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Energy Subsidies and Policy Commitment in Political Equilibrium

ABSTRACT

Because energy subsidies affect incentives to invest in energy-saving equipment and technologies, they entail a classic investment hold-up problem: once investment has taken place, policymakers will tend to overuse them, which will in turn depress investment by forward-looking agents. Reforming energy subsidies thus requires overcoming a policy commitment problem. In this paper we show that, even when commitment is feasible in principle, it may fail to materialize in a political equilibrium due to politicians' re-election incentives. In particular, it will be those politicians who are comparatively less favorable to energy subsidies who may fail to commit to phase them out.

KEY WORDS: Policy Commitment, Energy Subsidies

JEL CLASSIFICATION: H1, D7, D9

1 Introduction

Energy subsidies are widespread and substantial,[1] but are also a major source of inefficiencies: they encourage waste, overconsumption, and the adoption or maintenance of energy-intensive processes, discouraging the development and introduction of energy-saving techniques. Energy subsidies also entail large (and not fully transparent) fiscal costs, encourage smuggling and fraud, and promote excessive pollution and CO2 emissions.[2]

A likely reason for the popularity of energy subsidies is that they produce distributional effects that a majority of voters favor.[3] Whatever their distributional effects,

[1]The International Energy Agency (IEA, 2011) estimated the total world amount of energy subsidies in 2010 at approximately $410 billion (about 0.6 percent of world GDP, based on IMF estimates of world GDP at about $64 trillion in 2010: see IMF, 2014). Similarly, Cody *et al.* (2013) estimated that in 2011 global subsidies (net of the costs associated with consumption externalities) amounted to $492 billion, equivalent to 0.7 percent of the world's GDP. According to MISI (2011), the average annual energy subsidies provided by the U.S. federal government between 1950 and 2010 amounted to about $14 billion, of which about $6 billion accrued to the oil industry in the form of preferential tax treatment, favorable regulations, and free or below-cost public goods and services. The Environmental Law Institute (2009) estimated that U.S. federal energy subsidies during fiscal years 2002-08 amounted on average to $14.4 billion, equivalent to about 0.1 percent of GDP. Figures reported by Shang *et al.* (2013) are in line with these estimates for the U.S., and also suggest that in at least twenty countries energy subsidies in 2011 may have exceeded 5 percent of GDP. According to the UNEP (2008), energy subsidies in 2005 amounted to $40 billion in Russia, $37 billion in Iran, and exceeded $10 billion in six other countries, including China and India. According to the World Bank Independent Evaluation Group, in 2008 five countries had fuel subsidies equal or larger than 5 percent of GDP and nine countries spend more than twice on fuels subsidies than on public health (IEG, 2009). Data reported in Bauer *et al.* (2013) confirm this picture and suggest that at least ten countries spent more on energy subsidies than on public health and education services.

[2]The IEA (2011) estimated that, if fossil-fuel consumption subsidies were phased out by 2020, energy demand growth would decline by 4 percentage points, oil demand by 3.7 mbd, and growth in CO2 emissions would be cut by 1.7 Gt. According to Anderson and McKibbin (2000), removing coal subsidies in OECD and non-OECD countries would reduce global CO2 emissions by 8 percent, with little impact on GDP. Ivanic and Martin (2008) estimated that removal of energy subsidies in the Middle East and North Africa would raise welfare by $15.3 billion in the region and by $30.4 billion in non-OPEC countries outside the region, while reducing it by $2.5 billion in OPEC countries outside the region.

[3]Energy subsidies are a politically robust mechanism to convey transfers to the "energy-dependent

however, energy subsidies are a very inefficient way of achieving them. So why are energy subsidies so persistent?

A possible explanation for this persistence rests on the dynamic characteristics of energy use, and the time-inconsistency problem that arises as a result. Energy consumption can be reduced by investing in energy saving technologies and equipment, and private incentives for undertaking such investments are directly related to the price of energy – and hence negatively related to the size of energy subsidies. Thus, if individuals expect a reform of energy subsidies aimed at reducing their scope or phasing them out altogether, they will respond by investing more. To the extent that this investment is irreversible, however, policymakers' incentives to implement the reform weaken after individuals have undertaken energy-saving investments. Anticipating the ex-post incentives of policymakers, individuals may not believe the announcement of a future reform unless its credibility is backed by effective institutional arrangements.

In this paper we explore this issue in more detail, focusing on its interaction with the wider political economy, in an environment where the citizens elect public representatives ("policymakers") who decide both on the level (and reform) of energy subsidies and on various other issues of public policy. We show that, under certain conditions, an incumbent policymaker may deliberately refrain from reforming energy subsidies in order to ensure her future re-election, and that this may also occur in an infinite sequence of repeated elections. In certain circumstances, even the citizens may play this strategy by electing a policymakers that they know would behave in this way.

First, we characterize the policy commitment problem that confronts the policymaker elected at the beginning (the "incumbent"), in a setting where citizens have different, exogenous, energy-consumption needs, and where the policymaker – like all other citizens – cares not only about her own welfare but also about the welfare of

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poor". They target basic needs, such as domestic heating and transportation, but the rich also benefit from them: according to Bauer *et al.* (2013), in low and middle-income countries on average 43 percent of fuel subsidies accrues to the richest 20 percent of households, and only 7 percent to the poorest 20 percent (similar estimates, for Africa and other regions, are found in Clements *et al.*, 2010, and in IEA, 2011). However, the ratio of energy subsidies to income or consumption is larger for the poor. For instance, a 2004 study for Bolivia found that hydrocarbon subsidies were important for the poor, despite substantial leakages to richer households (IEG, 2009).

the "energy-dependent poor". The policymaker thus faces a conflict between distributional objectives (that justify the provision of energy subsidies) and efficiency and investment-promoting objectives (that require a reform of the subsidies).

We then examine under what conditions this type of problem may fail to be tackled by policymakers in political equilibrium, even when the policymakers have the technical/institutional capacity to make a credible commitment to reform. For this purpose, we develop a two-period model of political competition with multidimensional policy choices; we assume that policymakers elected in the first period (incumbents) have the option of making their announcements of future reforms credible by adopting a specific institutional arrangement ("commitment") that places a binding constraint on future subsidies. We then use this model to investigate whether such commitment mechanisms, when available, may remain deliberately unexploited, resulting in a a failure to engage in reform.

In our model, the subgame imperfection of optimal choice paths along the policy dimension of energy subsidies plays in favor of restricting the discretionary power of second-period policymakers. Such restrictions, however, transform the electoral game by effectively removing one policy dimension from the agenda, to the disadvantage of candidates that have an electoral comparative advantage on that dimension. Incumbent candidates anticipate this effects and take it into account when deciding whether or not to undertake a credible commitment to reform.

If voters' preferences over candidates are single-peaked – implying that the elected policymaker is always one who is favored by the median voter – this problem is irrelevant in equilibrium: a median citizen who stands for office would be always elected in every period anyway; the removal of one policy dimension from the agenda does not change the outcome of future elections, and as a result it is always optimal for the incumbent to commit to reforming energy subsidies. If, however – as frequently is the case in practice – the space of eligible candidates is restricted to a subset of citizens with specific policy preferences,[4] then a commitment to reform could alter the outcome of future elections in a direction that is unfavorable to the incumbent, who may thus refrain from undertaking such commitment in the first place. Since voters

[4]For instance, candidates may be drawn among the wealthiest and most educated members of the polity, whose distribution of policy preferences may differ from that of the entire community.

cannot commit to re-elect the incumbent – or, more generally, a policymaker whose policy preferences are close to the incumbent's – the incumbent may prefer to retain inefficient discretionary control of energy subsidies in order to secure a more favorable second-period electoral outcome.

This strategic behavior on the part of elected candidates will be anticipated by voters and will be reflected in the outcome of first-period elections. We show that two outcomes are possible, depending on the overall combinations of policy choices that the different candidates directly implement in the first period and indirectly induce in future periods. Voters may elect first-period candidates who, other things being equal, are more ready to adopt a credible commitment to subsidy reform, even if their position on other policy issues is farther from the one they favor; or they may elect a candidate who is unwilling to commit.

Our analysis of policymakers' commitment choices is related to earlier studies of the relationship between long-term policy choices and political equilibrium in a democracy (Persson and Svensson, 1989; Alesina and Tabellini, 1990; Aghion and Bolton, 1990; Milesi-Ferretti and Spolaore, 1994; Milesi-Ferretti, 1995). The political game that we formalize bears methodological similarities with the model of Besley and Coate (1998), who, however, focus on a situation where a current policy decision affects the preferences and welfare of the citizens in the future and no problem of policy commitment arises. Our study, instead, specifically focuses on the issue of the credibility of long-term policy targets, and on how the commitment to a policy target is determined in political equilibrium.

The paper is organized as follows. Section 2 characterizes the policy commitment problem. Section 3 examines the commitment incentives facing political competitors. Section 4 discusses results and concludes. Proofs of results are given in Appendix A.

2 Energy subsidies and the commitment to reform

In this section we describe the policy commitment problem that is associated with the reform of energy subsidies. This problem arises because of how distributional objectives are traded off against efficiency objectives by policymakers before and after individuals make their investment decisions. The basic idea is simple: energy subsidies are used as an instrument of redistribution, to soften the differential impact of energy costs across different individuals, but they discourage efforts to adopt new energy-saving technologies. This latter effect is accounted for by policymakers when choosing subsidies ex ante, but not ex post, after such investments have been made. Such omission results in a gap between the optimal ex-ante subsidy choice and the ex-post subsidy choice, weakening the credibility of any announcements of future subsidy reforms – a classical commitment problem. We formalize this idea below.

