A Simple Model for Setting Environmental Policy vis-à-vis Concerns over Wealth Inequality: Whither the Fruits of Environmental Justice?

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Abstract:

As people have become wealthier from economic development, they have demanded that their government do more to improve environmental quality. Conspicuous growth in income inequality has also heightened policymakers' concerns for the poor. Because these two policy objectives do not always align, policymakers face some daunting trade-offs. This paper presents a theoretical model for exploring the consequences on efficiency and wealth inequality of our current environmental policymaking practices. We show that the wealthy will naturally outbid for locations with superior environmental quality and current policy practices for addressing environmental externalities can exacerbate that apparent lack of Environmental Justice (EJ). This regressiveness of environmental policy can become even more pronounced when policy is constrained to second-best outcomes. Even when policymakers strictly operate within [viscerally appealing] environmental justice constraints, apparent improvements in environmental policy can perversely have the unintended consequence of making the poor worse-off. This novel finding raises serious questions about current practices in environmental policymaking; we conclude with a brief discussion of possible solutions to this quandary (e.g. Environmental Federalism, compensating the poor through reductions in their tax burdens, etc…).

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I. Introduction

Centuries of economic growth have been fueled by developments in human ingenuity and expansions in the factors of production: capital via investing savings, labor via population growth, and natural resources via extracting raw materials and emitting waste. With effluence building up alongside our affluence, in accordance with the theory of the Environmental Kuznets Curve, many countries reached a tipping point in the last century and demanded that policymakers address the externalities generating the excess pollution.[1] In the 1970s, the United States Congress responded to public outcry by issuing a juggernaut of authorizations to protect the environment through regulation: the National Environmental Protection Act, the Clean Air Act, the Clean Water Act, the Safe Drinking Water Act, the Toxic Substances Control Act, the Resource Conservation and Recovery Act, and the Comprehensive Environmental Response, Compensation, and Liability Act. Since then, the federal government has issued a growing stream of environmental regulations in step with (or sometimes even surpassing) the economic growth that we have witnessed over the past 4 decades.[2] These regulations are not cost free, with costs routinely exceeding the government's $100M threshold of "economic significance" according to EPA's own economic analyses, but the public tends to accept that they must sacrifice some wealth in market goods or order to improve the environmental quality that we consume.

Although the economy has grown demonstrably over the past 40 years, these gains have not been evenly distributed across society; the 1960's war on poverty was no more successful than the war on Vietnam. As with all policy interventions, policies to reduce poverty are distortionary but the public also tends to accept those distortionary drags on economic efficiency as the cost of attaining something else they value: a more equitable distribution of wealth. Yet, As Piketty and Saez (2003) have documented, the rise in income inequality in the United States has accelerated since the 1980s. As awareness has been raised, so has public outcry, most dramatically in the throngs who occupied a park near Wall Street and decried the injustice of the gains of the top 1% dwarfing the stagnation of the bottom 99% of the income distribution. While policymakers mull over enhancing their current suite of poverty-fighting tools (e.g. education, the earned income tax credit, and our progressively structured income tax rates), community activists have continued their push for liberally expanding the set of instruments that the government employs in an attempt to rectify such injustices.

Advocates in the Environmental Justice (EJ) movement are among those who seek to retool environmental regulation to both protect the environment and the poor. As discussed in Mohai et al. (2009), EJ has its origins in grass roots movements that grew in response to the siting of polluting facilities near impoverished communities of color. Empirical documentation of this phenomenon at the national level dates back at least to a landmark series of studies in the 1990s on siting hazardous waste facilities (Hamilton and Viscusi 1999). Such empirical investigations into EJ continue to this day, such as a

[1] See Dinda (2004) for a survey of empirical studies and empirical models of Environmental Kuznets Curves.
[2] See Al-Ubaydli and McLaughlin (2012) for an empirical documentation of the recent growth of environmental regulations.

series of studies by Gray et al. (2010).[3] Banzhaf (2012) includes a thorough review of the literature correlating the colocation of pollution and EJ communities of concern, where several careful distinctions are made – most notably between the refusal of land owners to rent or sell to ethnic minorities of means due solely to the color of their skin, which is illegal discrimination based on race, versus the legal self-segregation of the poor (who are more likely to be ethnic minorities) into cheaper communities with lower environmental quality. In this paper, our focus is on the latter cause of correlation between EJ communities of concern and environmental quality. Of course, we economists are often relied upon to provide both an understanding of these problems underlying EJ concerns and insights into solutions to such problems. That includes our dismal duty of educating policymakers on trade-offs. Unfortunately, the laudable objectives of improving environmental quality and equity do not always align.

