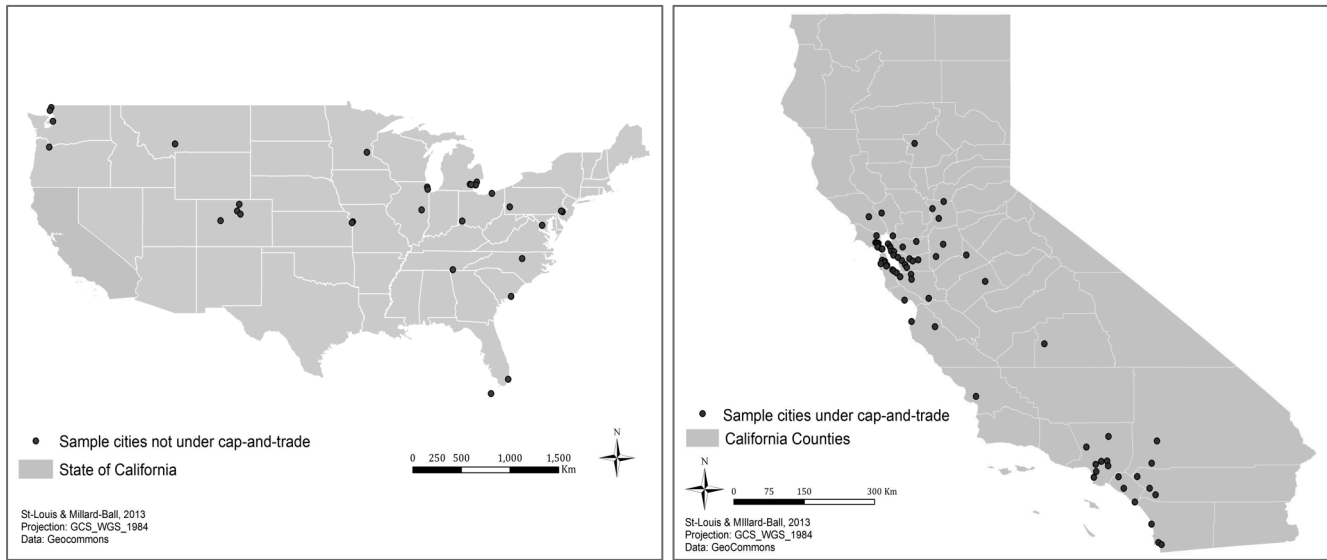

Figure 1. Map of the location of the control cities not under cap-and-trade (*left*) and of the Californian treatment cities under cap-and-trade (*right*)

Our primary dependent variable is the percentage of target emission reductions that a city plans to achieve in the energy and transportation (*energy_transport_share* in Eq. 1).[8] These two sectors affect emissions from electricity generation, transportation, and other fossil fuel combustion, which are covered by California's cap-and-trade program. Our definition of the transportation sector includes land-use policies such as transit-oriented development that are intended to reduce transportation emissions.

The remaining two sectors – waste and urban forestry/greening – affect emissions from sources such as methane from landfills, which are not capped in California. Note that we exclude emission reductions from a fifth sector, "other," as mitigation actions in this

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[8] In some cases, a city's overall target is greater than the emission reductions that the city expects to achieve from the mitigation measures included in its CAP. In these cases where there is a "challenge gap," we use the sum of expected emission reductions rather than the headline target. Where a given policy is associated with a range of emission reductions, we use the lower-bound estimate.

category (e.g. public education or purchasing local food) can affect both capped and uncapped emissions. Our preferred regression takes the form:

$$energy\_transport\_share_i = \alpha + \gamma Capped_i + \mathbf{x}_i\beta + \varepsilon_i \quad\quad (1)$$

Where i indexes cities; γ is the coefficient of interest; *Capped* is a binary variable indicating whether city i is in a state with a cap-and-trade program (i.e., California); $\mathbf{x}_i$ is a vector of control variables and β their coefficient; and ε_i is the error term. Table 1 reports descriptive statistics for all variables used in the analysis.