Consider an economy composed of a population of unit mass. Each individual has income $m \in [\underline{m}, \overline{m}] \equiv M$ and exogenous energy (fossil fuel) consumption needs equal to $i \in I \equiv [0, 1]$. Such heterogeneity could reflect, for example, heterogeneity in residential patterns, which in turn would translate into heterogeneity with respect to individuals' reliance on private forms of transportation. We assume that i – hereafter referred to as a consumer's energy requirement "type" – is uniformly distributed in I. For simplicity, we also assume that i and m are uncorrelated (i.e. independently distributed) in the population – in Appendix B we present an extension where, more realistically, they are positively correlated, and show that this does not alter our key conclusions.

The producer price of energy, gross of any subsidy, is unity. The consumer price of energy is p, which equals unity in the absence of any subsidies but is reduced to $p = 1 - s$ if energy products are subsidized at some rate $s \in [0, 1)$.[5] Energy use is purely a cost for individuals, i.e. individuals only derive utility from consumption of non-energy goods (hereafter called "consumer goods").

The total financial cost of the subsidies, F, is paid by the government by raising a uniform, lump-sum levy on all taxpayers.[6] Owing to various inefficiencies and dis-

[5]The subsidies we represent in this model by s could take many forms, including direct consumer price subsidies and production subsidies that are fully transferred to the consumers. We only consider the possibility of non-negative subsidies: although some governments actually tax energy products in order to encourage the adoption of energy-saving technology and habits, the effects of positive and negative subsidies can be asymmetric (for instance, while the collection of taxes to finance positive subsidies entails a deadweight loss, any distribution to taxpayers of the amount collected through negative subsidies would not produce any deadweight gains). For simplicity and without much loss of generality, we restrict our attention to non-negative subsidies. In the closed-economy context we examine here, subsidies on energy use are fully equivalent to production subsidies.

[6]This simplifying assumption is also relaxed in Appendix B, where the levy is assumed to be propor-

tortions, the total actual costs directly or indirectly incurred by the taxpayers, $T(F)$, (comprising the net amount used to pay the subsidies, administrative costs, and other deadweight losses) is larger than the financial costs of the subsidies themselves, and the difference due to the inefficiencies and distortions increases with the size of the subsidies. Formally, it is assumed that $T(0) = 0$, $T'(F) \geq 1$ and $T''(F) > 0$.

Before consuming energy, individuals can make investments that reduce their future energy consumption needs from i to $(1-a)\,i$ (for example, individuals can buy cars that are more fuel efficient but more expensive to buy). These investments have no impact on contemporaneous consumption. We assume that the cost of this investment per unit of energy requirement is a continuous, thrice differentiable and convex function of a, with the usual properties $c(0) = 0$, $c'(a) \geq 0$, $c''(a) > 0$, $c'(0) = 0$, $c'(1) > 1$; i.e. no costs are incurred if no investment takes place; costs increase with the size of the investment, and they do so at a rate that increases from zero when $a = 0$ to a level that lies above unity for $a = 1$.[7] It is further assumed — for reasons that will become clear later – that $c'''(0) \geq 0$ (the third derivative of investment costs with respect to investment size is non-negative; in other words, the rate of increase of marginal costs does not decrease with the size of the investment).

Given the energy-saving investment made by the consumers (which, as shown below, in this setting is the same for all consumers), total energy consumption (in physical units) is

$$E(a) = \int_0^1 (1-a)\,\mathrm{d}i = \frac{1-a}{2}, \tag{1}$$

and the total financial cost for the government of the subsidies actually paid to all consumers is equal to

$$F(s,a) = s\,E(a) = s\,\frac{1-a}{2}. \tag{2}$$

Since the mass of individuals is unity, the per capita cost of delivering the subsidy hereafter called "the tax", which comprises the levy plus any other losses due to distortions, equals $T\big(F(s,a)\big)$. Thus, the disposable income of an individual with energy

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tional to income.

[7]This latter condition implies that a is always less than one: a hypothetical investment that reduced energy consumption needs to zero is never economically viable.

requirement i and income m, net of the tax, of the cost of energy-saving investment, and of energy costs (net of subsidies), equals

$$y(s,a;\, i,m) = m - T\big(F(s,a)\big) - \big(c(a) + (1-a)(1-s)\big)\, i. \tag{3}$$

This is the amount that each citizen can spend on consumer goods and coincides, here, with the individual's purely private level of utility.

Individuals do not care only about their own private utility, but also about the welfare of the other members of society, and most notably that of less privileged individuals. These altruistic concerns are captured by a Rawlsian welfare function $W\big(y(s,a;\, i,m),\, i \in I,\, m \in M\big) = \min_{i,m} y(s,a;\, i,m) = y(s,a;\, 1,\underline{m})$ (since $y(s,a;\, i,m)$ is increasing in m and decreasing in i); in other words, social welfare coincides with the utility of the least well-off individual, who is the individual with the lowest income, $m = \underline{m}$, and with the highest energy requirement, $i = 1$. Each individual's overall utility, $g(s,a;\, i,m)$, is thus equal to a weighted average of her own disposable income, $y(s,a;\, i,m)$, and of the Rawlsian welfare level $y(s,a;\, 1,\underline{m})$, according to some weight ω which we assume to be the same for all citizens: [8]

$$\begin{aligned} g(s,a;\, i,m) &= \omega\, y(s,a;\, i,m) + (1-\omega)\, y(s,a;\, 1,\underline{m}) \\ &= \omega m + (1-\omega)\underline{m} - T\big(F(s,a)\big) - \big(c(a) + (1-a)(1-s)\big)\rho(i). \end{aligned} \tag{4}$$

where $\rho(i) \equiv (1-\omega)\, i + \omega$.

Consumers choose how much to invest in energy-saving technologies on the basis of the level of subsidies they expect. Each individual consumer chooses the amount of investment that minimizes her total expected energy-related costs (investment costs plus energy costs) given the expected retail price of energy (net of subsidies); this is the level for which the marginal cost of investment is equal to the expected retail energy price; this is the level of a for which $c'(a) = p = 1-s$, implying a choice $a = \theta(p) = (c')^{-1}(p) = (c')^{-1}(1-s)$ per unit of energy use, where $(c')^{-1}(p)$ is the

[8]Differences in citizens' preferences about the optimal level of subsidies are thus not determined by differences in the intensity of their concerns for the welfare of the poor, but only by the difference in their own private energy consumption needs. Incorporating such differences in attitudes in the model would not yield to major gains in terms of generality.

inverse of the first derivative of $c(.)$.[9] Since $\theta(p)$ does not depend on the consumer's type, (i, m), all consumers make the same energy-saving investment per unit of energy requirement – on the basis of the expected level of s. The total cost of this investment for a consumer with energy requirement i is thus equal to $c\big(\theta(p)\big)\, i$.

Suppose now that citizens appoint, through democratic elections, a citizen of type (i, m) as the officer charged to select a rate of subsidy (the "policymaker"), and that this rate is publicly announced and committed to before consumers make their investment decisions; and suppose that the appointed citizen makes her choice according to her own preferences, i.e. in order to maximize her overall utility $g(s, a; i, m)$, which depends on her type, (i, m).[10] Anticipating the citizens' investment response, the policymaker will incorporate in her decision how the subsidy affects a, i.e. she will choose a rate of subsidy that maximizes her ex-ante utility

$$
\begin{aligned}
g\big(s, \theta(1-s); i, m\big) = \;\; & \omega m + (1-\omega)\underline{m} - T\Big(F\big(s, \theta(1-s)\big)\Big) \\
& - \Big(c\big(\theta(1-s)\big) + \big(1-\theta(1-s)\big)(1-s)\Big)\, \rho(i). \qquad (5)
\end{aligned}
$$

The first-order condition for an interior optimum with $s > 0$ can be written (after simplification, and omitting arguments of functions) as

$$(1-\theta)\big(2\rho(i)/T' - 1\big)\, c'' - s = 0.^{11} \qquad (6)$$

Alternatively, the optimum may be at a corner with $s = 0$.[12] For simplicity, in the discussion that follows we shall assume that ω is large enough that the optimum is an

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[9] Given our earlier assumptions, $\theta(p)$ has the following properties: $\theta(0) = 0$; $\theta' = 1/c'' > 0$; $\theta'' = -c'''/(c'')^2 \leq 0$.

[10] This is in line with citizen-candidate models of political competitions, as first developed by Osborne and Slivinski (1996) and Besley and Coate (1997). Such behavior does not necessarily imply disregard of the public interest: first, public interest is already accounted for in the Rawlsian component of overall utility; in addition, a policymaker's perception and assessment of the needs of other citizens may be shaped by the same factors that enter her utility function even if the policymaker is fully benevolent. Note, too, that the policymaker's personal preferences, like those of all other citizens (elected and non-elected), incorporate a concern for the welfare of the least well off individual.

[11] One can verify that $c''' \geq 0$ is a sufficient condition for the second-order curvature conditions for an optimum to be satisfied given our other cost convexity assumptions.