This paper is a theoretical exploration of the theoretical consequences on wealth inequality of our current practices in environmental policymaking. Many of our insights are not entirely new to the lines of literature on the environment as a public good, tensions between the policy objectives of the wealthy versus the poor, and the like; however, we are unaware of any other work that has brought all of these insights together, applied them to environmental policymaking as currently practiced with consideration for potential EJ constraints, and captured it all with such a simple model. Moreover, we believe that one of our contributions is entirely novel: we show that heedlessly grafting well-intended EJ constraints onto our current process for environmental policymaking can perversely produce unintended consequences – the poor can actually be made worse off.

That environmental policy can be regressive is not a new revelation, with warnings appearing as early as Dorfman (1977). Fullerton (2008) catalogs and evaluates no less than 6 different mechanisms that tend to make environmental policy regressive, 2 of which are at the heart of our modeling efforts.[4] From theoretical work by Ebert (2003), we know whether environmental policy is more or less regressive depends crucially on a couple features of preferences: how willingness to pay for environmental quality changes with income and how well market goods substitute for environmental quality. Both of these features similarly play an important role in our model.

More recently, Thomas (2012) argued that our major environmental regulations effectively redistribute resources from the poor to the wealthy, reflecting the policy preferences of the wealthy who can afford to utilize private markets to mitigate their more common risks but depend on the government's economies of scale to affordably mitigate rarer risks. Unlike in Fullerton (2008), the explanation in Thomas (2012) for regressivity implicitly assumes that there is some bias in the policymaking process

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[3] Gray et al. (2010) is the latest EJ study in the series, which interestingly finds no evidence for EJ concerns with the enforcement of environmental regulations being more lax in communities of concern.

[4] Fullerton (2009) lists: the poor spend a greater fraction of their income on polluting goods (e.g. fuel), abatement technologies are capital-intensive which may lower wage rates for low-skilled labor, valuable scarcity rents (in the form of pollution permits) are often gifted to politically powerful opponents of environmental policy, the poor may value environmental quality less than necessities (food, clothing, shelter), the wealthy reap the most benefits from pollution abatement, the poor tend to not benefit from housing price capitalization due to environmental quality improvements because they tend to be renters, and they are more likely to be unemployed who can feel the brunt of transition effects.

itself that favors the wealthy. This insight is shared with our model, which builds on it. The process of environmental policymaking has been a focus of other researchers too. In their thorough review of the role of Cost-Benefit Analysis (CBA) in environmental policymaking, Atkinson and Mourato (2008) provide a bevy of criticisms which include concerns over the handling of distributional effects. Even the apologists for CBA are aware of these qualms. Frank (2002), an apologist for CBA, distills the challenge that distributional effects present to CBA-based policymaking into 3 issues: how CBA gives the wealthy greater weight, how the poor become worse off in practice without compensation, and how individuals may actually have preferences over the distribution (i.e. where they appear in that distribution relative to both the top and their peers). In our model, we explicitly deal with the first 2 of these 3 issues and hope to bring some clarity to point.[5]

The remainder of this paper is organized as follows. Section II presents the basic model with first-best outcomes. Section III explores the model when complicating constraints of the real world reduces results to second-best outcomes. Section IV concludes with a summary, discussion of alternative modeling assumptions, and some policy implications.

II. Model

Consider a population with individual j having preferences over market goods (m) and the environmental quality of their location (q_k), which is captured with a well-behaved utility function:[6]

$$U(q_k, m)$$

Note that we have narrowly defined these preferences to the individual's own consumption and restricted them to be shared by all in the population, simplifying the analysis by moving the focus away from heterogeneity in tastes and the potential for irreconcilable differences in opinions over fair policy. Naturally, environmental quality should be multidimensional, just as there is a myriad of marketed goods; so q and m can each been seen as a composite, e.g. a bundle of market goods, which conveniently requires homogeneous preferences to be valid (see Sieg, Smith, Banzhaf, and Walsh 2002). We have tied environmental quality to location with all in the same location sharing that same environmental quality. Given m, we can denote the willingness to pay (in terms of market goods) of individual j in location k for a higher level of environmental quality in some other location (i) as:

$$U(q_i, m - WTP) = U(q_k, m)$$

Which defines willingness to pay (WTP) as an implicit function:

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[5] In the conclusion, we speculate about the effect of altering our model to accommodate the third of the issues. Because preferences over the distribution of welfare complicate models immensely (in ways that are difficult to theoretically separate or empirically identify), we forego an explicit consideration that would have defeated one of our purposes (to present this collection of important ideas in a simple model).