Table 1. Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max
Energy & transport share (% of target)	103	0.850	0.150	0.275	1
Energy & transport target (% of base year emissions)	103	0.186	0.154	0.007	0.854
Capped (1 = in state with cap-and-trade program)	103	0.699	0.461	0	1
Target reduction (MtCO$_2$-e) by sector:					
Energy	103	289,554	1,083,105	204	9,930,000
Transport	103	164,854	496,457	8	3,610,000
Waste	103	56,120	217,995	0	2,030,000
Urban Forestry	103	2,757	14,577	0	120,000
Other	103	13,233	80,574	0	800,000
Target reduction (% of base year emissions) by sector:					
Energy	103	0.112	0.095	0.001	0.437
Transport	103	0.074	0.091	0.001	0.634
Waste	103	0.022	0.024	0	0.146
Urban Forestry	103	0.002	0.005	0	0.029
Other	103	0.005	0.013	0	0.063
Year of climate action plan adoption	103	2010.6	1.7	2006	2013
Log population (2010)*	103	10.986	1.385	6.916	14.807
Education (% with bachelor's degree or higher, 2010)*	103	0.422	0.193	0.034	0.812
Log median household income (2010)*	103	11.159	0.381	10.221	12.251

* Source: American Community Survey 5-year estimates, 2006-10. All other data extracted directly from climate action plans.

By focusing on the allocation of target reductions across sectors, we avoid the need to control for city-level variables such as political preferences that affect the overall ambition of GHG reductions. Our identifying assumption is therefore somewhat weaker. Rather than assuming the exogeneity of *levels* of planned emission reductions, we assume that the

allocation of emission reductions across sectors is conditionally exogenous. In other words, we assume that we capture and correctly specify the factors that cause a city to allocate (say) more emissions reduction effort to waste rather than transportation. Our controls, therefore, include variables that might affect the sectoral allocation of mitigation effort, such as population, income and education levels, and the year of plan adoption. For example, large, affluent and highly educated cities may have more resources to undertake mitigation in "harder" sectors such as transportation, or less conventional ones such as urban forestry. Changes in typical planning practices may also mean that the balance of mitigation effort varies depending on when the plan was developed.

We report several alternative specifications. In Eq. 2, we ask whether the emission reductions target in the energy and transportation sectors, measured as a percentage of base-year emissions (*energy_transport_target)*, varies depending on whether the city is in a state with a cap-and-trade program. In Eq. 3, we use a fixed effects specification that allows us to capture cross-sectoral variations in the level of targeted emission reductions. Rather than a single observation per city, each observation in Eq. 3 is a city-sector.

$$energy\_transport\_target_i = \alpha + \gamma Capped_i + \mathbf{x}_i\beta + \varepsilon_i \qquad (2)$$

$$target_{i,s} = \gamma Capped\_sector_{i,s} + \alpha_i + \beta_s + \varepsilon_{i,s} \qquad (3)$$

Where *target* is the target reduction (percentage of base-year emissions) for sector *s* in city *i*; γ is the coefficient of interest; *Capped_sector* is a binary variable indicating whether sector *s* is capped in city *i* (i.e., whether sector *s* is energy or transportation and city *i* is in California); α_i and γ_s are city- and sector-fixed effects; and ε is the error term.

Fixed effects are most commonly used in panel data settings, where the city-level fixed effect (a binary variable for each city) captures unobserved attributes of cities that are constant over *time*, such as staff capacity and political climate. Our data here are for a single period, but the statistical idea is the same as in the panel-data setting; our fixed effects control for unobserved attributes of cities that are constant across *sectors*, such as

local environmental preferences, and the state of a city's finances. We could equally well call these "city-level effects" rather than fixed effects.[9]

One challenge with our empirical design is that because all our treatment cities are located in California, cap-and-trade may be confounded with other California-specific effects that affect the allocation of mitigation effort between sectors. To the extent that other factors – perhaps a sunny California climate that makes solar energy more cost-effective – increase the mitigation potential from energy and transportation, a handcuffing effect would be masked.

Most California-specific factors, such as the AB32 legislation and the greater concern for environmental issues shown by staff of California cities (Kwon et al., 2014), would affect the overall level of mitigation, rather than the sectoral split that we analyze here. Other factors, such as the low-carbon nature of the California electricity generation mix, would bias our results in the opposite direction to our findings.[10] Moreover, most cities, in California and beyond, use standard software and guidebooks for selecting and quantifying mitigation measures, which apart from the carbon-intensity of the electricity grid and vehicle fleet, do little to reflect state-specific circumstances.

However, we recognize that our empirical design does not lend itself to a conclusive test.[11] Our quantitative results should be seen both in conjunction with the qualitative data and as a starting point for empirical research in this area.