[12] This assumes that subsidies are constrained to be non-negative. The model can be extended to

interior optimum identified by (6), i.e. that $\omega > \underline{\omega} \equiv T'(0)/2$, the latter value being identified by the condition $\rho(0)/T'(0) = 1/2$. As (6) is independent of m, we can express the ex-ante preferred subsidy as a function, $s_{EA}(i)$, of i alone.

Totally differentiating (6) with respect to s and i, we obtain (after simplification)

$$\frac{\mathrm{d}s_{EA}(i)}{\mathrm{d}i} = \frac{(1-\theta)\rho'}{\big(s\,\theta' + (1-\theta)\big)^2\, T''/4 - s\,T'\,\theta''/2 + (T'-\rho)\theta}. \tag{7}$$

A sufficient condition for this derivative to be uniformly positive in the interval $[0,1]$ is $\theta'' \leq 0$ – which always holds given our earlier assumption that $c''' \geq 0$.[13] The ex-ante preferred subsidy is therefore increasing in i.

If, on the other hand, the same individual is appointed to select a subsidy level ex post, i.e. after investment choices have been made, then the policymaker would take a as given and set the subsidy rate at the level that maximizes her own ex-post utility

$$g(s,a;\,i,m) = \omega m + (1-\omega)\underline{m} - T\big(F(s,a)\big) - c(a) - (1-a)(1-s)\,\rho(i). \tag{8}$$

Differentiating the above with respect to s (and bearing in mind that a is now given) yields the first-order condition

$$2\,\rho(i) - T' = 0. \tag{9}$$

For $\omega \geq \underline{\omega} = T'(0)/2$ (the minimum value of ω that ensures an interior ex-ante optimal choice of s) this identifies an interior ex-post optimal subsidy rate $\tilde{s}_{EP}(a;\,i)$, conditional on a given level of a, for all $i \in [0,1]$. This rate is increasing in i – the total derivative is $\mathrm{d}\tilde{s}_{EP}(a;\,i)/\mathrm{d}i = 4\rho'/\big((1-a)T''\big)$, which is positive for $a < 1$.

In a perfect-foresight equilibrium where all citizens (including the policymaker) anticipate the subsidy level that will be selected, we must have $a = \theta(\tilde{s}_{EP}(a;\,i))$, which, in conjunction with (9), identifies an equilibrium ex-post level of subsidy, $s_{EP}(i)$.[14]

include the possibility of negative subsidies, equivalent to a tax on energy products, as is enforced in many advanced economies. This modification would yield qualitatively similar results, with no major gains in generality.

[13]This condition is sufficient but not necessary. Even if $c''' < 0$, the optimal subsidy will still be increasing in i as long as negative third term in the denominator of (7) does not dominate the remaining positive terms, which amounts to the second-order conditions for (6) to identify an interior maximum.

[14]A necessary condition for this equilibrium to be stable is that $\mathrm{d}s_{EP}(i)/\mathrm{d}a < 1$ at the fixed point; this in turn requires $s\theta'/\theta < 1$.

Moreover, it can be shown that $s_{EP}(i)$ exceeds $s_{EA}(i)$:

Proposition 1 *For any given policymaker whose energy requirement, i, is such that $\rho(i) \geq 1/2$, the ex-post optimal subsidy $s_{EP}(i)$ is greater than (or equal to) the ex-ante optimal subsidy $s_{EA}(i)$, with equality holding only if $\rho(i) = 1/2$.*

PROOF: See Appendix A.

These results can be illustrated by means of an example. Let $c(a) = a^2$, $T(F) = F + F^2$, and $\omega = 1/2$. The ex-ante optimal choice of s by i in this case is equal to

$$s_{EA}(i) = \frac{1}{2}\left(\frac{(4/3)\,i - 1 + \Xi^2}{\Xi} - 1\right), \tag{10}$$

where

$$\Xi \equiv \left(2(1+i) + (1/9)\sqrt{405 + 12\big(27 + (63 - 16i)\,i\big)\,i}\,\right)^{1/3}. \tag{11}$$

whereas the corresponding ex-post optimal choice of s by i, after substituting the perfect-foresight abatement choice $a = \theta(1-s) = (1-s)/2$, is

$$s_{EP}(i) = \frac{\sqrt{1+8i} - 1}{2} > s_{EA}(i). \tag{12}$$

The equilibrium levels of subsidy under ex-ante and ex-post policy selection by policymakers of different types in this example are shown in Figure 1.

Ex post – after investments have been made – the policymaker does not need to worry about the (adverse) effects of the subsidy on energy-saving investment, and so the distributional objectives will carry a comparatively greater weight in her decision problem, implying that the subsidy that is chosen ex post is higher than the subsidy that would have been chosen ex ante by the same policymaker.

Hence, if the policymaker is unable to commit to the announced level of subsidy, the citizens anticipate that, after investments have been made, she will set the subsidies at her own preferred ex-post level, and make their ex-ante investment decisions accordingly. Lack of a credible commitment to a specific level of subsidies thus makes the policymaker unable to implement her preferred, lower, and (for her, at least) more efficient ex-ante level.

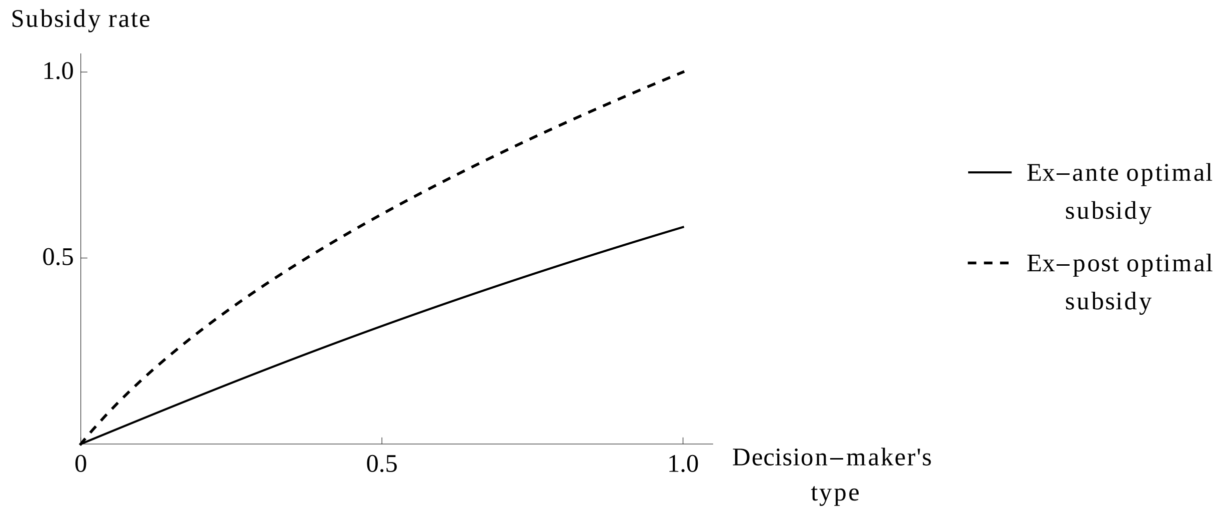

Figure 1: Subsidy choice by policymaker type
with and without policy commitment

This type of policy commitment problem has been extensively studied with reference to other policy dimensions – such as tax policy and monetary policy – although it has received comparatively less attention in the energy and environmental management literature.[15] It should be stressed that the commitment problem we describe does not hinge on the specific structure of the distributional problem as we have characterized it. Indeed the argument does not depend on what the distributional objectives of policymakers are, and would equally apply, for example, to scenarios where subsidies to energy production are aimed at boosting rents for industry stakeholders (energy producers and resellers, e.g. electricity companies) – as would be implied by a model of lobbying, such as that of Grossman and Helpman, 1994. The general point is that, no matter what the distributional concerns are, those concerns will be traded off ex ante with the adverse efficiency effects of subsidies on investment choices, but ex post those effects disappear, inefficiently raising the ex-post subsidy choice above the corresponding ex-ante choice. This commitment problem can arise even in the absence of

[15]Exceptions are Marsiliani and Renström (2000), Abrego and Perroni (2002), Dijkstra (2004).

any environmental costs (which would of course make the problem more serious).

In principle, this problem could be solved by introducing institutional devices that enable the policymaker to make a credible commitment to implement a specific level of subsidies, for instance, by delegating the authority to set the retail price of energy to an independent technical committee with a narrow policy mandate. In monetary matters, for example, some countries delegate the setting of central banks' interest rates to independent monetary policy committees, tasked to pursue specific targets that relate to inflation and to the operation of financial markets, to the exclusion of other policy objectives. There are also indications that policymakers have identified a need for policy delegation in the area of energy subsidies. In their efforts to reduce, or contain, fuel subsidies, many countries have adopted automatic mechanism that regularly update administrative fuel prices according to a pre-set formula aimed at ensuring that changes in (international) input prices are fully passed through to the consumer, after allowing for domestic storage and distribution costs and a reasonable profit margin. These mechanisms, frequently administered by special price-setting committees, have been implemented with good results in a number of countries; but in several cases they have been (either formally or effectively) abandoned following sharp increases in international prices. According to Coady *et al.* (2012), this fragility "in part reflects the reluctance of governments to fully pass through large price increases that they believe may be temporary and could cause a social and political backlash." The fact that these schemes could be abandoned at the very moment when their independent role would have been most significant suggests that they were not an effective commitment device, i.e. that they were set up with inadequate protections from political pressures or influence from special interest groups.