[6] Well-behaved here includes the common assumptions made on utility functions, like monotonicity and concavity.

$$WTP(q_i; q_k, m)$$

We further assume that environmental quality is a normal good: the willingness to pay for an increase in q is increasing in the individual's ability to pay. The quantity of market goods consumed is determined by the amount of individual j's resources left over after paying for location k:

$$m_{jk} = M_j - [c_k + t_k]$$

Where M_j is the income (endowment) of individual j, c_k is the pre-tax cost to individual j of locating in k, and t_k is the tax burden in location k. Embedded in this implicit budget constraint are two standard assumptions: the price of m_{jk} is 1 and each individual must consume exactly 1 unit of housing from 1 of the K locations. This model seems to lack explicit within-location heterogeneity in housing prices, which we are accustomed to seeing in housing data; however, the price of housing can be seen as both the cost of the location and the various housing characteristics which we have relegated to the bundle of market goods. Let the heterogeneity in the income endowment be given by two types:

$$M_j = \begin{cases} \overline{M} & j \in W \\ \underline{M} & j \in P \end{cases}$$

Where $\overline{M} > \underline{M}$, W is the set of (relatively) wealthy individuals, and P is the set of (relatively) poor individuals. Although this model could easily accommodate a much richer typespace, 2 income types is sufficient to illustrate our findings. Likewise, although this model could easily accommodate a much richer typespace, K = 2 is also sufficient to illustrate our findings.

A. Tiebout-sorted Locational Equilibrium

With preferences and budget constraint specified, we have fully specified the inputs needed to characterize the demand side of the market for housing locations. Abstracting away from the option of supplying denser development (e.g. subdividing parcels, converting green space to built environment, building upward, etc…), we invoke the common assumption of absentee landlords offering a fixed supply of land in each location (S_1 and S_2) so that the supply for housing locations is inelastic. We acknowledge that it would be more realistic to have a mixture of owner-occupied housing and renters occupying the rest of the housing, some of which is locally owned and some of which is owned by absentee landlords.[7] Unfortunately, this would greatly complicate the typespace – individuals would differ not just by their income endowment but also by housing endowment. Realistically, that housing endowment would be a large portfolio for some wealthy individuals but empty for most of the poor individuals. Some poor individuals might be fortunate enough to own a home in a great location and policy interventions can have interesting consequences on their decisions. Yet, even in this more

[7] According to the US Census Bureau, home ownership in the United States varies between 50% and 80% (depending on the state and the year). See Table 993 in the U.S. Census Bureau's "Housing Vacancies and Home Ownership" available at <http://www.census.gov/hhes/www/hvs.html>.

realistic setup, any housing endowment gets converted into the wealth endowment at the market price and individuals select their location just like renters but with that (possibly) larger endowment. Thus, we are fairly confident the results that we have presented here would apply to that more general model.[8]

We assume that the measure of housing supplied equals the measure of individuals so that markets clear nicely:

$$\mu(W) + \mu(P) = \mu(S_1) + \mu(S_2)$$

Where S_k is the supply of housing in location k and μ() is an operator that returns the measure of the set. In the real word, μ(P) tends to be considerably larger than μ(W), depending on where on draws the line.

Prior to introducing any interventions in environmental quality, we set the tax burden in the two locations to some baseline (i.e. $t_1 = t_2 = \underline{T}$) and assume away the relevance of the revenue raised from that baseline tax burden (e.g. it is spent on something that would enter an individuals' utility in a way that is entirely separable from the market goods and environmental quality that are the focus of this study). Without a loss of generality, beyond ruling out multiple equilibria (when individuals are indifferent between the two locations with the same quality and cost), we assume that location 1 has higher ex ante environmental quality (i.e. $Q_1 = \overline{Q} > \underline{Q} = Q_2$) due to natural geographic features.