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[9] For examples of the use of fixed effects in a cross-sectional setting see Hale & Long (2011) or Long (2010). For other examples, which use region fixed effects in a city-level, cross-sectional analysis, see Glaeser & Kahn (2004, 2010) or Bellini et al. (2013).

[10] For example, the California electricity supply has an unusually low CO_2 intensity by US standards (i.e., low CO_2 emissions per MWh). This means that reducing electricity demand in California has less mitigation potential, MWh for MWh, and might be expected to push mitigation efforts to other sectors and bias our results towards finding a handcuffing effect.

[11] A difference-in-differences analysis using California climate action plans written both before and after the enactment of cap-and-trade would have been an ideal approach, but is hampered by the small sample size of plans that meet the required criteria. Nevertheless, in qualitative terms, early plans adopted by California cities such as Berkeley (1998) and San Francisco (2004) seem to read similarly to more recent ones. For instance, the share of emission reductions from capped sectors is similar to the mean share of our sample (84% in Berkeley and 88% in San Francisco, as compared to the sample mean of 85%).

Results

Bivariate analysis

We first compare the sample means and medians of the dependent variables in the control (non-capped) and treatment (capped) cities. As shown in Figure 2 and Table 2, the share of emission reductions that are accounted for by energy and transportation is similar in capped and non-capped cities, with a mean of 85%. Likewise, the emission reduction target for energy and transportation, calculated as a percentage of base-year emissions, is similar in both groups, at about 19%. The large share of emission reductions allocated to energy and transportation is unsurprising, given that these two sectors constitute large portions of cities' total GHG emission inventories (Dodman, 2009).

If cities were responding rationally to handcuffing from cap-and-trade, we would expect the share of emission reductions accounted for by energy and transportation to be lower in the treatment group. We would also expect the emission reduction target in these two sectors to be lower. Figure 2 and Table 2 indicate that this is the case, but that the difference between capped and non-capped cities is not significant at conventional levels for either dependent variable. Moreover, at just 4-5%, the difference in means between the treatment and control groups is small. In other words, there is no major difference in the way that the two groups of cities allocate their reductions between capped and non-capped sectors.

Target emission reductions by individual sector are also similar between capped and non-capped cities (Figure 3). The difference in means is not statistically significant for any of the five sectors (results not shown). Cities in the treatment group tend to set less ambitious targets in the energy sector and more ambitious targets for transportation. If this behavior were a response to handcuffing, one would expect a more consistent pattern, with capped cities allocating less mitigation effort to both energy and transportation.

One reason for the pattern of lower energy targets and higher transportation targets may be that transportation accounts for a large share of GHG emissions in California compared to other US states, while energy-related emissions tend to be lower due to limited use of coal and a history of stringent energy efficiency standards. Unfortunately, we do not have

sector-specific GHG inventory data for individual cities that would allow us to include this in the analysis.

Figures 2 and 3 also highlight some notable outliers. For example, Alameda and Menlo Park allocate an unusually small share (less than 50%) of emission reductions to the energy and transportation sectors, and allocate much of their effort to the waste sector. These cities are the most likely to be responding to handcuffing incentives, and we review their CAPs from a qualitative perspective later in this paper.
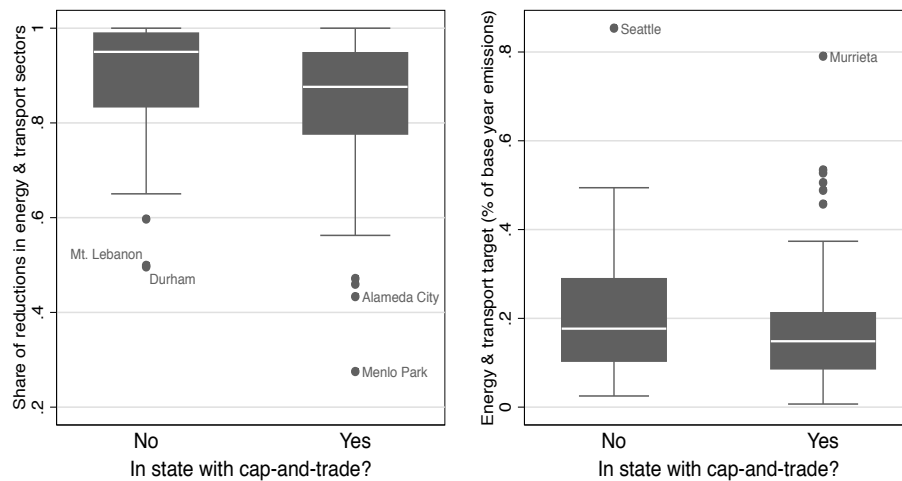

