Prices versus quantities with distributional rent seeking

Ian A. MacKenzie*†

†School of Economics, The University of Queensland, Brisbane, Australia 4072.

Abstract

This article investigates prices versus quantities when regulation generates contestable rents. A two-stage process is outlined where, in stage one, a politician selects a policy level in the presence of uncertainty. In stage two, players invest in distributional rent seeking, i.e., rent-capturing activities to obtain the rents generated from regulation. A clear distinction is derived between prices, revenue-raising quantities as well as non-revenue-raising quantities. The politician's payoff as well as equilibrium policy level are compared within a number of institutional environments, which take into account the politician's preferences over rent-seeking transfers and social welfare. A key determinant is the interaction between the efficiency of rent transfer and the composition of rent seekers within the economy.

Keywords: prices; quantities; rent seeking
JEL *classification numbers*: D72; D81; Q52; Q58

1 Introduction

The decision to select a regulatory instrument is a contentious aspect of environmental policy debates.[1] This controversy arises from the fact that there are many legitimate grounds to favor a specific instrument. For example, comparisons can be made with respect to cost effectiveness, political feasibility, incentives to innovate, revenue-raising capabilities, efficiency under uncertainty, among others. Two of the most prominent components within this debate are the political economy aspects of regulation and efficiency under uncertainty.

In terms of the political economy of regulation, many economists have argued in favor of implementing prices as quantity regulation generates a rent-seeking culture. For example, the typical argument, as highlighted in Nordhaus (2007, p. 39), suggests "[q]uantity-type systems are much more susceptible to corruption than price-type regimes. An emissions-trading system creates valuable assets in the form of tradable emissions permits" whereas "a price approach gives less room for corruption because it does not create artificial scarcities, monopolies, or rents....[t]here is no new rent seeking opportunity" (Nordhaus, 2007, p. 39).[2] Although, *prima facie*, this argument appears plausible as rents generated from quantity instruments do exist; this perspective fails to account for rents generated under a price mechanism. In particular, price regulation (and revenue-raising quantity regulation) generate rents in the form of public funds that may be contested by society.

*E-mail: i.mackenzie@uq.edu.au

[1]For example, continual debate exists in the US over whether prices or quantities (if any) should be implemented to control carbon dioxide (e.g., Goulder and Schein, 2013). Further, in Australia—where both a carbon tax and cap-and-trade scheme were legislated—an extensive debate covered their relative merits (e.g., Garnaut, 2008) prior to the policies being repealed in 2014.

[2]For similar arguments see, for example, Stavins (1998), Cramton and Kerr (2002), and Hepburn et al. (2006). Another argument extends this perspective by suggesting that the only politically feasible instrument is a non-revenue-raising quantity mechanism—such as freely allocated permits—as this reduces the financial burden on regulated entities (e.g., Goulder and Parry, 2008)

Thus to fully consider the political aspects of prices and quantities, one must investigate how the generation of regulatory rents from prices *and* quantities affects the preferred choice of instrument.

To compare the political aspects of instruments one must consider not only the rents that are generated but how these are affected by realistic regulatory environments. One such environment consists of a regulator experiencing uncertainty over the effectiveness and social optimality of their proposed policy. Taking uncertainty into account, Weitzman (1974), Adar and Griffin (1976), Fishelson (1976) and Roberts and Spence (1976), provide formal analysis over whether prices or quantities are the preferred instrument to maximize expected social welfare. At its core the prices versus quantities paradigm hinges on the relative slopes of an economy's cost and benefit functions as well as the structure of uncertainty. Yet the prices versus quantities framework abstracts from the political aspects of regulation, which is important if we want to understand how and why certain policies are chosen and implemented.

Combining aspects of political economy with policy choice under uncertainty provides a novel structure to compare the desirability of policy instruments. With such an approach numerous policy questions can be asked, such as, how does the prices versus quantities paradigm change when political economy aspects are taken into account? How do politicians decide on a preferred regulatory structure given these rents are contested within society? How does the existence of contestable rents distort the politician's choice of policy level?

To answer these questions, this article investigates the prices versus quantities paradigm when there exists rent seeking over regulatory rents. The model comprises of two stages. In the first stage, under uncertainty, a politician sets a policy level for either prices or quantities à la Weitzman (1974). In the second stage, players within the economy invest in distributional rent seeking to appropriate the rents generated from the implemented regulation. This may include activities such as lobbying, monetary transfers/favors, corruption, and so on. Further, the article allows for a host of alternative institutional environments: the politician may select a policy level based on alternative weights between social welfare and rent seeking. This article can thus include cases where the politician solely cares about social welfare as well as other extreme cases, where they care only about rent-seeking transfers or treat this activity as purely wasteful.

In comparing prices versus quantities a distinction is made regarding the source and contestability of the rents. More precisely, a useful distinction—used throughout this article—is whether the instruments generate revenue or not. Non-revenue-raising quantity mechanisms, such as freely allocated permits, create rents in the form of a fixed supply of tradable permits. What is generally observed in reality is that the distribution of permits is usually only contested by the regulated entities. Contrast this with mechanisms that generate revenues, such as taxes and quantity auctions. In such a case the collection of revenue is usually centralized, which allows members from the whole of society to capture these rents via investments in rent-seeking activities.

Another distinction in the level of contestability occurs due to specific institutional environments. For rents generated under non-revenue-raising quantity mechanisms, it is likely that rent transfers are costless: a finite number of permits are created and distributed without loss of rents within the bureaucratic system. Contrast this with revenue-raising instruments, where it is likely that the process of collecting revenue will generate revenue loss (marginal cost of public funds) and, as a result, lower the level of net rent that is contestable. For example, bureaucratic friction may exist, which reduces the potential size of contestable regulatory rents: revenue generated is rarely ever returned to the economy without revenue loss. Further, if elements of the revenue are *a priori* earmarked for specific purposes, this will also reduce the level of rent contestability. A final possibility is that the revenue-based rents provide benefits over-and-above the size of the revenue. This reflects the idea that a revenue-recycling effect exists, where the rents may be distributed within the economy so as to reduce distortionary taxation for rent winners.

A key component of this model is the existence of rent-capturing activities. In particular, players invest in sunk effort to appropriate the rents generated from regulation. This is achieved by allowing players to participate in a contest where a player's share (winning probability) of the rent is based on

their sunk rent-seeking investments relative to total outlays. Clear anecdotal evidence exists for the presence of distributional rent seeking. Rent seeking over freely allocated permits is commonplace in the U.S. Acid Rain Program (Ellerman et al., 2000) as well as the European Union Emission Trading Scheme (EU-ETS) (Zapfel, 2007).[3] In particular, Ellerman et al. (2000) provide clear evidence that rent seeking occurred over the distribution of pollution permits under the 1990 Title IV of the Clean Air Act Amendments. In fact, the political process was entirely distributional. This occurred due to a specific section of the legislation. Under Section 403 (a) of the 1990 Title IV of the Clean Air Act Amendments a 'ratchet' provision was created that ensured that any political lobbying over the legislation would not affect the aggregate level of emissions. This was achieved by reducing each state's final level emissions *pro rata* to meet the agreed target level. Evidence of rent seeking over public funds is also frequently observed, for example, Aidt (2010) provide details of how the revenue from green taxes have been appropriated by members of society. Further, within the Regional Greenhouse Gas Initiative (RGGI)—a cap-and-trade scheme regulating most Northeastern US states—it has been observed that some states have diverted auction revenues away from their intended recipients. For example, since 2009 New York State has diverted revenue away from energy efficiency projects towards reducing their budget deficit, the so-called 'Deficit Reduction Plan (DRP) Transfer'.[4]

Combining a model of prices versus quantities with distributional rent seeking, this article shows the existence of rent seeking over regulatory rents significantly alters the politician's preferred choices and policy level. Thus this provides a positive analysis as to why certain polices are more likely to be implemented and how the policy target is chosen. The results within this article show that if a politician has equal weighting between social welfare and rent-seeking transfers then a separation exists between revenue-raising and non-revenue-raising quantities. In particular this article shows cases where non-revenue-raising quantities may actually be preferred over revenue-raising mechanisms: something frequently observed in reality (e.g., Goulder and Parry, 2008).[5] Further, if the politician is solely concerned about maximizing rent transfers, then no difference exists between revenue-raising instruments but there continues to be a difference associated with non-revenue-raising instruments. In particular the key determinant is the relationship between the level of contestability (due to bureaucratic friction, earmarking, and the revenue-recycling effect) and the composition of rent seekers within the regulated industry as well as the wider economy.