Proposition 1. This locational equilibrium is Tiebout-sorted, which is an EJ concern but Pareto-efficient, with the location having higher [ex ante] environmental quality filled with as many wealthy households as it can hold and the poor then housed in the leftovers.

Proof: *Because this model is so similar to the general model of Nechyba (1997a), the proof of these equilibrium characteristics follows a similar line of argument. In order for a poor individual to reside in location 1, then they must be no worse off:* $WTP\left(\overline{Q}, \underline{Q}, \underline{M}\right) \geq c_1 - c_2$*. In order for a wealthy individual to reside in location 2, then then they must be no worse off:* $WTP\left(\overline{Q}, \underline{Q}, \overline{M}\right) \leq c_1 - c_2$*.Applying transitivity, this implies that* $WTP\left(\overline{Q}, \underline{Q}, \underline{M}\right) \geq WTP\left(\overline{Q}, \underline{Q}, \overline{M}\right)$*, which contradicts the assumption that environmental quality is a normal good. Hence, the poor only live in location 1 when none of the wealthy reside in location 2. Coupling this with market-clearing, location 1 will be filled with as many wealthy individuals as it can hold and the poor are then housed in the leftover housing supply. Because none of the premises of the First Fundamental Theorem of Welfare Economics are violated in the model setup so*

[8] Nechyba (1997a) has proven that the market's equilibrium assignment of individuals to locations is Tiebout sorted for a fairly general model, similar to our setup except that each individual is initially endowed with a home. This contrasts with the locational equilibrium models related to Epple, Filimon, and Romer (1993), where a Tiebout sorting equilibrium is achieved by invoking a single-crossing assumption on preferences and an assumption of absentee landlords to avoid their wealth effects. Nechyba (1997a) goes to great lengths to show that normality of public goods is sufficient in this sort of modeling, without any absentee landlord assumption required. We have built on that framework by invoking the same assumption of normal public goods but have also made the convenient (albeit unnecessary) assumption of absentee landlords.

far, this equilibrium sorting of types across locations is Pareto-efficient. Consider relocating a poor individual from location 2 to location 1, then supply constraints imply that someone would also have to be relocated from location 1 to location 2 – trading places. In order for the poor individual to be no worse off when relocated to location 1, the after-tax cost of location 1 must be sufficiently low for the wealthy individual to be strictly better off in location 1 – implying that relocating a wealthy individual to location 2 makes them worse off (and relocating a poor individual to location 2 is not a Pareto improvement because poor individuals living in both location 1 and 2 implies indifference).

The model need not have a strict stratification of individuals across locations (i.e. two different types do not reside in the same location) but it can be mathematically convenient, as in Nechyba (1997b); hence, we also invoke the assumption that the size (measure) of housing supply in the location with higher environmental quality exactly equals the number (measure) of individuals in the wealthier type:

$$\mu(W) = \mu(S_1)$$
$$\mu(P) = \mu(S_2)$$

Because this is a separating equilibrium, where the chosen location is the signal of the individual's type, the values of c_k are bound by the standard constraints (rationality and incentive compatibility, as in Mas-Colell, Whinston, and Green 1995):

$$WTP\left(\overline{Q}, \underline{Q}, \overline{M}\right) \geq c_1 - c_2$$
$$c_1 - c_2 \geq WTP\left(\overline{Q}, \underline{Q}, \underline{M}\right)$$
$$\underline{M} - \underline{T} > c_2 \geq \underline{C}$$

Where $\underline{C}$ is the actual cost to the landlords of supplying a unit of housing. These bounds effectively identify the potential surplus that is split between the individuals purchasing housing and the inelastic landlords supplying the housing locations. Because any surplus captured by absentee landlords leaks wealth out of the local economy, unlike with local owners, we additionally assume that the absentee landlords capture none of the surplus (including any additional surplus generated by improvements in environmental quality). This pins housing prices down to their lower bound:

$$\begin{aligned} c_1 &= WTP\left(\overline{Q}, \underline{Q}, \underline{M}\right) \\ c_2 &= \underline{C} \end{aligned}$$