Figure 2. Energy & transport shares and target, for capped and non-capped cities

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Table 2. Two-sample t-test for difference in means

|	Energy and transport share (% of target)				Energy and transport target (% of base year emissions)			
	N	Mean	Std. Error	Std. Dev.	N	Mean	Std. Error	Std. Dev.
Not in cap-and-trade state	31	0.882	0.026	0.144	31	0.216	0.031	0.174
In cap-and-trade state	72	0.836	0.018	0.152	72	0.173	0.017	0.144
All	103	0.850	0.015	0.150	103	0.186	0.015	0.154
Difference		0.046	0.032			0.043	0.033	
	p = 0.077 (one-tailed test)				*p = 0.098 (one-tailed test)*			
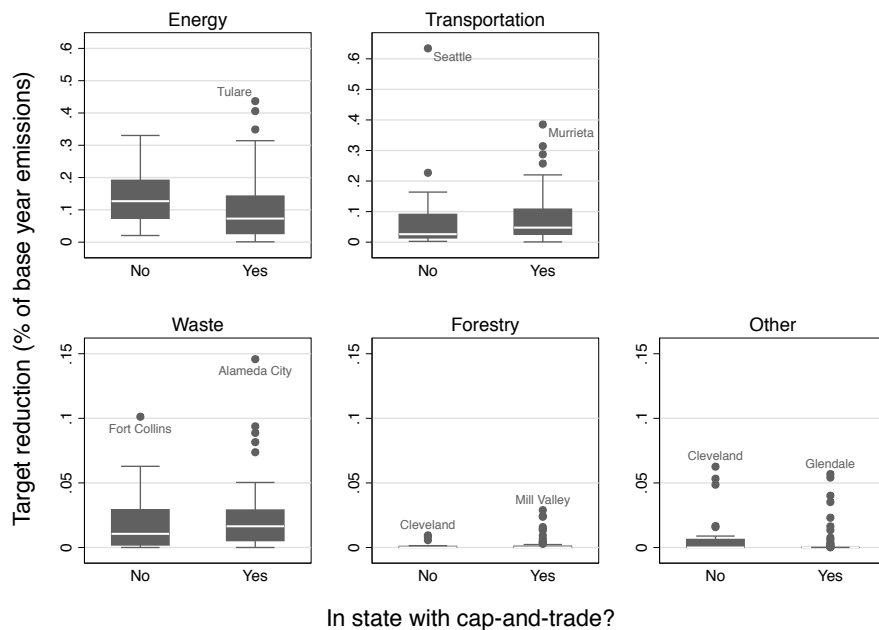
Figure 3. Target reductions by sector, as a percentage of base-year emissions

Multivariate regressions

In this section, we show the results of the regressions specified in Eqs 1-3. These regressions either control for additional city-level variables, or use fixed effects to control for unobserved characteristics of cities. The scatter plots in Figure 4 show the relationship between one of our dependent variables, energy & transport share, and other variables in our regressions: population; household income; education levels; and year of plan adoption. Two immediate conclusions can be drawn from Figure 4. First, the Californian and non-Californian cities in our sample do not differ greatly on any of the four variables, suggesting that our control and treatment groups represent similar types of cities. Second, there may be a weak relationship between our dependent variable and some of these variables. For completeness, we therefore include the four controls in our regressions.

Our first regression (Eq. 1) looks at whether the *share* of emissions accounted for by capped sectors (energy and transportation) varies according to whether a city is regulated by cap-and-trade (Table 3). Overall, the model explains almost none of the variance in the dependent variable ($R^2 = 0.06$). More importantly, our treatment variable (whether the city is located in a state with cap-and-trade) is not significant at conventional levels ($p = 0.21$).