1.1 Related literature

The approach detailed in this article advances two distinct literature fields; namely, the political economy of environmental policy and prices versus quantities. The literature on the political economy of environmental policy is vast (see Oates and Portney, 2003). In this literature there are two main branches of exploration. The first branch focuses on the endogenous determination of environmental policy (e.g., Fredriksson, 1997; Aidt, 1998; Aidt and Dutta, 2004; Lai, 2007; Aidt, 2010). Most follow frameworks associated with Grossman and Helpman (1994, 2002), which establishes a common-agency model where the lobbyists are principals and the government is the agent.[6] Lobbyists provide a menu of contributions for a government's policy decisions. The government then decides

[3] See http://ec.europa.eu/clima/policies/ets/pre2013/nap/index_en.htm

[4] See http://www.nyserda.ny.gov/-/media/Files/Publications/Energy-Analysis/RGGI/2009-Q4-RGGI-Status-Report.pdf.

[5] Indeed a common argument for the non-revenue-raising instruments being so frequently used is that it is the 'path of least resistance' as the regulated entities try to persuade the regulator to avoid raising revenue (Buchanan and Tullock, 1975). In the framework of Buchanan and Tullock (1975) firms prefer direct control over taxes as this provides a form of monopoly rent whereas society prefers the tax due to the revenue-raising capabilities. It is argued, then, that direct control occurs as the firms are more organized in lobbying the government than society.

[6] Finkelshtain and Kislev (1997) use the model of Grossman and Helpman (1994) to compare tax and quota regimes. They find that the relative difference between taxes and quotas depends on the elasticity of the demand, supply of the product and the number of politically organized firms. Their approach, however, is not concerned with uncertainty of control costs nor the revenue-raising capabilities of regulatory regimes, which is central to the argument about regulatory instrument choice presented in this article.

a policy level based on their weighted sum of social welfare and political contributions. Thus the policy level is determined, in part, by lobbying activity. Although this literature provides a solid foundation to explain how environmental policy is determined, it often pays less attention to the distributional conflict that arises in environmental policy. In particular, it is often ignored that there exists bifurcation in the policy process, where, first, the policy is decided and then second, the details of the policy (i.e., the distributional components) are separately determined. The second branch focuses on this distributional conflict within environmental policy (e.g., Buchanan and Tullock, 1975; Dijkstra, 1998; Malueg and Yates, 2006; Dijkstra, 2007; Hanley and MacKenzie, 2010; MacKenzie and Ohndorf, 2012). One can view this approach, in some respects, as the opposite of the first branch: the lobbyists are the agents and the government is the principal.[7] Stemming from the early work of Tullock (1980), this literature views the establishment of environmental policy as a basis for the creation of rents that are distributional in nature.[8] In this approach, political influence occurs due to the investment in sunk costs, and, as a result, much use is made of contest theory to analyze these problems. Although fixed rents and the associated distributional conflict do exist, it would appear that these games are often zero-sum and the costs involved are less significant than externality (policy-level) distortions.[9] As such, given there are inevitable winners and losers with all policies, this literature usually only focuses on the distributional process and ignores the endogenous formation of policy.

This article, in contrast, shows that the existence of distributional rent seeking alters the politician's preferred choice of instrument as well as the equilibrium policy level. This, then, bridges the gap between the two branches of political economy literature by providing a positive analysis of the distributional process. In comparison to these branches of literature, the results of this article show that policy distortions can result from an inherent distributional game rather than an explicit lobbying process over the policy level. By deliberately abstracting from direct lobbying over the policy level, the model shows how distributional conflict alone can alter the prices versus quantities paradigm. Thus the approach presented here provides a novel method to analyze political influence under prices versus quantities.

The second literature field is prices versus quantities. Many additional directions have extended the core result of Weitzman (1974). Attention has been given to stock pollutants and alternative uncertainty structures (Stavins, 1996; Hoel and Karp, 2001, 2002; Pizer, 2002; Newell and Pizer, 2003; Wirl, 2012), tradable and bankable quantities (Williams III, 2002; Fell et al., 2012), technology choice (Krysiak, 2008; Storrøsten, 2014; D'Amato and Dijkstra, 2015), incomplete enforcement issues (Montero, 2002; Rohling and Ohndorf, 2012), as well as the analysis of second-best settings (Schöb, 1996; Quirion, 2004). The majority of this literature finds similarities with the core result: the most important determinants of instrument choice are the relative slopes of the marginal cost and benefit functions. A key weakness in this literature, however, is that it abstracts from political influence. Yet without investigating the impact of political influence on a regulator's instrument choice, very little can be said about prices versus quantities in reality (and any divergence from the social optimum).[10]

The main contribution of this article, then, is to provide a positive analysis of how distributional rent-capturing activities can distort the prices versus quantities paradigm. The results not only show that taking political influence into account is vital in explaining regulatory policy choice but also provides additional reasoning for focusing on distributional conflict. The article shows that modeling lobbying activity via a distributional conflict approach provides a basis for analyzing both

[7] See Epstein and Nitzan (2010, pp. 1-6) for a comprehensive discussion and evaluation of these two branches.

[8] For a collection of seminal papers see Congleton et al. (2008).

[9] The approach presented in this article is similar to MacKenzie and Ohndorf (2012) in that they analyze distributional rent seeking over environmental policy rents. Yet in the MacKenzie and Ohndorf (2012) approach the policy level is exogenously fixed and social welfare is compared among polices. As such, the MacKenzie and Ohndorf (2012) approach neither investigates the regulator's policy choice nor the prices versus quantities paradigm, which is the main objective of this article.

[10] An exception is Miyamoto (2014), which uses the framework of Grossman and Helpman (1994). Yet no consideration is given to the distributional conflict within the political system—the main objective of this article.

the distributional- and policy-level aspects of regulatory instruments. In this regard, the article enhances the view that the political economics of prices versus quantities has distributional conflict at its core. This article establishes a clear link between both branches of political economy literature and shows how models of distributional conflict can mirror those of the endogenous policy frameworks, as well as providing a new perspective on how choices within prices versus quantities may misalign from the traditional normative paradigm.

The article is structure as follows. In Section 2 the economic environment is outlined. In Section 3 the distributional game is detailed for the relevant mechanisms and in Section 4 the politician's choice of policy is outlined. In Section 5 comparisons are made between prices, revenue- and non-revenue-raising quantities. Section 6 provides some concluding remarks.

2 The economic environment

Consider an economy with an index set of players $\Psi = \{1, 2, \ldots, m\}$.[11] Within this population, a subset of players $\Phi = \{1, 2, \ldots, n\} \subseteq \Psi$ have their activity restricted by regulation. Let group Φ's aggregate cost of regulation be $C(q, \theta)$ where q is the activity restriction and θ is a random variable with $E[\theta] = 0$ and $E[\theta^2] = \sigma^2$. It is assumed that $C(q, \theta)$ is continuous, twice differentiable, and convex in q. For the general population $\Psi \setminus \Phi$, aggregate benefits obtained by the restriction of activity q are given by $B(q)$, where $B^{'}(q) > 0, B^{''}(q) < 0$, $B^{'}(0) > C^{'}(0)$ and $B^{'}(q) < C^{'}(q)$ for a sufficiently large q.[12] Denote $\bar{q} > 0$ as the level of abatement that reduces the activity to zero.