B. Pareto Optimality of Local Policy Intervention

We now consider that environmental quality can be improved by expending some market goods (or, equivalently, foregoing some income). Let the production function for ex post environmental quality be given by an enhancement, denoted by g() as a reminder that environmental quality here is a public good, over the ex ante environmental quality:[9]

$$q_k = Q_k + g\big(\mu(S_k) \times [t_k - \underline{T}]\big)$$

Where $\mu(S_k) \times [t_k - \underline{T}]$ is the sum total of the additional expenditure on environmental quality by individuals in location k. Note that the endogeneity of environmental quality does not fundamentally change the locational equilibrium because individuals sort across locations by their willingness to pay for public goods and all share the same well-behaved production function to increase their ex ante environmental quality. Hence, we can treat the individual's equilibrium location as given. If expenditure on environmental quality is the result of the voluntary contributions, then the best response (t) of individual j [of measure $\mu(j)$] given the total contributions (T) made by others [of measure $\mu(S_k)$- $\mu(j)$] is:

$$\underset{t}{\operatorname{argmax}}\, U\big(Q_k + g\big(T + \mu(j)t - \mu(S_k)\underline{T}\big), m_j - [c_k + t]\big)$$

Because all individuals in k are identical, it is fairly straightforward to find the optimal local policy intervention as:

$$\underset{t_k}{\operatorname{argmax}}\, U\big(Q_k + g\big(\mu(S_k)[t_k - \underline{T}]\big), m_j - [c_k + t_k]\big)$$

Proposition 2. A Policy Intervention on Environmental Quality at the local level is a Pareto improvement over voluntary contributions but may exacerbate EJ concerns.

Proof: *This is an example of the classic under-provision of public goods (environmental quality) due to free-riding, which can be easily shown with a bit of calculus. The best response of individual j is found by comparing the marginal benefit (additional utility from individual j's contribution toward increasing the public good) of t to its marginal cost (foregone consumption of market goods). Marginal benefit is given by* $U_1\big(Q_k + g\big(T + \mu(j)t - \mu(S_k)\underline{T}\big), m_j - [c_k + t]\big)g'(T + \mu(j)t) \times \mu(j)$*, which is increasing but decreasing; the positive and increasing marginal cost is given by* $U_2(\cdot)$*. The symmetric Nash Equilibrium can be found by substituting the symmetry condition,* $T = [\mu(S_k) - \mu(j)]t$*, into the expression for marginal benefit to yield* $U_1\big(Q_k + g\big(\mu(S_k)[t - \underline{T}]\big), m_j - [c_k + t]\big)g'\big(\mu(S_k)[t - \underline{T}]\big) \times \mu(j)$*. If each individual j is truly atomistic, i.e.* $\mu(j) = 0$*, then each individual will see their contribution as entirely negligible and will free-ride in the extreme to the corner solution of* $t = \underline{T}$*. The optimality condition for a policy intervention has the same marginal cost but marginal benefit is now the product of the marginal utility of the public good and the marginal product of all contributions, scaled up by the measure of all individuals at that location:* $U_1(\cdot)g'\big(\mu(S_k)[t_k - \underline{T}]\big) \times \mu(j)$*. Therefore the policy intervention will set a higher level of* t_k*, resulting in a higher level of environmental quality than voluntary contributions. That it is a Pareto improvement can be verified by substituting the expression for t back into individual j's*

[9] We assume that g() is well-behaved, which includes monotonic and concave.

objective. Note that because policy is made at the local level and the location with higher ex ante environmental quality also has more resources to dedicate to environmental improvement, policy interventions on environmental quality at the local level exacerbates EJ concerns.

III. Results

In the previous section, we developed our basic model and established a couple of its important characteristics: that the locational equilibrium produces a Pareto-efficient Tiebout sorting of EJ concern and that an environmental policy intervention at the local level is Pareto improving but may even exacerbate the EJ concern. These properties reinforce the common conception of a trade-off between EJ and the Pareto-efficiency delivered by the market and standard environmental policy interventions. However, constraints can change this calculus. We identify 3 such constraints in this section and explore their effects.