Similar to the bivariate results presented above, the negative coefficient ($\beta = -0.05$) is consistent with a rational response by cities to handcuffing, but the effect size is small. While the coefficients of the control variables correspond to the relationships observed in Figure 3, none approach conventional levels of significance.
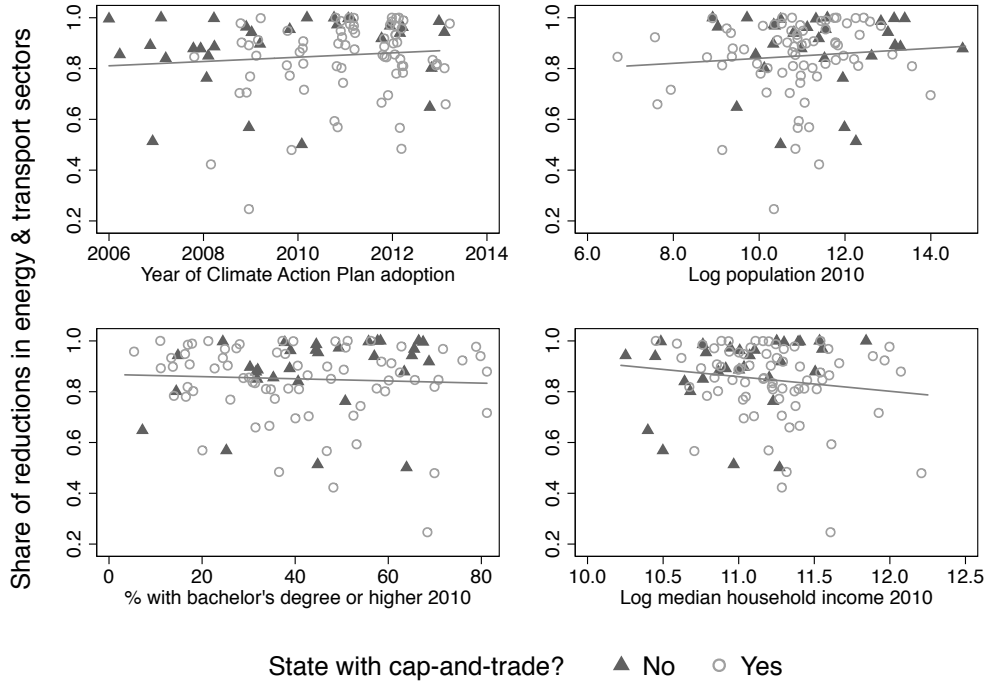

Figure 4. Distribution of energy & transport share against control variables

The second regression (Eq. 2) looks at whether the *quantity* of emission reductions in capped sectors varies according to whether a city is regulated by cap-and-trade. We obtain almost identical results (Table 3): almost none of the variance explained by the model; and a coefficient on our variable of interest that is neither large ($\beta = -0.02$) nor statistically significant ($p = 0.651$).

Table 3. Regressions controlling for city-level variables

	Dependent variable:					
	energy_transport_share			energy_transport_target		
	Coefficient	Robust std error	p-value	Coefficient	Robust std error	p-value
State with cap-and-trade?	-0.051	0.040	0.210	-0.020	0.045	0.651
Log population 2010	0.004	0.011	0.685	0.005	0.016	0.752
% with bachelor's degree or higher 2010	0.069	0.114	0.544	0.037	0.122	0.761
Log median household income 2010	-0.055	0.064	0.387	-0.067	0.076	0.376
Year of Climate Action Plan adoption	0.015	0.010	0.132	-0.003	0.009	0.744
Constant	-27.741	19.205	0.152	7.014	19.107	0.714
R^2	0.0578			0.0384		

N = 103

In the two previous regression models, we do not include city-level fixed effects, because we have only one observation per city. In effect, by expressing our dependent variables as a share of either the emission reduction target (Eq. 1) or baseline emissions (Eq. 2), we are already controlling for either the ambition of a city's target or current emission levels.

An alternative approach is to model sector-level mitigation targets and use fixed effects to capture unobserved characteristics at the level of the city. (The fixed effects mean that we can no longer include variables such as population, which are constant across sectors within a city.) Rather than a single observation per city, each observation is a city-sector (Eq. 3). The independent variable of interest here is the interaction between the state (capped or non-capped) and the sector (capped or non-capped), i.e. whether the city is in a state with a cap-and-trade program and the sector is covered by that program. As before, we find that the coefficient is neither large (β = –0.03) nor statistically significant (p = 0.34).

We do find large differences in targets across sectors (Table 4). For example, a target in the energy sector is on average 18.8% greater than a target in the transportation sector, and 39.4% greater than one in the waste sector. This makes sense given that energy and transportation represent a large portion of a city's total GHG emissions.