The focus of this article is to investigate how distributional rent seeking—the use of resources to capture rents generated from the regulatory system—alters the prices versus quantities paradigm. To highlight the fundamental differences, this environment is modeled as a two-stage game. In the first stage—and similar to traditional prices versus quantities analysis—a politician selects a level of regulation under the presence of uncertainty $\{p, q\}$: either a price level p or quantity restriction q. In the second stage, players compete for the rents generated from the introduction of regulation. Uncertainty over the level of costs is realized after stage one but prior to stage two.[13]

To present players' rent-capturing activities, the model follows the rent-seeking literature. In particular, a strategic contest is used to model the appropriation of rents within an economy (e.g., Congleton et al., 2008). In a contest, players invest in sunk effort, which will determine their probability of winning the rent. Formally, the probability of player $i \in \Psi$ obtaining the rent is given by:

$$\rho_i(\kappa_i, \kappa_{-i}) = \begin{cases} \frac{\kappa_i}{\kappa_i + \kappa_{-i}} & \text{if } \max\{\kappa_i, \kappa_{-i}\} > 0, \\ \frac{1}{m} & \text{otherwise,} \end{cases} \tag{1}$$

where κ_i and κ_{-i}, for $i \in \Psi$ and $-i \in \Psi \setminus \{i\}$, are the sunk resources used to appropriate the rent.[14] From (1), player i's probability of winning the rent is the ratio of their sunk effort relative to total outlays. Thus their probability of wining the rent (weakly) increases in their own effort and (weakly) decreases in rivals' efforts. One can interpret (1) as player i winning the entire rent with probability $\rho_i(\kappa_i, \kappa_{-i})$, or, perhaps more realistically, the share of rent attributed to risk neutral player i. Note that these rent-seeking efforts—although costly to the individuals expending the effort—may be viewed by the politician as socially wasteful, beneficial or simply a costless transfer between players in the economy.

[11] These can be interpreted as individuals or special-interest groups.

[12] This benefit can also be experienced over the population Ψ without any difference in results.

[13] This assumption is easily relaxed: if uncertainty is realized after players invest in capturing the rents players will rent seek over the expected rents rather than the realized value.

[14] This contest structure is the most commonly used mechanism to investigate rent seeking (Congleton et al., 2008). The contest can also be extended to include an exponent parameter $r \in [0, 2]$ that adjusts the marginal impact of rent-seeking investments. This has an effect of adjusting the level of aggregate rent-seeking investments. An alternative contest—an all-pay auction—is also a feasible mechanism. Using such a mechanism results in a mixed-strategy Nash equilibrium, where aggregate expected rent-seeking investments are larger that what is presented here.

To solve the model the Subgame Perfect Nash equilibrium solution concept is used, and thus the analysis begins with stage two.

3 Stage two: distributional conflict

3.1 Price regulation

Let $\tilde{p}$ denote the level of price regulation that was determined in stage one. For a realized level of uncertainty θ^0, denote the level of aggregate activity reduction as $h(\tilde{p}, \theta^0)$, which is derived from $C'(h(\tilde{p}, \theta^0), \theta^0) = \tilde{p}$. Thus the level of remaining (and taxable) activity is given by $\left(\bar{q} - h(\tilde{p}, \theta^0)\right)$. The rents generated from price regulation (tax revenue) are, therefore, given by:

$$\delta \tilde{p} \cdot \left(\bar{q} - h(\tilde{p}, \theta^0)\right). \tag{2}$$

The rent $\tilde{p} \cdot \left(\bar{q} - h(\tilde{p}, \theta^0)\right)$ is illustrated in Figure 1(a). Figure 1 shows the conventional prices versus quantities argument, with the addition that the rents generated from regulation are also altered due to the realization of uncertainty. In particular, it is clear that the rent is increasing in θ. The parameter δ is introduced in order to reflect the efficiency of transfers within the economy. If $\delta \in [0, 1)$ then there is a loss of rent within the economy. For example this could represent a marginal cost of social funds or bureaucratic friction within an economy.[15] Further, it could also be interpreted as a situation where a proportion $(1 - \delta)$ of the revenue is earmarked for specific use and the remainder δ is a contestable component.[16] Alternatively if $\delta > 1$ then the generation of this rent has the potential to be used to provide benefits to some members of the economy over-and-above the value of the rent. For example, this could reflect aspects of a revenue-recycling effect. That is, public funds could be used to reduce distortionary taxation for individuals or specific groups within the economy. From (2), note that the rent (tax revenue) is contestable to the whole population Ψ as all players can invest in rent-capturing resources to obtain the rent from the politician.

Using (1) and (2), player i's objective function is given by:

$$\max_{\kappa_i} \quad \rho_i(\kappa_i, \kappa_{-i}) \delta \tilde{p} \cdot \left(\bar{q} - h(\tilde{p}, \theta^0)\right) - \kappa_i. \tag{3}$$

This game has a pure-strategy Nash equilibrium. Thus the equilibrium appropriation effort of player i, is given by:

$$\kappa_i^*(\tilde{p}, \theta^0) = \left(\frac{m-1}{m^2}\right) \delta \tilde{p} \cdot \left(\bar{q} - h(\tilde{p}, \theta^0)\right). \tag{4}$$

Aggregating over the population Ψ, total appropriation effort is given by:

$$K_T^*(\tilde{p}, \theta^0) = \left(\frac{m-1}{m}\right) \delta \tilde{p} \cdot \left(\bar{q} - h(\tilde{p}, \theta^0)\right), \tag{5}$$

where subscript T denotes price regulation, i.e., tax.[17] Equation (5) shows that aggregate appropriation activity is increasing in the population m, the value of the rent $\delta \tilde{p} \cdot \left(\bar{q} - h(\tilde{p}, \theta^0)\right)$, as well as the level of transfer efficiency δ.

[15] The marginal cost of social funds, then, is represented by a reduction of the gross rent rather than an additional cost associated with transferring a fixed amount of revenue within the economy.

[16] Under the interpretation of earmarked revenues, it is possible that the process of earmarking incurs additional rent-seeking. This is compatible with the analysis presented here as the important link is the interaction between players and the politician. In such a case, the politician's rent being diminished due to earmarking can be interpreted as additional regulatory or legislative checks and balances. It is unlikely that a politician has full control over the entire revenue raised, thus, in such a case, we would expect $\delta < 1$.

[17] Throughout this article players non-cooperatively invest in rent-capturing activities. The framework can easily be extended to include groups. Either one can interpret each player as a specific lobbying group or one can enhance the model by allowing for an additional stage where inter-group rent seeking occurs followed by intra-group rent seeking or sharing of the rent (see, for example, MacKenzie and Ohndorf, 2012). Similar findings occur. Additionally one must consider how rents are shared among group members (normally achieved by an exogenous sharing rule). This then usually reduces rent-seeking efforts.

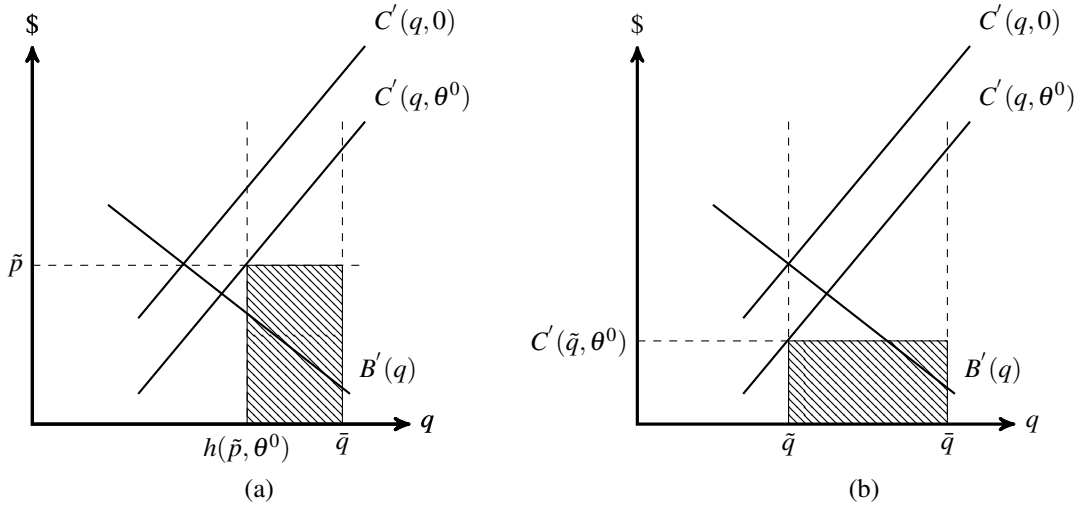

Figure 1: Rents generated from (a) price regulation and (b) quantity regulation, for a given realization of uncertainty θ^0.