So, why do we not see robust policy delegation mechanism being adopted more widely and effectively?

3 Policy reform incentives and re-election incentives

The question we address here – and which the rest of our paper is concerned with – is whether a commitment to reform energy subsidies may fail to materialize in a political-economy equilibrium where elected policymakers must trade off the advantages of commitment against re-election concerns. To develop our arguments, we focus on a simplified multidimensional policy framework, where energy subsidies are selected by policymakers jointly with other policy issues.[16]

The literature on the political economy of policy commitment choices has pointed out that an incumbent may choose strategically to deviate from the efficient level of commitment in order to influence the outcome of future elections. This deviation can take the form of an excessive degree of commitment to future policy choices in response to dynamically-inconsistent behavior on the part of voters, an issue discussed by Persson and Svensson (1989) and Alesina and Tabellini (1990): since voters cannot commit to re-elect the incumbent (or to elect any other candidates who support specific policy choices), the incumbent can attempt to constrain future policymakers to specific choices that they, and the majority that will elect them, may not favor. Thus, strategically motivated policy choices by the incumbent can impose inefficiently strong constraints ("too much reform") over future policy choices. However, the opposite phenomenon – an inefficiently low degree of commitment – could be observed for analogous reasons: commitment may be forgone by an incumbent if it adversely affects her relative standing in future elections, a point made by Milesi-Ferretti (1995) with reference to the choice between different exchange-rate systems.[17] Thus, dynamic inconsistency in policy choices could arise as the result of dynamically inconsistent voting choices.

A question naturally arising from the above argument is whether such behavior would ever be observed in equilibrium. With repeated elections, if voters anticipate that a certain candidate will decide strategically not to commit if elected, such a candidate may never be elected in the first place. In other words, strategic non-commitment on the part of the incumbent may only be a relevant choice "off the equilibrium path". Furthermore, if strategic non-commitment by elected candidates in anticipation of fu-

[16]We cast our analysis in the context of a political-economy model of pure representative democracy. As we noted earlier, analogous incentives can arise in a setting where political support is shaped by lobbying from special interest groups, such as energy industry stakeholders.

[17]This possibility is also mentioned in Persson and Svensson (1989). The strategic manipulation of a state variable by an incumbent in order to alter her relative popularity has also been addressed by Aghion and Bolton (1990) and by Milesi-Ferretti and Spolaore (1994).

ture elections is undesirable to a majority of citizens, then the same majority may be able to bring about a change in the political system which reduces the scope for such behavior. Yet, we observe that policymakers are *de facto* given the option to retain discretionary control over policy instruments even when means of credible commitment are in fact available.

To look at this question we examine a model where elected candidates make decisions along two distinct policy dimensions. For the first of these – setting the rate of energy subsidies – the optimal choice of policy is not credible unless it is supported by pre-commitment, but institutional arrangements exist that would enable an incumbent government to credibly commit to any target. Voting decisions and political equilibria are modelled here along the lines of the "citizen-candidate" approach developed by Osborne and Slivinski (1996) and Besley and Coate (1997), whereby individual citizens vote for candidates, drawn among the citizens themselves, who are expected, once elected, to make policy choices that are in line with their own (known) preferences. Unlike in the pure citizen-candidate model, however, we model the political system simply as a (hypothetically infinite) sequence of pairwise majority voting contests; in other words, among the set of eligible candidates, the one who is actually elected is assumed to be the candidate who cannot be defeated by any other candidate in a pairwise contest.[18]

3.1 Policy preferences and the political system

Consider a two-period economy ($t = 0, 1$) with two policy choices in period 1, s (the energy subsidy) and a choice x along a policy dimension completely unrelated to energy policies – say, education. Commitment to reform along policy dimension s can be made in period $t = 0$ by setting a ceiling s_0 on the energy subsidy rate s that can be granted in period $t = 1$; it is assumed that, under existing institutional arrangements, this constraint is always enforced if it is introduced. No commitment is feasible or

[18]This is a simplifying assumption that weakens the requirements that ensure the existence and uniqueness of an equilibrium, and rules out any strategic behavior on the part of both candidates (concerning entry) and voters.

desirable with respect to x.[19]

There is a continuum of voters, each identified by a two-dimensional vector $v \equiv (i, j)$ – which denotes the voter's "type" and determines her policy preferences along the two policy dimensions – and uniformly distributed over a square support of unit side $V \equiv \{(i, j) \mid i, j \in [0, 1]\}$. All voters live for two periods, and their preferences over policies are assumed to be intertemporally separable, with preferences for first-period policies summarized by

$$u(s, x; i, j) \equiv g\big(s, \theta(s); i, m\big) + h(x; j), \tag{13}$$

where $g\big(s, \theta(s); i, m\big)$ is as defined in the previous section, and

$$h(x; j) \equiv -\eta(x - j)^2, \tag{14}$$

with the latter being maximized for a voter of type (i, j) by a policy choice $x = j$. Quadratic utility functions are frequently used in economic models of political equilibrium (e.g., Cremer and Palfrey, 1996), because they ensure that voters' preferences are single-peaked, i.e. voters have an ideal policy and their payoffs are monotonically decreasing as the policy deviates from this ideal policy in either direction. In turn this implies that final outcome of a pairwise majority ballot between two policy choices is determined by the preferences of a pivotal voter at the centre of the voters' distribution – the *median citizen* – thus ensuring the existence of a voting equilibrium under fairly general conditions. The curvature assumptions we have made in the previous section ensure that single-peakedness also applies with respect to the s policy dimension.

Policy choices are made by elected policymakers, who cannot pre-commit to a certain policy action before they are elected. Individual citizens vote over candidates through a sequence of pairwise ballots, and the elected candidates set their own preferred policies without regard to any pre-electoral promises or to the preferences of the other citizens (except insofar as they are internalized in their own utility function, as discussed in the previous section). In this framework policymakers do not derive any

[19] This could be because of institutional reasons, or because flexibility is required. For example, suppose that the economy can experience a shock ε at $t = 1$, having zero mean and known variance, which causes a certain policy choice x to have the same effect as a choice $x + \varepsilon$. Then, if the variance of ε is sufficiently large, it will never be desirable to commit to a given level of x.

direct utility from holding office, and only favor being elected insofar as this enables them to implement their favorite policies.

3.2 Commitment choices in a two-candidate contest

In the following, we shall first focus on a stylized scenario involving a sequence of four actions: (i) in period $t = 0$ an incumbent, who has been elected beforehand, must choose whether or not to make a binding commitment to a policy s_0 that will fully constrain the choice of s in period $t = 1$; (ii) at the end of period $t = 0$, after having observed the commitment choice, consumers decide how much to invest in energy saving technologies; (iii) at the beginning of period $t = 1$, voters elect a policymaker amongst a set of eligible candidates; (iv) the newly elected policymaker selects a combination of policies (s, x) for for period $t = 1$, with her choice of s being constrained to equal s_0 if the period-0 incumbent chose to commit to that level in period $t = 0$. No further elections or policy choices take place after $t = 1$ (we will later briefly discuss a scenario where there is an indefinite sequence of elections and policy choices). Note that any policy choices made by the incumbent at $t = 0$ with respect to period-0 policies can be separated out from the problem, as they do not affect period-1 elections, period-1 choices, nor the policy commitment choice made by the incumbent at $t = 0$ with respect to period-1 policies.

We will restrict attention to a scenario with only two candidates, labeled respectively A and B, one of which is the incumbent policymaker, and having policy preferences such that: (C1) $j_A \leq j_B \leq 1/2$ – meaning that candidate B is closer to the median voter's preference type with respect to policy x; (C2) $i_B \geq 1/2$ – meaning that the ex-ante preferred subsidy levels of candidate B is (weakly) greater than that favored by the median voter, and consequently the ex-post subsidy choice of candidate B is strictly above the ex-ante choice favored by the median type, i.e. for i_A lying in some neighborhood $I_A(i_B)$ to the left of i_B (i.e. with $i_A < i_B$), a majority of voters favor the ex-post subsidy choice of candidate A to that of candidate B; (C3) i_B is sufficiently high that, ex ante, the median type prefers a subsidy $s = 0$ to the ex-post subsidy choice of candidate B, i.e. the set $I_A(i_B)$ contains the point $i_A = 0$; (C4) $i_A \in I_A(i_B)$.

We can then establish the following result:

Proposition 2

I. *If candidate B is the incumbent, she will always commit and be re-elected;*

II. *If candidate A is the incumbent, there exists a non-empty subset of candidate types, (i_A, j_A), with $i_A < i_B$ and $j_A \leq j_B$, such that, if the incumbent's type belongs to this set, the incumbent will choose not to commit and will be re-elected.*

Proof: See Appendix A.