Table 4. Sector-level fixed effects regression

	Dependent variable: sector target		
	Coefficient	Robust std error	p-value
Sector			
Energy	(Omitted category)		
Transportation	-0.188	0.043	0.000
Waste	-0.394	0.037	0.000
Urban Forestry	-0.519	0.030	0.000
Other	-0.510	0.031	0.000
Sector is covered by cap-and-trade program?	-0.029	0.030	0.339
Fixed effects for cities	Yes		
Constant	0.534	0.033	0.000
R^2	0.6210		
N = 515			

Robustness tests

To validate our findings, we conduct a series of robustness tests. We re-run the same three regressions while excluding:

(1) Eight cities that had not officially adopted their climate action plan at the time we gathered data, even though a complete draft was available online.

(2) Two Californian cities that adopted their plan in 2008, and may not have realized that cap-and-trade was imminent. (We already exclude pre-2008 plans for California cities.)

(3) Four cities in Washington and Oregon, which from 2008 to 2011 were exploring cap-and-trade programs through the Western Climate Initiative. We already exclude pre-2011 plans from these states, but city officials may have continued to believe that cap-and-trade was a possibility.

(4) Six non-Californian cities with plans dating from before 2008, for sake of consistency with the plan dates of the California treatment group.

In these robustness checks, our results are similar to those reported above. None of the coefficients of interest attain statistical significance, and in most cases they are close to zero.

Qualitative Review

Our quantitative results suggest that cities are not responding to the changed mitigation incentives from state-level cap-and-trade policy. It is worth verifying whether these aggregate results conceal a small number of individual cities that may be taking handcuffing into account in developing their climate action plans. The outliers shown in Figures 2 and 3 – Californian cities that allocate a much greater portion of their mitigation effort to non-capped sectors – are the "most likely" cases (Flyvbjerg, 2006) where we may be able to identify an effect. Here, we provide a brief qualitative review of the climate plans, focusing on two notable outliers, Menlo Park and Alameda. We conducted a formal examination of these CAPs to look for evidence that these cities considered the handcuffing effect of state-level cap-and-trade in allocating emission targets by sector. Thus, we looked for (1) explicit references to cap-and-trade, (2) broader discussions of state-to-municipal climate policy interactions, and (3) motivations for elaborating a CAP.

First, the plan for Alameda (City of Alameda, 2008) does not include any reference to cap-and-trade, nor in fact, to any other state-level measure and how these may interact with local measures. As seen in Figure 2, Alameda demonstrates a high share of total emission reduction dedicated to the Waste sector (57% or 44,183 Mt CO_2 eq.), mainly through the implementation of an ambitious "Zero Waste Strategy" program. However, the plan does not specify anywhere that reduction efforts are targeted in this sector because of the crowding out that could occur in the energy and transportation sectors. In addition, the stated motivations for adopting this plan are to respond to the "serious threats posed to Alameda's climate, sea levels, native wildlife, and public health" (p. 15) by global climate change.

The plan for Menlo Park, on the other hand, includes an entire section on State and regional strategies and their quantified contribution to local emission reductions (City of Menlo Park, 2009). For example, the plan mentions the Low Fuel Carbon Standard and SB 375 for reductions in the transportation sector, and several statewide building energy efficiency policies for reductions in the energy sector (p. 85-86).

However, cap-and-trade is not included in this discussion of State measures. It is named once in the introduction, and mentioned in the conclusion as a possible source of funding for the City.

Similarly to Alameda, Menlo Park demonstrates a high share of total emission reduction dedicated to the Waste sector (72% or 43,557 Mt CO2 eq.), mainly through enhanced recycling services and a zero solid waste program. Still, the CAP is not explicit on why efforts are targeted in this sector. It is possible that Menlo Park plans for limited local reductions in energy and transportation (in comparison to waste) because it expects that State and regional measures will accomplish major reductions in these sectors. In all cases, however, it is clear that cap-and-trade is not the reason that Menlo Park anticipates a larger share of emission reductions in non-capped sectors. Indeed, the plan implies that state-level policies *augment* city-level mitigation, rather than (as with cap-and-trade) neutralizing a city's effort.

We also conducted a brief review of other CAPs in California, searching for key words such as "cap-and-trade" and "trading." We found limited recognition of cap-and-trade. In some cases, plans include a general reference to state regulations (e.g. AB32) and to the market mechanisms to be implemented. Some cities such as Sacramento, Albany, and West Hollywood do not reference cap-and-trade at all. In other cases, cap-and-trade is mentioned – for example plans drafted by the City of Hayward (2009), Fullerton (2012), or San Diego (2012) detail how a cap-and-trade system works, how it could influence the cost-effectiveness of mitigation for industries, or how non-covered entities can voluntarily join the program by holding allowances. However, the limitation of cap-and-trade on the city's ability to reduce aggregate emissions is not addressed in any of the 72 Californian plans reviewed.