3.2 Quantity regulation

Let $\tilde{q}$ denote the level of quantity regulation derived in stage one. For a realized level of uncertainty θ^0, the level of marginal cost associated with $\tilde{q}$ is given by $C'(\tilde{q},\theta^0)$. Thus the total rent available to be appropriated is given by:

$$C'(\tilde{q},\theta^0)\cdot(\bar{q}-\tilde{q})\,. \tag{6}$$

This can be observed as the hatched area in Figure 1(b). At this point we have to differentiate between quantity mechanisms that generate revenue (e.g., auctions) and those that do not generate revenue (e.g., freely allocated pollution permits). Two key distinctions arise. First, revenue-generating mechanisms have the potential to be contested by the entire population Ψ whereas this is less likely under a non-revenue-raising mechanism. For example, revenue generated from a quantity mechanism is usually treated like any other government revenue, such as the tax revenue previously described. Thus the entire population has the ability to obtain this generated revenue. In contrast, non-revenue-raising quantity mechanisms, such as freely allocated pollution permits, are frequently contested only by the population of regulated players Φ. Indeed quantities in this case only provide a rent to the regulated players.[18] Second, the rents generated from revenue-raising quantity mechanisms may also be affected by the efficiency of government transfer. As both auction and tax revenues are transferred to the government, the transfer efficiency is likely to be the same, thus it is assumed that δ is identical for a price mechanism and revenue-raising quantity mechanism.[19] In contrast, for a non-revenue-raising mechanisms the creation of a finite amount of quantity is usually transferred to regulated entities without efficiency loss, thus $\delta = 1$.[20]

[18]It is, of course, feasible that non-regulated entities rent seek for quantities, e.g., environmental groups, but this appears not to be the case. To include such aspects in the analysis, one simply needs to incorporate a further subgroup of the entire population Ψ into the game.

[19]Throughout this analysis administration costs assumed to be comparable for all mechanisms. Inclusion of these costs does not alter the results of this article. Note that when $\delta < 1$ under prices and revenue-raising quantities, this reflects inherent bureaucratic inefficiencies over and above any administration costs. Another possible interpretation is that $(1-\delta)$ of the rent is earmarked for use and thus non-contestable. Thus $\delta < 1$ of the rent is contestable.

[20]It can, of course, include a $\delta \neq 1$ to incorporate cases where the rent can be used to represent regulated players using the rent as investments, and so on.

3.2.1 Revenue-raising quantities

For revenue-raising quantity mechanisms, then, the rent is contestable by the whole population Ψ. Using (1), and (6), player $i \in \Psi$ has the expected payoff:

$$\max_{\kappa_i} \quad \rho_i(\kappa_i, \kappa_{-i}) \delta C^{'}(\tilde{q}, \theta^0) \cdot (\bar{q} - \tilde{q}) - \kappa_i. \tag{7}$$

The equilibrium appropriation effort of player i, is given by:

$$\kappa_i^*(\tilde{q}, \theta^0) = \left(\frac{m-1}{m^2} \right) \delta C^{'}(\tilde{q}, \theta^0) \cdot (\bar{q} - \tilde{q}) . \tag{8}$$

Aggregating over all the population, total appropriation effort is given by:

$$K_A^*(\tilde{q}, \theta^0) = \left(\frac{m-1}{m} \right) \delta C^{'}(\tilde{q}, \theta^0) \cdot (\bar{q} - \tilde{q}) , \tag{9}$$

where subscript A denotes the case of revenue-raising quantity mechanism, such as an auction. Again we can see that aggregate appropriation effort is increasing in population, rent, and the efficiency of transfer.

3.2.2 Non-revenue-raising quantities

For non-revenue-raising quantity regulation, it is likely that only the regulated population expend resources in order to win quantity rents. For example, under the allocation of pollution permits, it is often observed that polluting firms are the only firms to rent seek for permits. Restricting $\rho_i(\kappa_i, \kappa_{-i})$ in (1) to the regulated population Φ only, the expected payoff for player $i \in \Phi$ is given by:

$$\max_{\kappa_i} \rho_i(\kappa_i, \kappa_{-i}) C^{'}(\tilde{q}, \theta^0) \cdot (\bar{q} - \tilde{q}) - \kappa_i. \tag{10}$$

Not only is there a lower level of population incentivized to contest the rent but also $\delta = 1$, i.e., there is a direct transfer of permits without efficiency loss. The pure-strategy Nash equilibrium appropriation effort of player i is given by:

$$\kappa_i^*(\tilde{q}, \theta^0) = \left(\frac{n-1}{n^2} \right) C^{'}(\tilde{q}, \theta^0) \cdot (\bar{q} - \tilde{q}) . \tag{11}$$

Aggregating over all the population, total appropriation effort is given by:

$$K_G^*(\tilde{q}, \theta^0) = \left(\frac{n-1}{n} \right) C^{'}(\tilde{q}, \theta^0) \cdot (\bar{q} - \tilde{q}) , \tag{12}$$

where G denotes the case of non-revenue-raising quantity regulation, such as the freely allocated grandfathered permits.

Table 1 provides a summary of the components for all instruments. For revenue-raising instruments, $\delta \in [0, \infty)$ whereas for non-revenue-raising quantities $\delta = 1$. A clear separation exists over the composition of rent when either a price or quantity instrument is chosen. The other remaining difference is the number of players that contest the rent, which is higher for revenue-raising instruments, $m \geq n$.

4 Stage one: politician's choice of policy level

In stage one the politician decides on the level of regulation. As the main objective of this article is to investigate how rent-seeking efforts alter the prices versus quantities paradigm, it is paramount to identify potential institutional rent-seeking environments. There are four main scenarios of

Rent Properties			
Instrument	δ	Rent	Number of players
Price (T)	$\delta \in [0, \infty)$	$\delta \tilde{p} \cdot \left(\bar{q} - h(\tilde{p}, \theta^0)\right)$	m
Revenue-raising quantity (A)	$\delta \in [0, \infty)$	$\delta C^{'}(\tilde{q}, \theta^0) \cdot (\bar{q} - \tilde{q})$	m
Non-revenue-raising quantity (G)	$\delta = 1$	$C^{'}(\tilde{q}, \theta^0) \cdot (\bar{q} - \tilde{q})$	n

Table 1: Comparison of rents among alternative instruments.

importance. First, a politician may be solely committed to maximizing social welfare and perceive the transfer of rent-seeking efforts as a loss. The most likely interpretation is where the rents offered to the politician are illegal and the acceptance of such rents generates a negative expected gain due to the (high) probability of being found guilty of corruption. Second, the politician may still be committed to the maximization of social welfare but may perceive rent seeking as a transfer between players in the economy and thus not of inherent social loss. Third, the politician may continue to view social welfare as an objective but also receives benefits in the form of players' rent-seeking transfers. In this case, for example, the politician may place equal weight on the maximization of social welfare and the generation of rent-seeking efforts. Fourth, the politician may have a sole objective to maximize the generation of rent-seeking transfers and simply disregard social welfare.

Generating this spectrum of environments can easily be achieved by creation of an institutional parameter $\mu \in [0, 1]$. The politician places weights on the importance of social welfare and rent-seeking activity: the politician will place a weight of μ on social welfare and a weight of $(1 - 2\mu)$ on rent-seeking activities. Note that the weight $(1 - 2\mu)$ is used to reflect the scenario that the politician can either have positive ($\mu < 1/2$) or negative ($\mu > 1/2$) payoffs from rent-seeking activity.[21]

Using (5) the politician's objective function under price regulation is given by

$$\max_p E\left[\mu\left(B(q(p,\theta)) - C(q(p,\theta),\theta)\right) + (1-2\mu)K_T^*(p,\theta)\right]. \tag{13}$$

Using (9), under a revenue-raising quantity mechanism we have:

$$\max_{q_A} E\left[\mu\left(B(q) - C(q,\theta)\right) + (1-2\mu)K_A^*(q,\theta)\right], \tag{14}$$

and finally, using (12), for a non-revenue-raising mechanism, the objective function is given by:

$$\max_{q_G} E\left[\mu\left(B(q) - C(q,\theta)\right) + (1-2\mu)K_G^*(q,\theta)\right]. \tag{15}$$

In all types of regulation, if $\mu = 0$ this details a case where the politician's sole focus is on maximizing rent-seeking effort. If $\mu = 1/3$ there is equal weight between social welfare and the generation of rent-seeking benefits for the politician. If $\mu = 1/2$ the politician cares about social welfare but also views rent seeking only as a transfer without any loss to society. If $\mu = 1$ the politician not only cares about social welfare they also view rent-seeking efforts as socially wasteful.[22]

[21] The objective function presented here can be rewritten to balance social welfare (inclusive of rent-seeking costs) and rent-seeking transfer benefits to the politician. Under price regulation, for example, the objective function can be rewritten as $\max_p E\left[\mu\left(B(q(p,\theta)) - C(q(p,\theta),\theta) - K_T^*(p,\theta)\right) + (1-\mu)K_T^*(p,\theta)\right]$.