The second part of Proposition 2 – which is our main result – is best illustrated with the help of an example. Let $i_B = j_B = 1/2$, $\eta = 1/5$, and let $g(s, a; i, m)$ be defined as in the example we presented in Section 2. The relevant regions described in the Proof of Proposition 2 are shown in Figure 2. The monotonically decreasing curve in the diagram represents the locus of points (i_A, j_A) (representing candidate A's type) for which candidate A is indifferent between commitment and election defeat and non-commitment and election success (identified as the locus NN in the proof). Points below that curve represent the types of candidate A that would be willing to forgo commitment if this ensured their own re-election. The non-monotonic (U-shaped) curve in the diagram represents the locus of points (i_A, j_A) for which the two candidates receive the same number of votes under non-commitment (locus VV in the proof); points above that curve represent candidate A types who could defeat candidate B in an election by refraining from committing to a given level of subsidies. The darker shaded area in the figure thus represents the set of candidate A types who can be re-elected if they choose non-commitment, and are also willing to do so. The lighter shaded area below locus VV (the U-shaped curve) identifies candidate A types who cannot defeat candidate B whether or not they commit, and therefore choose to commit because, *ceteris paribus*, this is the most efficient decision; whereas the lighter shaded area above locus NN (the monotonically decreasing curve) identifies candidate A types who could be re-elected if they chose not to commit, but prefer to commit even at the cost of losing the next election.[20]

[20] Note that condition (C3), which we imposed at the outset, is sufficient but not necessary for non-commitment to be possible; i.e. non-commitment can also happen if (C3) is not satisfied. With reference

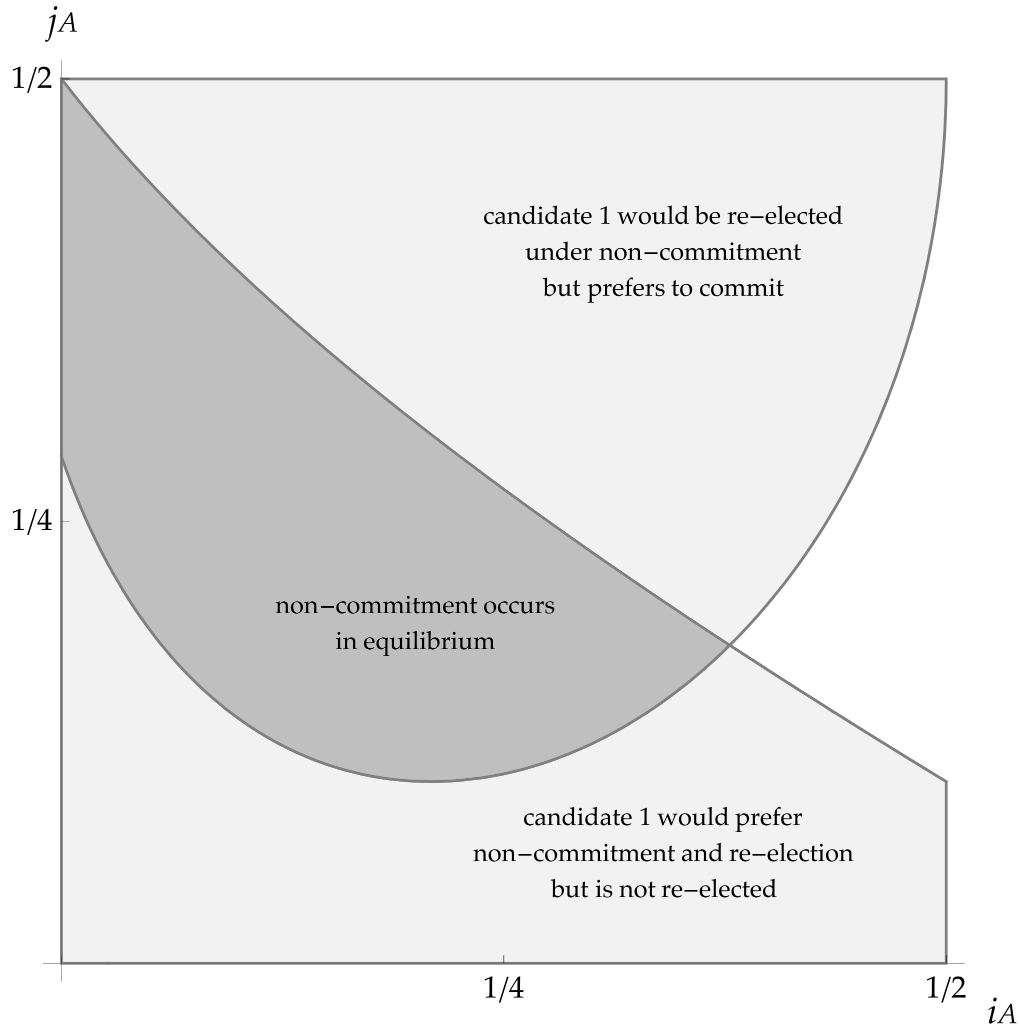

Figure 2: Equilibrium non-commitment outcomes
by incumbent type

Non-commitment can occur in political equilibrium because committing to future policies means removing one of the policy dimensions that determine voters' preferences amongst competing political candidates. A candidate whose views are comparatively popular on the policy dimension requiring commitment but comparative unpopular along other, unrelated policy dimensions, may therefore forgo policy commitment in order to keep on the agenda the dimension on which he enjoys the comparative electoral advantage, because this would enhance her chances of winning the next election. In other words, locking in policy measures through policy reform along a certain policy dimension knocks out a politically convenient "talking point" for those candidates who are comparatively strong along that dimension and comparatively weaker along others. Such candidates, precisely because they are politically strong along the policy dimension requiring reform, may find it politically expedient to forgo reform.

For this option to be attractive to the incumbent, however, her preferences along the other policy dimensions must be sufficiently different from those of her challenger to make incurring the cost of non-commitment worthwhile; and for this option to be viable, the incumbent must be sufficiently strong in political terms along the other policy dimensions to make re-election possible under non-commitment. This outcome therefore can only occur if the incumbent is a "moderate" candidate – reasonably (but not "extremely") disciplined with respect to the use energy subsidies, and having, on the other policy dimensions, a position that is sufficiently different from that of the challenger (and of most of the other citizens) to justify her efforts to remain in power, but not so different to hamper is possibility of re-election.

3.3 Non-commitment under repeated elections

The above analysis abstracts from the long-run political calculations that arise under repeated elections (an indefinite sequence of two-candidate contests) – namely, that both forward-looking voters and candidates would account for the fact that, once elected, a candidate of a certain type may be able to secure re-election indefinitely. It can nevertheless be shown that non-commitment can arise in equilibrium under repeated voting:

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to Figure 1, even if locus VV (the U-shaped curve) does not cross the vertical axis at a point lying below $j_A = 1/2$, it is still possible for the two loci to cross and for the non-commitment region to be non-empty.

Proposition 3 *If, in addition to the above conditions, individuals sufficiently discount future payoffs, non-commitment can arise in equilibrium under repeated elections.*

Proof: See Appendix A.

As shown in the proof, two equilibria are possible, one in which candidate A does not constrain the value of s and is re-elected indefinitely, and the other in which candidate B, elected once, sets $s = \bar{s}_1$ and is then re-elected indefinitely. Under certain conditions (discussed in the proof), a majority of citizens would be better off in the long term in the second equilibrium, but transitioning from the first to the second outcome is overly costly for them in the short term. When Candidate B is elected for the first time, her choice of subsidy is unconstrained (since Candidate A chooses not to constrain A in the equilibrium under consideration). If the rate at which voters discount future payoffs is sufficiently high, then for a majority of voters Candidate B's subsidy choice during the transition imposes a short-run cost on them that is too large in comparison with the long-term gain that they would experience after transitioning to Candidate B, and so voters are "stuck" in the sub-optimal outcome (which is therefore an equilibrium). Other things equal, this is comparatively more likely to occur the longer the period of tenure of elected policymakers – which is homologous to citizens discounting future payoffs at a higher rate.

3.4 Options for reform

The above discussion has highlighted how a desirable reform of energy subsidies can be hampered by policymakers' strategic efforts to enhance their re-election prospects, when the adverse impact of energy subsidies on private incentives to undertake energy-saving investments results in a classic time-inconsistency problem.

When this problem is a key obstacle to reform, how can it be overcome? We discuss here a number of policy options that have been considered (and, in some instances, applied) with the purpose of facilitating the reform of inefficient energy subsidies: (a) the adoption of automatic pricing formulas; (b) the delegation of authority to an independent price-setting committee; (c) the subsidization of energy-saving investments, and (d) the replacement of universal subsidies with more narrowly targeted direct transfers.

Our preceding analysis offers a specific, political-economy based framework to interpret the obstacles to reform, and a specific lens through which these various policy alternatives can be assessed.

Automatic pricing formulas

One measure that has been implemented, with varied success, in some countries, is the replacement of discretionary decisions on administrative retail prices of selected energy products, with automatic adjustments of these prices on the basis of a pre-determined fixed formula. The underlying idea is that, while changes in the cost of inputs require periodic adjustments to the administrative retail prices, the rate of subsidies implicit in the difference between the retail price and the total cost of inputs should not be subject to the short-term discretion of public officials and elected policymakers, and hence to short-term political pressures, but should reflect more sound long-term considerations. Pre-determined formulas can incorporate a "smoothing mechanism" aimed at reducing the volatility of retail prices (absorbing the high-frequency changes in the cost of some inputs into the public budget or some dedicated stabilization fund).

In principle, these formulas provide an institutional instrument for credibly committing to a specific subsidy rate: for instance, a formula could prescribe that gasoline be sold to consumers at a discount of, say, 10% on the wholesale price of imported gasoline (gross of transportation and storage costs as and of a "normal" operating margin). The subsidy rate would thus be fixed at 10%, and protected from short-term discretionary changes.