Looking at how California CAPs take into account state mitigation measures in relation to local mitigation efforts, we thus find no systematic and consistent approach to this city-state interaction. While some plans explicitly count on state policies to achieve their reduction targets (perhaps indicating some degree of crowding out), other cities are clear on the fact that they believe they must achieve their reductions independently from the

state. For example, San Carlos recognizes that it cannot achieve any ambitious mitigation goal without the contribution of statewide strategies (City of San Carlos, 2009). Thus, the plan adds estimates of statewide reductions to the city's total emission reduction target (59.7% of total planned reductions is attributed to statewide reductions), even though cap-and-trade is only mentioned once. In contrast, cities such as Citrus Heights assert they will *not* depend on statewide measures to achieve their own local objectives, suggesting that it is their duty to share the burden of mitigation efforts (City of Citrus Heights, 2011).

Discussion

A consistent picture emerges from the analysis above: there is no robust evidence that cities are handcuffed by cap-and-trade systems implemented by higher tiers of government. Cities allocate their mitigation efforts in similar ways regardless of whether or not they are in a state with a cap-and-trade program. The differences between cities in California (the treatment group with cap-and-trade) and other states (the control group) are neither large nor statistically significant. While several theoretical studies (Shobe and Burtraw, 2012; Twomey et al., 2012) suggest that state cap-and-trade programs would crowd out local mitigation efforts, we offer the first empirical evidence to show that this does not appear to be happening in practice. Of course, failure to reject the null does not demonstrate that the null hypothesis is true, but the absence of any large effects on city behaviour suggests, at the minimum, that any handcuffing effect is likely small and/or mediated by a complex mix of city motivations.

One might argue that cities are constrained in their mitigation options. Even if capped cities wished to place more mitigation effort in non-capped sectors, the potential for them to do so is limited. Energy and transportation provide more mitigation opportunities than do waste and urban forestry. However, in the presence of handcuffing, one would still expect a city to scale back or eliminate emission reductions in capped sectors, even if it did not redirect these efforts elsewhere.

A further argument is that it is simply too soon to expect a response from cities to cap-and-trade, given that obligations under California's program only began in January 2013. However, the enabling legislation was passed in 2006 as part of AB32, and the state's 2008

Scoping Plan for AB32 implementation reaffirmed the commitment to cap-and-trade. Moreover, several of the earlier CAPs *mentioned* the prospect of cap-and-trade in their climate action plans, and included emission reductions from other planned (but perhaps still-to-be-implemented) state-level policies in their emissions analysis.

Thus in the remainder of the paper, we discuss more plausible reasons for our findings, referring to the typology of four explanations developed earlier in the paper. Why do capped cities fail to adjust their mitigation planning in the presence of handcuffing? While grounded in our own results and the wider literature, our explanations are necessarily somewhat speculative, and further quantitative or qualitative work is needed to arrive at firmer conclusions.

Knowledge and understanding

The simplest set of explanations relate to a city's understanding of the handcuffing phenomenon. Many cities, particularly in California, follow a standard template and base their mitigation plans on recommendations, tools and models provided by ICLEI, a non-profit that promotes local climate action planning. CAPs from diverse cities can look surprisingly similar in terms of targets and mitigation options proposed.

Even if city staff is more centrally involved in developing locally tailored mitigation options, they may not realize how cap-and-trade affects their city's ability to influence aggregate mitigation. Although most Californian plans that we reviewed include a chapter dedicated to presenting the state's climate legislation, a fair number of these plans do not refer to cap-and-trade, or do not give much attention to how it affects the city's efforts. While handcuffing has been actively debated in Australia (Twomey et al., 2012) it has received limited attention in California.

Alternative motivations for municipal climate planning

Cities may have alternative motivations for their climate planning efforts: a desire for the "warm glow", socio-political motivations, or the allure of local co-benefits. This set of explanations seems plausible based on the literature and on our qualitative review of CAPs.

First, a city may have preferences over its own contribution to mitigation, rather than emissions at the aggregate scale. The local climate benefits of reducing GHG emissions from a single city will be infinitesimal even in the absence of handcuffing, but the "warm glow" that locals obtain from taking such action may be substantial.