[22] As already discussed, δ can represent the revenue-recycling effect. To take into account a tax interaction effect this analysis can follow Quirion (2004) and allow a parameter to alter the slope of the marginal cost function. In the current context this would simply result in a redefinition of the cost function, without any significant difference to the results. The approach followed here is similar to the 'weak double dividend' (e.g., Goulder, 1995; Parry, 1995; Goulder et al., 1999).

5 Prices versus quantities

In this section comparison of prices versus quantities is investigated under alternative institutional settings. For each institutional setting, we start by investigating how distributional rent seeking affects the politician's choice of policy level under alternative mechanisms. Then focus moves to the primary goal: to provide a positive analysis that assists in explaining why certain policies may be chosen over others within the prices versus quantities paradigm. More precisely pairwise comparisons are provided that detail the politician's payoffs for taxes as well as revenue- and non-revenue-raising quantity mechanisms. To start, denote Δ_{TA} as the relative payoff difference between prices and a revenue-raising quantity mechanism, such as a tax versus a permit auction. Similarly denote Δ_{TG} as the relative payoff difference between prices and non-revenue-raising quantity mechanism, such as a tax versus grandfathered (freely allocated) permits. Finally, let us denote Δ_{AG} as the relative payoff difference between revenue and non-revenue-raising mechanisms, such as auctioned permits versus grandfathered (freely allocated) permits.

Following the literature on prices versus quantities, costs are detailed as

$$C(q,\theta) = \theta q + \frac{c}{2}q^2, \tag{16}$$

where $c > 0$ is a parameter. The benefits obtained by the restriction of activity q are given by

$$B(q) = aq - \frac{b}{2}q^2, \tag{17}$$

where $a, b > 0$ are parameters.

5.1 Rent seeking as a costless transfer (Benchmark)

As a starting point—and to provide a benchmark—consider a scenario similar to Weitzman (1974), where the politician's objective is to maximize expected social welfare. Within the framework presented here, this requires an additional assumption that any distributional conflict within the economy is a non-wasteful transfer and simply ignored by the politician. That is, any rent-seeking activity is a transfer from the players to the bureaucracy, which is redistributed back to the economy in a lump-sum fashion without any transfer inefficiency. Formally this is modeled by setting $\mu = 1/2$. Beginning with price regulation, substitute $\mu = 1/2$, (16) and (17) into (13), the equilibrium level of price regulation is:

$$p^* = E\left[\frac{ac + b\theta}{b + c}\right] = \frac{ac}{b + c}. \tag{18}$$

Thus given the equilibrium price regulation, the level of quantity is

$$E\left[q(p^*,\theta)\right] = \frac{a}{b + c}. \tag{19}$$

Substituting (18) into (13) yields the expected net benefit of price regulation:

$$E\left[\frac{(ac - (b + c)\theta)(ac + (b - c)\theta)}{2c^2(b + c)}\right]. \tag{20}$$

Now consider quantity mechanism. As $\mu = 1/2$, it is trivial to show that that there is no distinction needed between revenue-raising and non-revenue-raising quantities. Thus using (16) and (17), optimization over (14) (and (15)) with respect to q and solving yields

$$q_A^* = q_G^* = E\left[\frac{a - \theta}{b + c}\right] = \frac{a}{b + c}. \tag{21}$$

Comparison of (19) and (21) shows that

Proposition 1. *Let rent seeking be non-wasteful. If the politician maximizes expected social welfare then:*

$$E[q(p^*, \theta)] = q_A^* = q_G^*. \tag{22}$$

Similar to Weitzman (1974), the expected regulation levels are identical. For use later in the article, let us denote this level of benchmark quantity by q^W. Substituting (21) into (14) (and 15) yields the net benefit from quantity regulation:

$$E\left[\frac{a(a-2\theta)}{2(b+c)}\right]. \tag{23}$$

Subtracting (23) from (20) and taking expectations yields Proposition 2.

Proposition 2 (Weitzman 1974)**.** *Let rent seeking be non-wasteful. If the politician maximizes expected social welfare then:*

$$\Delta_{TA} = \Delta_{TG} = \frac{(c-b)}{2c^2}\sigma^2, \tag{24}$$

$$\Delta_{AG} = 0. \tag{25}$$

Proposition 2 shows a comparative result to Weitzman (1974): if distributional conflict is simply a non-wasteful transfer within the economy, then it has no bearing on the politician's preferred type of regulation: the politician's relative payoff differences perfectly align with social welfare. The relative difference is dependent on the variance of the error term and the relative slope of the marginal benefit and cost functions. Proposition 2 also shows that there is no relative difference between revenue and non-revenue-raising quantity mechanisms—something implicit within Weitzman (1974). As will be shown later in the article, however, this result does not hold for alternative—and arguably more realistic—institutional settings.

5.2 Equal weight between social welfare and transfers

Let us now analyze a more plausible institutional environment; namely, where a politician not only cares about social welfare but also cares about receiving benefits from players in the form of rent-seeking transfers. To showcase how the introduction of rent-seeking benefits alters the prices versus quantities paradigm, let us assume that the politician places an equal weight on social welfare and rent-seeking benefits. In such a case $\mu = 1/3$. Let us begin with price regulation. Substituting $\mu = 1/3$ into (13) and optimizing yields:

$$p^* = E\left[\frac{acm + b\theta m + c^2\delta(m-1)\bar{q} + c\delta\theta(m-1)}{m(b+c) + 2c\delta(m-1)}\right], \tag{26}$$

which yields

$$E\left[q(p^*, \theta)\right] = \frac{am + (m-1)\bar{q}c\delta}{(b+c)m + 2(m-1)c\delta}. \tag{27}$$

For revenue-raising quantity regulation, optimization of (14) yields:

$$q_A^* = \frac{am + (m-1)\bar{q}c\delta}{(b+c)m + 2(m-1)c\delta}, \tag{28}$$

and for the non-revenue-raising regulation it follows that:

$$q_G^* = \frac{an + \bar{q}c(n-1)}{bn + (3n-2)c}. \tag{29}$$

Note now that $E[q(p^*, \theta)] = q_A^* \neq q_G^*$. By comparing the benchmark quantity level q^W in (21) with (26), (28), and (29), we can observe how the existence of a politician's transfer benefits alter the equilibrium quantities chosen.

Proposition 3. *Let the politician have equal weight between social welfare and rent-seeking transfers.*

- *If* $\bar{q} \lessgtr \frac{2a}{(b+c)}$ *then* $q_A^* = E[q(p^*, \theta)] \lessgtr q^W$ *and* $q_G^* \lessgtr q^W$.
- $q_G^* - q_A^* = \frac{c(m(-\delta n+n-1)+\delta n)(\bar{q}(b+c)-2a)}{(bn+c(3n-2))(m(b+c)+2c\delta(m-1))} = q_G^* - E[q(p^*, \theta)]$.

The first component of Proposition 3 shows that the policy levels chosen by the politician—when there exists a rent-seeking influence—are distinct from the conventional Weitzman (1974) result. Indeed, it is clear that if $\bar{q} \neq \frac{2a}{(b+c)}$ the politician will choose a level of policy that will not maximize expected social welfare. If $\bar{q} > \frac{2a}{(b+c)}$, Proposition 3 shows that the policy level chosen by the politician is, in fact, *more* stringent than that proposed under Weitzman (1974). The intuition is as follows. Given rent-seeking transfers are beneficial to the politician, a relatively high $\bar{q}$ will result in larger rent-seeking transfers. Thus to maximize expected payoffs, the politician re-optimizes between rent-seeking transfers and social welfare, and, as a result, proposes a more stringent policy, which equates the marginal changes in welfare with the marginal change in rent-seeking transfers. It follows that for cases where the unconstrained level of externality is relatively large (i.e., large $\bar{q}$), a politician will choose a relatively more stringent policy compared to one that only maximizes expected social welfare. For cases where $\bar{q} < \frac{2a}{(b+c)}$ where the unconstrained level of externality is relatively small, the politician selects a policy level less stringent that what is desirable to maximize expected social welfare.