Adopting such a formula would be equivalent, in our model, to the incumbent policymaker committing to a given subsidy rate for the subsequent period, that any policymaker elected in that period would be unable to alter. The formula would solve the time-inconsistency problem (allowing the incumbent to set the subsidy rate at his ex-ante preferred level), but would only be adopted if the incumbent is willing to undertake such a commitment, which – as discussed above – may not always be the case.[21]

Price setting committees

Delegating the determination of subsidy levels to an independent committee can serve different purposes, depending on the powers, composition, and tenure of the committee. One possible arrangement involves delegating the authority to modify the subsidies to a long-standing technical committee composed of experts with specific views on the topic, who would – ex post – prefer to enforce the rate that the policymaking authority appointing them would set ex ante (a process that is analogous to the delegation of the authority to set monetary policy to a 'conservative' central banker: see Rogoff, 1985). To the extent that the delegation decision is left to elected policymakers, however, our previous analysis suggests that they may choose not take advantage of this option if doing so weakens their re-election prospects. Alternatively it may be possible to rely on a stronger, "constitutional" arrangement whereby policy-making authority on energy matters is transferred to a separate group of representatives, appointed through various mechanisms by citizens' organizations and professional groups, an arrangement that would be equivalent to splitting decision making powers while still maintaining political representation in each policy dimension. This institutional arrangement would remove the incentives for non-commitment associated with the strive for re-election, but it would not solve the underlying time-inconsistency problem in policy making: if the preferences of committee members are representative of those of the voters (rather than being more "conservative" than those of voters), the members of the committee, and the committee itself, would, ex post, select above-optimal subsidies.

[21] In practice, if political pressure to adopt such a formula is strong, the incumbent could formally introduce it but refrain from adopting effective provisions to ensure its enforcement. The experience of some countries shows, for instance, that these formulas are not always applied rigorously, especially when increases in international prices would require a corresponding increase in domestic retail prices (Clements *et al.*, 2013).

Subsidization of energy-saving investment

If reforming energy subsidies proves too difficult, the authorities may encourage investment in energy-saving technologies by subsidizing this investment as well, thereby offsetting the disincentive to invest arising from the energy subsidies.

Suppose, for example, that citizens investing in energy-saving technology benefit from a proportional subsidy that reduces the cost of this investment per unit from $c(a)$ to $(1-z)c(a)$. For a given (expected) level of energy subsidy, s, the optimal investment choice of each citizen would thus be to set a equal to $\xi(1-s) \equiv \theta\big((1-s)/(1-z)\big) = (c')^{-1}\big((1-s)/(1-z)\big) > \theta(1-s)$. Consider then the sequential choice of a given policymaker who selects a level of abatement subsidy z at $t=0$ and follows this by the choice of an energy subsidy s at $t=1$: it can be shown that, when the policymaker selects z optimally at $t=0$, the policymaker's ex-post preferred level of energy subsidy coincides with her ex-ante preferred level. Thus, in principle, the introduction of subsidies on energy-saving investments can make commitment unnecessary.

In practice such subsidies may be difficult to target precisely: while energy subsidies directly reduce the price of energy, abatement subsidies reduce the price of investments that may be correlated only imperfectly with energy use and could thus leak beyond their intended purpose, supporting investments that do not reduce energy consumption, or even (perversely) encouraging energy consumption.

More importantly for the purpose of the present discussion, when there is political competition among multiple potential candidates, the choice of subsidies on energy-saving investments at $t = 0$ and the choice of energy subsidies at $t = 1$ may not necessarily be made by the same policymakers, potentially generating incentives for strategic behavior on the part of the incumbent(s). For instance, an incumbent would be able to use the abatement subsidy at $t=0$ in order to condition the choice of energy subsidy at $t=1$. If the incumbent chooses her preferred level of abatement subsidy and is re-elected, then the energy subsidy chosen will be the same as with commitment; however, if she is not re-elected, the ex-post energy subsidy level will be chosen by a successful challenger. Anticipating this, the incumbent may depart from her preferred level of abatement subsidy at $t=0$ in order not to "accommodate" the energy subsidy choice of an elected challenger, and, by so doing, ensure re-election. So the use of subsidies for energy-saving investment reshapes, but does not fully resolve, the problem of energy subsidy reform: the strategic non-commitment problem with respect to energy subsidies may translate into a strategic non-optimal abatement subsidy choice on the part of the incumbent, which in turn would make the incumbent's ex-post choice non-optimal.

Targeted tranfers

When energy subsidies are justified primarily on redistributive concerns, their reform may need to be accompanied by the introduction of alternative (and more efficient) mechanisms to achieve the same social objectives, such as the introduction of direct transfers specifically targeted at the "energy-dependent poor".

In our theoretical setup (where citizens have the same income but differ in their consumption needs), this would be equivalent to ensure that all citizens can achieve a minimum level of disposable income net of energy costs. Let $\underline{y} > 0$ be this level; in the absence of subsidies ($s = 0$, implying $p = 1$), the required lump-sum transfer would be equal to $\max\left\{\underline{y} - y\big(0, \theta(1); i, m\big), 0\right\} \equiv T(i, m)$, which depends on both i and m, i.e. it must be "means tested". Because of the informational constraints the government faces, this can induce further distortions as it generates incentives for individuals to manipulate i and m (which are not exogenous in reality) – a problem that has been extensively studied in the public finance literature. To avoid such distortions, transfers must be conditioned only on characteristics that are both verifiable and exogenous, e.g. calendar age;[22] but this makes the targeting very imprecise.

There are additional political-economy implications associated with such measures. If the introduction of targeted transfers lowers the need for subsidies, then, for the reasons we have already discussed, an incumbent may choose to forgo their use or set them at a low level, retaining a role for a positive level of subsidies – and the discretion that is associated with it – in order to secure re-election. Thus, targeted transfers may themselves be used as a strategic tool of political competition.

[22]This is the approach adopted by the UK government, who grants lump-sum "Winter Fuel Payments" to individuals age 62 or above, irrespective of their income.

4 Concluding remarks

In this paper, we have analyzed some political factors that can hinder the reform of energy subsidies even when the latter would improve the welfare of most citizens by encouraging the adoption of energy-saving technologies.

We have shown first that a classical policy commitment problem arises when a conflict between efficiency-related and distributional objectives is resolved *ex post* in favor of the latter: once energy-saving techniques are adopted, motives to reduce energy subsidies as initially announced are weakened, as doing so may hurt low-income or energy-dependent households; since investors anticipate this outcome, any announcement that subsidies will be reformed in the future is not sufficiently credible to encourage a desirable, but costly, private investment in energy-saving techniques.

The issue is further complicated in a democratic environment where the policymakers that select the current and future level of subsidies are also responsible for taking other types of policy decisions. A credible commitment to reform energy subsidies (for instance, by delegating price-setting authority to an independent committee with a limited policy mandate) could remove a politically salient policy dimension from the political agenda, thereby shifting the future electoral outcome in a direction unfavorable to the incumbent policymaker. In this case, some – but not all – incumbents would be reluctant to commit to reform; anticipating this behavior, voters could then choose to elect a less-preferred candidate who is willing to commit (and thus encourage energy-saving investment), or to elect their more preferred candidate even if the latter does not commit. In both cases, the presence of a commitment problem shifts the political equilibrium away from the first best toward a second-best outcome; in other words, if the commitment problem did not exist, a majority of citizens would be better off.

Altogether, our analysis suggests that reforming energy subsidies may be difficult precisely because these subsidies are important to individuals and affect different individuals differently – both characteristics that make them politically salient. The key conclusion to be drawn from our analysis, however, is that a country's ability to effectively carry out policy reforms along specific dimensions, such as energy subsidies, could be enhanced through more fundamental institutional reforms.

Appendix A

Proof of Proposition 1: Differentiating (5), substituting T' from (9) into the resulting expression, and using the condition $c' = 1 - s$, we obtain

$$\left| \frac{\mathrm{d}g\big(s, \theta(1-s);\, i, m\big)}{\mathrm{d}s} \right|_{s=s_{EP}(i)} = -\frac{\rho(i)\, s_{EP}(i)}{c''} < 0, \tag{15}$$

which, with the second-order curvature conditions for an optimum being satisfied, implies that $s_A(i)$ – the value of s that makes $\mathrm{d}g\big(s, \theta(1-s);\, i, m\big)/\mathrm{d}s$ equal to zero – is less than $s_{EP}(i)$. □

Proof of Proposition 2:

I. To simplify notation, let $\hat{g}(s;\, i) \equiv g\big(s, \theta(s);\, i, m\big)$. If there is commitment on the subsidy, the outcome of the election is decided exclusively on the basis of preferences over policy x, independently of the level at which s has been set. Then assumption (C2) in the text (Section 3.2) implies that if there is policy commitment candidate B is elected. In turn this means that if candidate B is the incumbent, she will always choose to commit to her ex-ante favored level of s; by doing so, she will be re-elected and obtain her ideal policy combination $\big(s = s_{EA}(i_B),\ x = j_B\big)$.