Relatedly, city leaders may be responding to citizen pressures (Kousky and Schneider, 2003) or opportunities for political entrepreneurship (Engel and Orbach, 2008). Local politicians may see climate planning as a way to gain attention or recognition, and receive credit for policies that would have been implemented anyway.

Third, a city may be motivated by the co-benefits of reducing GHG emissions (Bulkeley and Betsill, 2003; Kousky and Schneider, 2003) – local environmental benefits, such as increased air quality; social benefits such as increased active transportation and reduced traffic congestion; and economic benefits such as reduced dependency to oil or the creation of jobs. Studies looking at motivations for climate planning, such as Krause (2013), confirm that the most cited motivation for voluntary CAP adoption is cost savings (and other financial reasons), while pure altruism only constitutes a secondary motivation.

Strategic indirect effects: A complicated state-local relationship

More generally, there is a complicated relationship between city and state climate change policy under cap-and-trade, and cities may see an avenue to bring about emissions reductions indirectly, through influencing future decisions on the cap.

On the one hand, certain Californian plans *rely* on state regulation to achieve the local target they set out for themselves, as mentioned in the Qualitative Review section. On the other hand, many California cities frame their efforts as contributing to the wider state-level goal, almost to the point as acting as an implementation agency for the state's climate policy. In part, this is due to legal concerns: following action by the state attorney-general, two local governments developed climate action plans as part of a legal settlement, and the threat of further legal action motivated other cities to follow suit (Bedsworth and Hanak, 2013).

In both instances, the implication is that planners are aware that they are working within, and are interdependent to, a larger geographical and political framework. It may seem contradictory that cities take into consideration reductions induced by state measures, yet fail to consider the impacts of cap-and-trade on city actions. But this merely reinforces the complex nature of multilevel governance. Cities act independently from states, but are also constrained by legal forces, and perhaps a commitment to help the state implement its policies. Moreover, cities might have in mind a long-term goal to influence state policy: if the price of carbon falls because of voluntary action from cities, then the state may make a future cap-and-trade program more stringent.

Cap-and-trade design

As discussed earlier, California's cap-and-trade program includes a price floor, below which carbon allowances are not released at auction by the regulator. It is possible that cities expected the price to fall to the level of the floor and the cap to cease to bind, in which case city action could affect aggregate mitigation. However, this is unlikely in practice. None of the plans reviewed mention the price floor. Moreover, CARB's 2008 Scoping Plan indicated that the cap would bind and that the price would be above the level of the floor, and early forecasts also predicted a carbon price well above the floor.[12]

Conclusion

Handcuffing presents a challenge to the efficiency of cap-and-trade programs. Some of the most effective climate policy measures, such as transportation planning and building efficiency policies, are best undertaken by local governments. Yet rational cities may choose to scale back or abandon these policies if cap-and-trade prevents them from reducing aggregate emission levels.

Several authors have identified the problem of handcuffing and set out policy solutions. For example, Twomey et al. (2012) propose that cap-and-trade allowances be automatically retired following verified mitigation by outside sources. In other words, the

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[12] Table 2 of the 2008 Scoping Plan indicates that 34.4 of the 146.7 $MMTCO_2$-e of reductions in capped sectors would be achieved through the carbon price, i.e. that the cap would be binding. For some early forecasts, see Henderson (2011).

cap could be lowered to ensure that action by cities and other entities would reduce aggregate emissions. Fortunately for policy makers, we find no evidence that such remedies are warranted in practice, as cities are not dramatically changing their behavior in response to handcuffing. (Needless to say, one might question whether this state of affairs will continue, particularly as city officials become more familiar with cap-and-trade.) Given the difficulties in distinguishing between cap-and-trade and other California-specific factors in our dataset, our results should be seen as suggestive rather than conclusive, and as a starting point for further empirical research. However, at a minimum, it is clear that cities are still allocating the vast majority of their mitigation efforts to capped sectors.

Crowding out of local policy action by state efforts has been observed in other domains such as highway spending (Knight, 2002). Why not then, in the climate policy arena, where one might expect considerably greater crowding out because the impacts of local policy are not just diminished but precluded altogether? From this perspective, city behavior may seem irrational. But then, given the nature of climate change as a global commons problem, a rational city might not wish to undertake any mitigation in the first place. That cities act on climate policy when it might seem optimal to free ride, and fail to scale back their efforts in response to state policies, suggests that cities might be primarily motivated by benefits to themselves, rather than an altruistic desire to reduce global emissions.

Acknowledgments

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