The second component of Proposition 3 compares the relative policy level for the three alternative instruments. Note that there exists a difference between revenue- and non-revenue-raising instruments. In particular, if $\bar{q} > \frac{2a}{(b+c)}$ and $\delta < (>) \frac{m}{(m-1)} \frac{(n-1)}{n}$ then non-revenue-raising quantities generate a more (less) stringent target than revenue-raising instruments. Note that $\delta \lessgtr \frac{m}{(m-1)} \frac{(n-1)}{n}$ connects the degree of earmarking/transfer inefficiency/revenue-recycling effect with the population of rent seekers. We return to a discussion of this later in the article. It is immediately clear, however, that if the level of transfer efficiency δ is relatively small and $\bar{q}$ is sufficiently large then the policy level of a non-revenue-raising instrument will be more stringent that revenue-raising mechanisms. Intuitively, for the case of revenue-raising instruments, if the value of the rent is sufficiently low the politician obtains less rent-seeking transfers and accordingly reduces the stringency of the target to increase such transfers. For the case $\bar{q} < \frac{2a}{(b+c)}$, the results are reversed.

We now consider the expected differences in the politician's payoff under alternative regulatory instruments. Substituting (26), (28), and (29), into (13), (14), and (15), respectively yields:

Proposition 4. *If the politician has an equal weight between social welfare and rent-seeking transfer benefits then:*

$$\Delta_{TA} = \frac{(c-b)}{6c^2}\sigma^2, \tag{30}$$

$$\Delta_{TG} = \frac{(c-b)}{6c^2}\sigma^2 + \Lambda, \tag{31}$$

$$\Delta_{AG} = \Lambda. \tag{32}$$

where:

$$\Lambda = \frac{c\left(m(1+n(\delta-1))-n\delta\right)\left(2amn\bar{q}(b+c) - 2a^2mn + \bar{q}^2c\left(m(n-1)(b+c)+(m-1)(bn+(3n-2)c)\delta\right)\right)}{6mn(bn+(3n-2)c)\left(m(b+c)+2(m-1)c\delta\right)}. \tag{33}$$

Proposition 4 shows that the relative difference between prices and revenue-raising quantity regulation, again, depends on the relative slopes of the cost and benefit functions. As can be seen from (30), if $c > b$ then prices are preferred over revenue-raising quantities. Thus the politician's preferences align with social welfare. Note, however, that the relative difference is scaled down

due to the politician having an equal preference for rent-seeking transfers. One can see from (32) that there now exists a difference between revenue-raising and non-revenue-raising quantities. The term Λ has ambiguous sign. Closer analysis of Λ shows if $\bar{q} > \frac{a}{b+c}$ then all terms are positive except $(m(1+n(\delta-1))-n\delta)$, which is ambiguous. This is formalized in the following corollary.

Corollary 1. *Let* $\bar{q} > \frac{a}{b+c}$ *then* $\Delta_{AG} \lesseqgtr 0 \iff \delta \lesseqgtr \frac{m}{(m-1)}\frac{(n-1)}{n}$.

Corollary 1 shows that the politician's preference over revenue-raising or non-revenue-raising quantities is dependent on the transfer efficiency δ and the composition of rent seekers in the regulated market as well as the whole economy. Note that as $m \geq n$ then $\frac{m}{(m-1)}\frac{(n-1)}{n} \leq 1$ so that if a revenue-recycling effect existed such that $\delta > 1$ then auctions would be preferred. Under this institutional setting, auctions are preferred due to the additional rent-seeking benefits obtained by the politician. More likely we would expect that $\delta < 1$—as revenues may be earmarked or there may exist bureaucratic friction—and, therefore, non-revenue-raising quantities are the politician's preferred choice. Thus in contrast to the conventional regulator in Weitzman (1974), a clear distinction arises over the revenue-raising capabilities of quantity mechanisms. This may provide an additional theoretical explanation as to why we observe mainly non-revenue-raising quantity regulation, especially at the implementation stage of regulation. Once the politician is modeled realistically—in that there is a private benefit from rent seeking and bureaucratic inefficiency exists—then it is clear that a preference may be directed towards freely allocated quantities. For cases $\bar{q} < \frac{a}{b+c}$, the second term in the numerator now has ambiguous sign. Yet it is clear that the relationship between the politician's preferred instrument and the level of transfer efficiency and population of rent seekers is maintained.

Noting Corollary 1 and comparison of prices versus non-revenue-raising quantities in (31), shows that non-revenue-raising quantities may even be preferred over prices. In particular, if $b > c$ and δ is sufficiently small then non-revenue-raising quantities are unambiguously preferred over prices. In particular, combining Proposition 3 and Corollary 1 reveals that if $\bar{q} > \frac{2a}{(b+c)}$ and $\delta < \frac{m}{(m-1)}\frac{(n-1)}{n}$ then not only are non-revenue-raising instruments preferred to all other instruments, but they also generate the most stringent level of equilibrium policy level.

Further consideration of (31) shows that a trade-off may exist in that the relative efficiency from social welfare (first term) is counteracted by the rent-seeking influences (second term). This occurs in the presence of bureaucratic frictions and $b < c$. Thus it is clear situations exist where non-revenue-raising quantities would be preferred over prices, even though—under a normative social welfare perspective—prices should be chosen (as $b < c$). Conversely, if $b > c$ occurs then under a normative social welfare perspective quantities should be chosen. Yet (31) shows that if Λ is sufficiently large and positive (for example, a sufficiently large revenue-recycling effect and large $\bar{q}$) then prices may actually be chosen by the politician in order to obtain rent-seeking transfers.

5.3 Rent-maximizing politician

At another extreme, it is possible that the politician ignores the benefits and costs of regulation entirely and instead sets regulation solely to maximize the gains from rent-seeking transfers. Substituting $\mu = 0$ into (13), (14), and (15) yields objective functions that aim to maximize the aggregate level of rent seeking. Let us begin with the price mechanism. Optimization of (13) and solving yields the following expected price regulation

$$p^* = E\left[\frac{\bar{q}c + \theta}{2}\right], \tag{34}$$

thus we obtain

$$E[q(p^*, \theta)] = E\left[\frac{\bar{q}c - \theta}{2c}\right] = \frac{\bar{q}}{2}. \tag{35}$$

Substituting into (13) yields the expected rent-seeking benefit:

$$E\left[\frac{(m-1)\bar{q}\delta(\bar{q}c+2\theta)}{4m}\right]. \tag{36}$$

Next consider the two cases for quantity regulation. Under revenue-raising quantity regulation the optimal level of quantity is given by

$$q_A^* = E\left[\frac{\bar{q}c-\theta}{2c}\right] = \frac{\bar{q}}{2}, \tag{37}$$

which yields expected benefits of:

$$E\left[\frac{(m-1)\bar{q}\delta(\bar{q}c+2\theta)}{4m}\right]. \tag{38}$$

For non-revenue-raising quantity regulation, the optimal level of quantity is identical to (37). The net benefit is thus given by:

$$E\left[\frac{(n-1)\bar{q}(\bar{q}c+2\theta)}{4n}\right]. \tag{39}$$

Comparison reveals $E[q(p^*,\theta)] = q_A^* = q_G^*$, where the equilibrium level of q chosen by the politician is exactly half of the total possible reduction of activity. Note that even though the politician aims to maximize rents transfers, it chooses a non-zero level of regulation. Comparison of (21) and (37), generates a similar result to Proposition 3; namely, if $\bar{q} \lesseqgtr \frac{2a}{(b+c)}$ then $E[q(p^*,\theta)] = q_A^* = q_G^* \lesseqgtr q^W$. Again we can see that the key determinant of whether the equilibrium level of regulation is more or less stringent compared to the benchmark case depends on $\bar{q}$. Note here that the expected quantities established from these regulations are identical.

Pairwise comparisons of (36), (38), (39), yields the following proposition.