II. If candidate A is the incumbent and she chooses to commit to her ex-ante favored level of subsidy, $s_{EA}(i_A)$, candidate B will be elected. In this case, if $j_A = j_B$, candidate A will also obtain her ideal policy combination $\big(s = s_{EA}(i_A),\ x = j_A = j_B\big)$ whereas by not committing she will be elected and obtain, at best, a combination $\big(s = s_{EP}(i_A),\ x = j_A = j_B\big)$ (if re-elected), which gives her a lower payoff. Thus, there always exists a neighborhood $J_A(j_B)$ to the left of j_B such that, for $j_A \in J_A(j_B)$, candidate A will choose to commit, and for j_A lying below j_B but outside $J_A(j_B)$ candidate A will choose not to commit if this can induce re-election. Specifically, the difference $\hat{g}\big(s_{EA}(i_A);\, i_A\big) - \hat{g}\big(s_{EP}(i_A);\, i_A\big)$ equals zero for $i_A = 0$ (where $s_{EA}(i_A) = s_{EP}(i_A) = 0$) and is monotonically increasing in i_A. As the difference $h(j_A;\, j_A) - h(j_B;\, j_A)$ is zero for $j_A = j_B$ and monotonically increasing in the distance $j_B - j_A$ (and thus decreasing in j_A), the locus of the indifference points $u\big(s_{EP}(i_A), j_A;\, i_A, j_A\big) - u\big(s_{EA}(i_A), j_B;\, i_A, j_A\big)$ (which we shall refer to hereafter as NN) will go through point $(i_A = 0, j_A = j_B)$ and will have a negative slope in (i_A, j_A) space, i.e. the size of the neighborhood $J_A(j_B)$ will be zero at $i_A = 0$ and will be increasing in i_A.

Election outcomes under non-commitment can be characterized as follows. For $i_A = 1/2$ and $j_A = j_B$, a majority of voters will support candidate A over candidate B (weakly so if $j_B = 1/2$); thus the locus of points where the voting support for the two candidates is the same under non-commitment (which we shall refer to hereafter as VV) crosses the horizontal $j_A = j_B$ line in (i_A, j_A) space at a point where $i_A \leq 1/2$. Assumption (C3) in the text implies that for $i_A = 0$ a majority of voters will support candidate A over candidate B – which in turn implies that VV crosses the vertical line $i_A = 0$ at a point where $j_A \leq j_B$.

Since locus NN goes through point $(i_A = 0, j_A = j_B)$ and is decreasing in i_B and VV goes through points $(i_A = 0, j_A \leq j_B)$ and $(i_A \leq 1/2, j_A = j_B)$, by continuity the two loci must cross, and therefore there must exist a region lying below and the left of locus NN and above locus VV where non-commitment by candidate A guarantees her re-election and candidate A prefers this outcome to the alternative of committing to her ex-ante favored subsidy level and losing the election to candidate B.

□

Proof of Proposition 3: This proof proceeds in three parts. In the first part, we show that the median voter is pivotal: she votes with the majority in any contest between two candidates or two (infinite) sequences of policies. In the second part, we characterize how candidates' equilibrium strategies depend on the candidates' types, identifying conditions under which one of the candidates, once elected, refrains from committing with respect to s.

Part I. First, we show that the median voter is pivotal. Notice first that the expected ex-ante utility that a generic citizen of type (i, j) derives from a subsidy level equal to s is a linear function of i: equation (5) can be re-written as

$$g(s; i) = A(s) + \omega m + B(s)\, i, \tag{16}$$

where

$$A(s) = (1-\omega)\, \underline{m} - T\Big(F\big(s, \theta(1-s)\big)\Big) - \Big(c\big(\theta(1-s)\big) + \big(1-\theta(1-s)\big)\,(1-s)\Big)\,\omega, \tag{17}$$

and

$$B(s) = -\Big(c\big(\theta(1-s)\big) + \big(1-\theta(1-s)\big)\,(1-s)\Big)\,(1-\omega)\,. \tag{18}$$

In turn, the utility that a generic citizen of type (i, j) derives from a policy x on the second policy dimension is a quadratic function of j. Rearranging (14), we obtain:

$$h(x; j) = C(x) + D(x)\, j - \eta\, j^2, \tag{19}$$

where $C(x) = -\eta x^2$ and $D(x) = 2\eta x$. Hence, the instantaneous total expected utility that a citizen of generic type (i, j) derives from a policy couple (s, x) is equal to

$$P(s, x) + B(s)\, i + D(x)\, j - \eta j^2 + \omega m, \tag{20}$$

where $P(s, x) = A(s) + C(x)$. Consider now two infinite sequences of policies Ω_A and Ω_B, where

$$\Omega_h = \left\{ (s_{h1}, x_{h1})\,, (s_{h2}, x_{h2})\,, \ldots, (s_{ht}, x_{ht})\,, \ldots \right\}, \quad h \in \{A, B\}, \tag{21}$$

where t, running from 1 to infinity, represents the time period. The discounted expected utility that a generic citizens derives from each of these policy sequences is equal to

$$\begin{aligned} U\left(\Omega_h; i, j\right) &= \sum_{t=1}^{\infty} \delta^t \left(P(s_{ht}, x_{ht}) + B(s_{ht})\, i + D(x_{ht})\, j - \eta j^2 + \omega m \right) \\ &= \overline{P}\left(s_h, x_h\right) + \overline{B}\left(s_h\right) i + \overline{D}\left(x_h\right) j - \frac{\delta}{1-\delta} \eta j^2 + \frac{\delta}{1-\delta} \omega m, \end{aligned} \tag{22}$$

where $\overline{P}(s_h, x_h) = \sum_{t=1}^{\infty} \delta^t P(s_{ht}, x_{ht})$, $\overline{B}(s_h) = \sum_{t=1}^{\infty} \delta^t B(s_{ht})$, and $\overline{D}(x_h) = \sum_{t=1}^{\infty} \delta^t D(s_{ht})$. Hence, a generic citizen of type (i, j) prefers the policy sequence Ω_A to the policy sequence Ω_B if and only if $U(\Omega_A; i, j) > U(\Omega_B; i, j)$, i.e. if

$$\overline{P}(s_A, x_A) + \overline{B}(s_A)\, i + \overline{D}(x_A)\, j \;>\; \overline{P}(s_B, x_B) + \overline{B}(s_B)\, i + \overline{D}(x_B)\, j; \tag{23}$$

and so if

$$\widetilde{D}(x_A, x_B)\, j > -\widetilde{P}(s_A, x_A, s_B, x_B) - \widetilde{B}(s_A, s_B)\, i, \tag{24}$$

where $\widetilde{D}(x_A, x_B) = \overline{D}(x_A) - \overline{D}(x_B)$, $\widetilde{P}(x_A, s_A, x_B, s_B) = \overline{P}(x_A, s_A) - \overline{P}(x_B, s_B)$, and $\widetilde{B}(s_A, s_B) = \overline{B}(s_A) - \overline{B}(s_B)$. Hence, the boundary of the region of citizen types that prefer policy sequence A to policy sequence B is a linear function of i and j; which implies (given that the citizens' types are uniformly distributed over a square) that the median voter (whose type lies at the center of that square) always votes with the majority.

Part II. We now proceed to analyze the possible equilibria that can emerge when two candidates, A and B, contest an infinite sequence of elections. Let $i_B < i_A < 1/2$ and $j_A < j_B < 1/2$ – so that A is preferred by a majority along the s policy dimension and B is preferred along x. Assume furthermore that the instantaneous utility $u^M(s^A_{EP}, x_A) \equiv u(s^A_{EP}, x_A; 1/2, 1/2)$ that the median voter gets in one period if A is elected (with no previously set constraint on s) is greater than the utility $u^M(s^B_{EP}, x_B) \equiv u(s^B_{EP}, x_B; 1/2, 1/2)$ that she would get if B is elected. Consider now what happens if A is elected at the beginning of time ("period 0"). Note that candidate

A would not constrain the value of s in equilibrium. If she did, the voters could then elect candidate B who could ensure her own re-election by constraining s at the same level while offering a policy x that is preferred, by a majority, to x_A. Hence, candidate A, once elected, does not set any constraints on the value of s. What happens at the subsequent elections?

(a) If the voters elect B in period 1, it is because they expect B to set binding constraints on s (otherwise they would re-elect A, whose unconstrained policies they prefer). In this case, B could set s at a sufficiently high level (close enough, or equal to, the median voter's preferred ex-ante subsidy s_{EA}^{M}) to ensure her own indefinite re-election; since candidate B would be unconstrained in period 1 on the s policy dimension, in that period she would set $s = s_{EP}^{B}$. The corresponding median voter's net present discounted utility (NDPU), calculated in period 1, would then be equal to $u^M(s_{EP}^B, x_B) + \delta V^M(\overline{B})$, where $V^M(\overline{B}) = u^M(\bar{s}_1, x_B) + \delta V(\overline{B}) = \dfrac{1}{1-\delta} u^M(\bar{s}_1, x_B)$.