Proposition 5. *If the politician maximizes rent-seeking benefits then:*

$$\Delta_{TA} = 0, \tag{40}$$

$$\Delta_{TG} = \Delta_{AG} = \frac{c\bar{q}^2\left(m(1+n(\delta-1))-n\delta\right)}{4mn}. \tag{41}$$

Proposition 5 shows that $\Delta_{TA} = 0$, i.e., the politician is indifferent between prices and revenue-raising quantities and is not affected by the relative slopes of the benefit and cost functions: a clear contrast to the normative prices versus quantities paradigm. The relative difference between non-revenue-raising quantities and the remaining mechanisms is ambiguous. This difference is similar—but not identical—to that derived in Corollary 1, in that

$$\Delta_{TG} = \Delta_{AG} \lesseqgtr 0 \Longleftrightarrow \delta \lesseqgtr \frac{m}{(m-1)}\frac{(n-1)}{n}. \tag{42}$$

Again, whether prices and revenue-raising quantities are preferred over non-revenue-raising quantities crucially depends on δ: the degree of transfer efficiency with the economy. In this case, if the primary goal is to maximize rent-seeking transfers, then the politician will choose a mechanism that generates the largest rent: prices or revenue-raising quantities if a revenue-recycling effect exists, or non-revenue-raising quantities if relatively large bureaucratic frictions (or earmarking) exists within the economy.

5.4 Rent seeking as socially wasteful

Let us now consider an institutional environment where the politician not only cares about social welfare but also the minimization of wasteful rent seeking transfers. In such a case the politician perceives rent seeking as an additional loss. For example, it may be interpreted as some form of corruption that generates losses to the politician (an expected loss from taking bribes due to either a high probability of enforcement or large penalty). For price regulation, optimization with $\mu = 1$, yields the following price:

$$p^* = E\left[\frac{acm + b\theta m + c^2\delta(-(m-1))\bar{q} - c\delta\theta(m-1)}{m(b+c) - 2c\delta(m-1)}\right], \tag{43}$$

with the following level of quantity:

$$E[q(p^*, \theta)] = \frac{am - \delta(m-1)c\bar{q}}{m(b+c) - 2c\delta(m-1)}. \tag{44}$$

For revenue-raising quantities, the optimal level of quantity is given by:

$$q_A^* = \frac{am - \delta(m-1)c\bar{q}}{m(b+c) - 2c\delta(m-1)} \tag{45}$$

and for non-revenue-raising quantities:

$$q_G^* = \frac{(n-1)\bar{q}c - an}{(n-2)c - bn}. \tag{46}$$

In the current setup, an interior Nash equilibrium is not guaranteed. In particular, for an interior Nash equilibrium to exist, the following conditions must be satisfied for non-revenue-raising quantities and prices (revenue-raising quantities), respectively:

$$\frac{b}{c} > 2\frac{n-1}{n} - 1, \tag{47}$$

$$\frac{b}{c} > 2\delta\frac{m-1}{m} - 1. \tag{48}$$

These conditions are intuitive: if rent-seeking activity is socially wasteful to the politician, a sufficiently large marginal benefit is required for an incentive to exist to select a non-zero level of regulation. If marginal benefits are sufficiently small then the politician would simply not regulate as the process would generate too much cost (abatement cost plus rent-seeking losses). If $b \geq c$ then the conditions are satisfied when $\frac{n}{(n-1)} > 1$, which always holds, and $\frac{m}{(m-1)} > \delta$. Throughout this subsection it is assumed that these conditions are satisfied. Thus the following proposition exists.

Proposition 6. *Let the politician maximize social welfare and minimize rent-seeking activity,*

- *If* $\bar{q} \lesseqgtr \frac{2a}{(b+c)}$ *then* $q^W \lesseqgtr q_A^* = E[q(p^*, \theta)]$ *and* $q^W \lesseqgtr q_G^*$.
- $q_G^* - q_A^* = \frac{c(m((\delta-1)n+1)-\delta n)(\bar{q}(b+c)-2a)}{(bn-c(n-2))(m(b+c)-2c\delta(m-1))} = q_G^* - E[q(p^*, \theta)]$.

Proposition 6 shows that when the politician perceives rent-seeking transfers as socially wasteful then the opposite result from Proposition 3 is derived. In particular, if $\bar{q} > \frac{2a}{(b+c)}$ then the benchmark policy level is more stringent when rent-seeking transfers are socially wasteful. Furthermore, non-revenue raising quantities now result in less stringent polices than prices and revenue-raising quantities when $\bar{q} > \frac{2a}{(b+c)}$. When an interior Nash equilibrium exists—by assuming (47) and (48) are satisfied—the following proposition holds:

Proposition 7. *If the politician objective is to maximize social welfare and minimize rent-seeking activity, then:*

$$\Delta_{TA} = \frac{(c-b)}{2c^2}\sigma^2 < 0, \tag{49}$$

$$\Delta_{TG} = \frac{(c-b)}{2c^2}\sigma^2 + \Gamma, \tag{50}$$

$$\Delta_{AG} = \Gamma, \tag{51}$$

where $\Gamma = \frac{c(m(1+n(\delta-1))-n\delta)(2a^2mn-2a(b+c)mn\bar{q}+c\bar{q}^2((b+c)m(n-1)+(m-1)(bn-c(n-2))\delta))}{2mn(bn-c(n-2))((b+c)m-2c(m-1)\delta)}$.

From Proposition 7, $\Delta_{TA} < 0$, i.e., if the regulator aims to maximize social welfare and minimize the social loss from rent seeking then it would implement revenue-raising quantities over prices. Note further that from (50) the case for prices over non-revenue raising quantities is substantially weakened as the first term is now negative. The ambiguous efficiency comparisons depend on the sign of Γ (that has similar characteristics to Λ), which depends on the level of δ with respect to the number of rent seekers, as well as the level of unconstrained externality $\bar{q}$.

In summary, what has been observed—regardless of the institutional environment—is that a distinction between prices, revenue-raising quantities and non-revenue-raising quantities exists when distributional rent seeking is taken into account. The fundamental determinants of the politician's preferred policy options are the efficiency of rent transfer as well as the composition of rent seekers within the economy and the regulated market. This analysis, then, may assist in explaining how and how certain environmental policies are determined.

6 Concluding remarks

The purpose of this article is to investigate prices versus quantities when the creation of regulation generates contestable rents. A two-stage process is outlined where, in the first stage, a politician selects a policy level for either a price or quantity, à la Weitzman (1974). In the second stage, players invest in rent-capturing activities in order to obtain the rents. The main objective of this article is to provide a tractable positive analysis of how and why a politician selects regulatory instruments under political influence and compare this with the traditional (normative) prices versus quantities paradigm.

A key distinction between the different types of regulation is the way the generated rents diffuse within the economy. First, non-revenue-raising quantity mechanisms, such as freely allocated permits, generate rents that are usually only contested by the regulated entities. Whereas rents from revenue-raising mechanisms (both prices and quantities) are usually collected by the government in which case centralized rent seeking can occur from the whole economy. Second, for instruments that generate revenues there may exist transfer inefficiencies, such as a marginal cost of funds, or perhaps a proportion of the rent has been *a priori* earmarked resulting in a lower level of rent that is contestable. Additionally, the revenue may also generate a revenue-recycling effect.

In this article pairwise comparisons are provided between prices and quantities (and whether they generate revenue or not). This is achieved under a number of institutional environments in order to reflect realistic bureaucratic scenarios. For example, one such scenario occurs where the politician's preferences equally weight social welfare and rent-seeking transfers. Alternatively, other cases exist where the politician perceives rent-seeking activities as socially wasteful or costless as well as cases where the politician entirely neglects social welfare. This article provides conditions where, under bureaucratic friction (or the existence of earmarked revenues), non-revenue-raising quantity mechanisms tend to be preferred by the politician. This provides additional reasoning for the frequent use of such mechanisms in environmental policy. A key determinant is the interaction between the inefficiency of the rent transfer/ earmarking (or revenue-recycling effect) and the composition of players that rent seek both at the regulated market and economy level.

The approach detailed in this article bridges the gap between different branches within the literature on the political economy of environmental policy and provides reasoning why distributional rent seeking should be investigated within the prices versus quantities paradigm as well as other environmental regulatory problems.

References

Adar, Z. and Griffin, J. M. (1976). 'Uncertainty and the choice of pollution control instruments', *Journal of Environmental Economics and Management*, **3**, pp. 178 – 188.

Aidt, T. S. (1998). 'Political internalization of economic externalities and environmental policy', *Journal of Public Economics*, **1**, pp. 1–16.

Aidt, T. S. (2010). 'Green taxes: Refunding rules and lobbying', *Journal of Environmental Economics and Management*, **1**, pp. 31–43.