(b) If candidate B is elected in period 1, however, she could also set s at a level that is too low to ensure her immediate re-election, inducing the citizens to elect A again in period 2 (and then B in period 3 and A again in period 4, and so on indefinitely). If this alternation occurs in equilibrium, the median voter's NPDU is equal to

$$
\begin{aligned}
V^M(\overline{B}, A) &= u^M(s_{EP}^B, x_B) + \delta u^M(\bar{s}_2, x_A) + \delta^2 V^M(\overline{B}, A) \\
&= \frac{1}{1-\delta^2} u^M(s_{EP}^B, x_B) + \frac{\delta}{1-\delta^2} u^M(\bar{s}_2, x_A).
\end{aligned}
\tag{25}
$$

(c) If the voters instead re-elect A (indefinitely), the median voter's NPDU equals

$$
V^M(A) = u^M(s_{EP}^A, x_A) + \delta V^M(A) = \frac{1}{1-\delta} u^M(s_{EP}^A, x_A). \tag{26}
$$

Hence the citizens prefer to alternate between the two candidates than to re-elect A all the time if and only if $V^M\left(\overline{B}, A\right) > V^M(A)$, i.e. if

$$
\frac{1}{1+\delta} u^M(s_{EP}^B, x_B) + \frac{\delta}{1+\delta} u^M(\bar{s}_2, x_A) > u^M(s_{EP}^A, x_A). \tag{27}
$$

Notice that, since by assumption $u^M(s_{EP}^A, x_A) > u^M(s_{EP}^B, x_B)$, $\bar{s}_2$ must be larger than s_{EP}^A; candidate B would set $\bar{s}_2$ at the minimum level that satisfies the inequality in (27). In turn, from period 2 onwards, the citizens prefer always re-electing candidate B than alternating between the two candidates if and only if $V^M(\overline{B}) \geq V^M(\overline{B}, A)$, i.e. if

$$
u^M(\bar{s}_1, x_B) \geq \frac{1}{1+\delta} u^M(\bar{s}_2, x_A) + \frac{\delta}{1+\delta} u^M(s_{EP}^B, x_B). \tag{28}
$$

Candidate B would set $\bar{s}_1$ at the level that satisfies this constraint as an equality; since the median voter prefers x_B to x_A, this level is lower than $\bar{s}_2$ but still larger than s^B_{EP}. Finally, from period 1 onwards, the voters prefer to re-elect B all the time than to re-elect A all the time if and only if $V^M(\overline{B}) \geq V^M(A)$, i.e. if $u^M(\bar{s}_1, x_B) \geq u^M(s^A_{EP}, x_A)$. With $\bar{s}_1$ and $\bar{s}_2$ thus defined, candidate B in period 1 has three choices: setting s equal to $\bar{s}_1$, setting s equal to $\bar{s}_2$, or imposing no constraints on s and allowing candidate A to be elected in period 2 and then re-elected indefinitely. She chooses the first alternative if $V^B(\overline{B}) > \max\left\{V^B(\overline{B}, A), V^B(A)\right\}$, the second alternative if $V^B(\overline{B}, A) > \max\left\{V^B(\overline{B}), V^B(A)\right\}$, and the third if $V^B(A) > \max\left\{V^B(\overline{B}), V^B(\overline{B}, A)\right\}$, where $V^B(.)$ denotes the NPDU in period 2 perceived by candidate B in each of these cases. Since $\bar{s}_1 < \bar{s}_2$, $V^B(\overline{B})$ is always greater than $V^B(\overline{B}, A)$; hence, if $u^B(\bar{s}_1, x_B) \geq u^B(s^A_{EP}, x_A)$ candidate B is willing to be re-elected indefinitely, otherwise she prefers an equilibrium in which A is re-elected indefinitely.

In summary, two equilibria are possible, one in which candidate A does not constrain the value of s and is re-elected indefinitely, and the other in which candidate B, elected once, sets $s = \bar{s}_1$ and is then re-elected indefinitely.

Part III. If $u^B(\bar{s}_1, x_B) < u^B(s^A_{EP}, x_A)$, proving that candidate A would not constrain s and be re-elected in equilibrium is trivial: if she constrains s, she loses all subsequent elections to candidate B, while if she leaves s unconstrained, candidate B will be unwilling to set s at a level that enables her to win the election and Candidate A will be re-elected indefinitely. In this case, provided that the preferences of the two candidates are sufficiently different, candidate A obviously prefers not to commit to any level of s in order to be indefinitely re-elected. Consider now the case where $u^B(\bar{s}_1, x_B) \geq u^B(s^A_{EP}, x_A)$. Candidate A, again, leaves s unconstrained, but candidate B is willing to set s sufficiently high to win all subsequent elections if she is only once elected. In these conditions, the voters re-elect candidate A indefinitely if and only if $u^M(s^{EP}_B, x_B) + \delta V^M(\overline{B}) > V^M(A) = u^M(s^{EP}_A, x_A) + \delta V^M(A)$. Notice that, by assumption, $u^M(s^{EP}_B, x_B) < u^M(s^{EP}_A, x_A)$ and $V^M(\overline{B}) > V^M(A)$; hence, the voters re-elect candidate A if and only if

$$\delta < \frac{u^M(s^A_{EP}, x_A) - u^M(s^B_{EP}, x_B)}{V^M(\overline{B}) - V^M(A)}. \tag{29}$$

That is to say, the citizens re-elect candidate A only if they discount future utility at a rate that is sufficiently high to make them value the cost of "transitioning" from candidate A to candidate B (having s set, for one period, at the level s^B_{EP} that is too low for most voters) more than the benefits that will accrue, thereafter, as a result of the transition. □

Appendix B

Consider a model variant where energy consumption is proportional to income, and equal to $\psi m i$, and the distribution of the cost of the subsidy also depends on income, according to a mapping $T(F, m)$. Utility for an individual of type (i, m) is then

$$m - T\big(F(s,a), m\big) - \big(c(a) + (1-a)(1-s)\big)\,\psi\, i\, m. \tag{30}$$

The public funds required for a subsidy at rate s amount to

$$F(s,a) = \int_0^1 \int_{\underline{m}}^{\overline{m}} s(1-a)\,\psi\, i\, m \,\mathrm{d}m\,\mathrm{d}i. \tag{31}$$

The cost of the subsidy – which, as before, equals, $F + F^2$, is distributed through a linear progressive tax whereby an individual with income m pays a tax $tm - D$, where D is a demogrant. Equating $F + F^2$ with total tax revenues and solving for t, we obtain

$$T\big(F(s,a), m\big) = -D + m\left(\frac{2D}{\underline{m} + \overline{m}} + \frac{1}{2}\,\psi\, s\,(1-a) + \frac{1}{8}\,\psi^2 s^2 (1-a)^2 \left(\overline{m}^2 - \underline{m}^2\right)\right), \tag{32}$$

which is increasing in m.

In the following, we focus on a parameterized scenario with $\psi = 1/2$, $D = 1/5$, $\underline{m} = 1$, $\overline{m} = 3$. Assuming a social welfare weight $\omega = 1/2$, and proceeding as in Section 2 to derive ex-post and ex-ante preferred subsidy levels for an individual of type (i, m), we obtain

$$s_{EP}(i,m) = \max\left\{\frac{1 + m(2i-1)}{2(1+m)}, 0\right\}^{1/2}, \tag{33}$$

which, for $1 > i > (m-1)/(2m)$ is increasing in i and decreasing in m (and is zero otherwise); and

$$s_{EA}(i,m) = 0 \;\le\; s_{EP}(i,m). \tag{34}$$

The cumulative probability distribution for the ex-post preferred subsidy level – showing, for any subsidy level, the proportion of individuals whose favored subsidy level lies at or below that level – is shown in Figure 3.

This can be used to analyze strategic commitment choices along the lines we followed in Section 3, leading to qualitatively analogous conclusions.

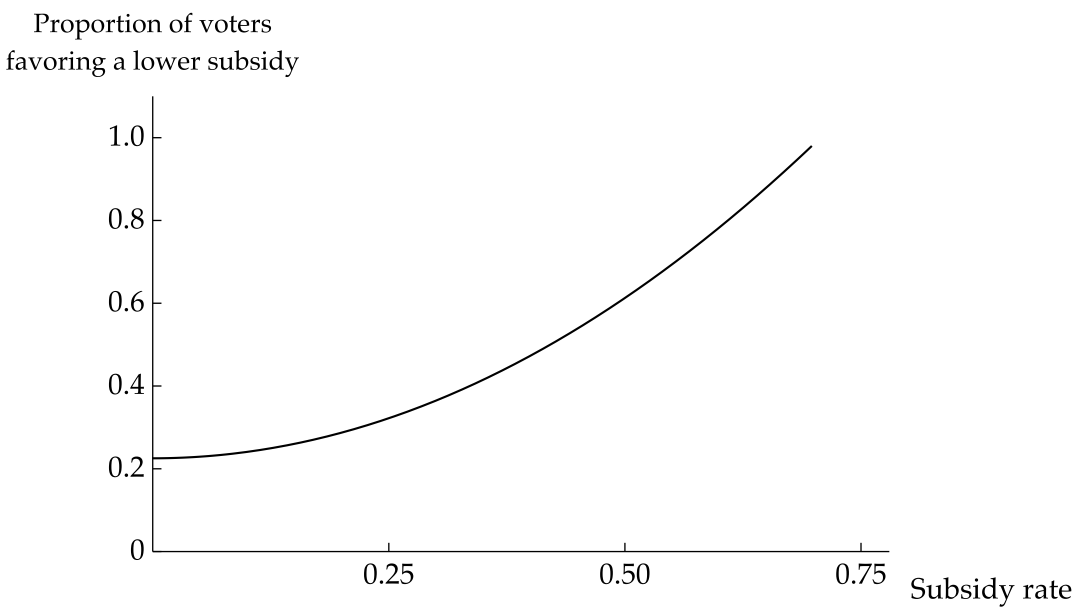

Figure 3: Cumulative distribution of the ex-post preferred subsidy level in the population of voters

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