Aidt, T. S. and Dutta, J. (2004). 'Transitional politics: emerging incentive-based instruments in environmental regulation', *Journal of Environmental Economics and Management*, **47**, pp. 458–479.

Buchanan, J. M. and Tullock, G. (1975). 'Polluters' Profits and Political Response: Direct Controls versus Taxes', *The American Economic Review*, **65**, pp. pp. 139–147.

Congleton, R., Hillman, A. and Konrad, K. (2008). *40 Years of Rent-Seeking Research*: Springer Verlag.

Cramton, P. and Kerr, S. (2002). 'Tradeable carbon permit auctions: How and why to auction not grandfather', *Energy Policy*, **30**, pp. 333 – 345.

D'Amato, A. and Dijkstra, B. R. (2015). 'Technology choice and environmental regulation under asymmetric information', *Resource and Energy Economics*, **41**, pp. 224 – 247.

Dijkstra, B. R. (1998). 'A two-stage rent-seeking contest for instrument choice and revenue division, applied to environmental policy', *European Journal of Political Economy*, **14**, pp. 281 – 301.

Dijkstra, B. R. (2007). 'An investment contest to influence environmental policy', *Resource and Energy Economics*, **29**, pp. 300–324.

Ellerman, A. D., Joskow, P. L., Schmalensee, R., Montero, J.-P. and Bailey, E. M. (2000). *Markets for clean air: The US acid rain program*: Cambridge University Press (New York).

Epstein, G. S. and Nitzan, S. (2010). *Endogeneous public policy and contests*, Berlin: Springer.

Fell, H., MacKenzie, I. A. and Pizer, W. A. (2012). 'Prices versus quantities versus bankable quantities', *Resource and Energy Economics*, **34**, pp. 607 – 623.

Finkelshtain, I. and Kislev, Y. (1997). 'Prices versus Quantities: The Political Perspective', *Journal of Political Economy*, **105**, pp. 83–100.

Fishelson, G. (1976). 'Emission control policies under uncertainty', *Journal of Environmental Economics and Management*, **3**, pp. 189 – 197.

Fredriksson, P. G. (1997). 'The political economy of pollution taxes in a small open economy', *Journal of Environmental Economics and Management*, **33**, pp. 44–58.

Garnaut, R. (2008). *The Garnaut climate change review*: Cambridge University Press.

Goulder, L. H. (1995). 'Effects of Carbon Taxes in an Economy with Prior Tax Distortions: An Intertemporal General Equilibrium Analysis', *Journal of Environmental Economics and Management*, **29**, pp. 271 – 297.

Goulder, L. H., Parry, I. W., III, R. C. W. and Burtraw, D. (1999). 'The cost-effectiveness of alternative instruments for environmental protection in a second-best setting', *Journal of Public Economics*, **72**, pp. 329 – 360.

Goulder, L. H. and Parry, I. W. H. (2008). 'Instrument Choice in Environmental Policy', *Review of Environmental Economics and Policy*, **2**, pp. 152–174.

Goulder, L. H. and Schein, A. R. (2013). 'Carbon taxes versus cap and trade: A critical review', *Climate Change Economics*, **4**, pp. 1350010:1– 1350010:28.

Grossman, G. M. and Helpman, E. (1994). 'Protection for Sale', *The American Economic Review*, **84**, pp. 833–850.

Grossman, G. M. and Helpman, E. (2002). *Special Interest Politics*: The MIT Press.

Hanley, N. and MacKenzie, I. A. (2010). 'The Effects of Rent Seeking over Tradable Pollution Permits', *The B.E. Journal of Economic Analysis & Policy*, **10**, p. 56.

Hepburn, C., Grubb, M., Neuhoff, K., Matthes, F. and Tse, M. (2006). 'Auctioning of EU ETS phase II allowances: how and why?', *Climate Policy*, **6**, pp. 137–160.

Hoel, M. and Karp, L. (2001). 'Taxes and quotas for a stock pollutant with multiplicative uncertainty', *Journal of Public Economics*, **82**, pp. 91 – 114.

Hoel, M. and Karp, L. (2002). 'Taxes versus quotas for a stock pollutant', *Resource and Energy Economics*, **24**, pp. 367 – 384.

Krysiak, F. C. (2008). 'Prices vs. quantities: The effects on technology choice', *Journal of Public Economics*, **92**, pp. 1275 – 1287.

Lai, Y.-B. (2007). 'The optimal distribution of pollution rights in the presence of political distortions', *Environmental and Resource Economics*, **36**, pp. 367–388.

MacKenzie, I. A. and Ohndorf, M. (2012). 'Cap-and-trade, taxes, and distributional conflict', *Journal of Environmental Economics and Management*, **63**, pp. 51 – 65.

Malueg, D. A. and Yates, A. J. (2006). 'Citizen participation in pollution permit markets', *Journal of Environmental Economics and Management*, **51**, pp. 205 – 217.

Miyamoto, T. (2014). 'Taxes versus quotas in lobbying by a polluting industry with private information on abatement costs', *Resource and Energy Economics*, **38**, pp. 141 – 167.

Montero, J.-P. (2002). 'Prices versus quantities with incomplete enforcement', *Journal of Public Economics*, **85**, pp. 435 – 454.

Newell, R. G. and Pizer, W. A. (2003). 'Regulating stock externalities under uncertainty', *Journal of Environmental Economics and Management*, **45**, pp. 416 – 432.

Nordhaus, W. D. (2007). 'To Tax or Not to Tax: Alternative Approaches to Slowing Global Warming', *Review of Environmental Economics and Policy*, **1**, pp. 26–44.

Oates, W. E. and Portney, P. R. (2003). 'The political economy of environmental policy', In K.-G. Mäler and J. Vincent eds. *Handbook of Environmental Economics*, **1**: Elsevier, pp. 325–354.

Parry, I. W. (1995). 'Pollution Taxes and Revenue Recycling', *Journal of Environmental Economics and Management*, **29**, pp. S64 – S77.

Pizer, W. A. (2002). 'Combining price and quantity controls to mitigate global climate change', *Journal of Public Economics*, **85**, pp. 409 – 434.

Quirion, P. (2004). 'Prices versus Quantities in a Second-Best Setting', *Environmental and Resource Economics*, **29**, pp. 337–360.

Roberts, M. J. and Spence, M. (1976). 'Effluent charges and licenses under uncertainty', *Journal of Public Economics*, **5**, pp. 193 – 208.

Rohling, M. and Ohndorf, M. (2012). 'Prices vs. Quantities with fiscal cushioning', *Resource and Energy Economics*, **34**, pp. 169 – 187.

Schöb, R. (1996). 'Choosing the right instrument', *Environmental and Resource Economics*, **8**, pp. 399–416.

Stavins, R. N. (1996). 'Correlated Uncertainty and Policy Instrument Choice', *Journal of Environmental Economics and Management*, **30**, pp. 218 – 232.

Stavins, R. N. (1998). 'What Can We Learn from the Grand Policy Experiment? Lessons from SO2 Allowance Trading', *The Journal of Economic Perspectives*, **12**, pp. pp. 69–88.

Storrøsten, H. B. (2014). 'Prices Versus Quantities: Technology Choice, Uncertainty and Welfare', *Environmental and Resource Economics*, **59**, pp. 275–293.

Tullock, G. (1980). 'Efficient Rent Seeking', In J. M. Buchanan, R. D. Tollison and G. Tullock eds. *Toward a Theory of the Rent-Seeking Society*: Texas A&M University Press.

Weitzman, M. L. (1974). 'Prices vs. Quantities', *The Review of Economic Studies*, **41**, pp. 477–491.

Williams III, R. (2002). 'Prices vs. Quantities vs. Tradable Quantities', Working Paper 9283, National Bureau of Economic Research.

Wirl, F. (2012). 'Global warming: Prices versus quantities from a strategic point of view', *Journal of Environmental Economics and Management*, **64**, pp. 217 – 229.

Zapfel, P. (2007). 'A brief but lively chapter in EU climate policy: the Commission's perspective', In A. D. Ellerman, B. K. Buchner and C. Carraro eds. *Allocation in the European Emissions Trading Scheme: Rights, rent and fairness*: Cambridge University Press, Cambridge, UK, Chap. 2, pp. 13–38.