A. Environmental Quality Crosses Borders

An implicit assumption in the preceding section was that environmental quality in one location is completely independent of the environmental quality in the other. In reality, the natural environment is a complex and interconnected system that results in environmental quality crossing jurisdictional borders. We can represent this as a binding constraint on the ex post environmental quality production functions as a reduced-form of some quasi-fate/transport function, f():

$$q_k = f\left(q_{-k}, Q_k + g\big(\mu(S_k) \times [t_k - \underline{T}]\big)\right)$$

Where q_{-k} is the environmental quality in the locations other than k.[10] This coupling of environmental quality creates another Pareto-inefficient externality, where the free-riding is between locations setting local environmental policy instead of the free-riding voluntary contributions within locations. Of course, with just two locations, centralized environmental policy may not be necessary because the two locations should be able to reach a Coasian bargain without hurdling too many bargaining impediments. However, one can easily imagine a more realist setting where this model is extended to a multitude of locations where a reasonably structured bargaining framework has no equilibria (i.e. bargaining is too costly). Nonetheless, we can use the Coasian bargain setup to show that one location would be willing to pay the other to further improve its environmental quality relative to when its policy intervention ignores the neighbor, which implies that a Pareto improvement is possible. The optimal policy intervention for location k, given a Coasian payment from the neighboring location:

[10] We could subscript the quasi-fate/transport function to indicate that it may not be symmetric – a symmetric f equal to the simple average of its two arguments would represent uniform mixing (such as with global air pollution) and a departure from that would represent differentiated mixing (such as with local air pollution where prevailing winds result in upwind and downwind locations).

$$\underset{t}{\operatorname{argmax}}\, U\left(q_k, m_j - [c_k + t] + \frac{\mu(S_{-k})WTP(q_k, Q_{-k}, m_i)}{\mu(S_k)}\right) \Bigg| \; q_k = f\left(q_{-k}, Q_k + g\big(\mu(S_k) \times [t_k - \underline{T}]\big)\right)$$

Where the additional term in the second argument of the utility function is the share of the Coasian payment accruing to individual j.[11] Without that term, we get the optimal policy intervention for location k, ignoring the spillover to the neighboring location:

$$\underset{t}{\operatorname{argmax}} U\big(q_k, m_j - [c_k + t]\big) \mid q_k = f\left(q_{-k}, Q_k + g\big(\mu(S_k) \times [t_k - \underline{T}]\big)\right)$$

Proposition 3. Without centralized environmental policy, the outcome is Pareto inefficient and may exacerbate EJ concerns.

Proof: *This argument is quite similar to that used to prove Proposition 2. The optimal policy intervention when ignoring the spillover is implicitly defined by the same marginal cost and marginal benefit terms for the optimal policy intervention in Proposition 3, except that the function for transforming taxes into environmental improvement is more complicated – g() is nested inside of f() and hence the factors of marginal benefit will additionally be scaled by $f_2() > 0$. Accounting for spillovers adds an additional term to the expression for marginal benefit – the additional market goods from the Coasian payment [transformed into utility by $U_2()$]. EJ concerns are due to the poor not fully harnessing the wealthy's self-interest in spending additional market resources on improving the environmental quality of the poor.*

Taken together, Proposition 2 and 3 provide a rationale for the Environmental Federalism advocated by Oates (2002) – environmental policy should be made at the lowest level of government that has full jurisdiction over the extent of the externality's scope but no lower. For the remainder of this section, we shall return to the simplifying assumption from earlier that environmental quality is not coupled across locations.

B. Uniformity Constraints in Environmental Quality Improvement

Concerns over fairness have sometimes caused legislatures to codify uniformity constraints in environmental policy so that all jurisdictions have the same improvements, which can be represented in this model as equal burdens:

$$t_k = t_{-k}$$

Because the policy intervention is the same at all jurisdictions, it must be made at the higher level of government (i.e. the central government). Up to this point, we have eschewed from specifying how policy would be made over a population where individuals had competing preferences – we have only

[11] Note that the definition of the function for WTP has been altered slightly from where it is first introduced in this paper because now it is the WTP to improve the neighboring location's environmental quality.

considered local policy given within-location homogeneity due to Tiebout sorting. With competing preferences, economists tend to fall back on the Pareto Criterion because Pareto improvements are so unobjectionable – a Pareto-improving policy intervention (compared in isolation to the status quo) should receive unanimous support in a society with a modicum of good will. In practice, cost-benefit analysis (CBA) remains the primary tool for identifying whether a proposed policy intervention represents a Pareto improvement.

In theory, CBA works by simulating a market. Benefits are computed by aggregating up the maximum willingness to pay for each individual who stands to benefit from the proposed policy intervention. Costs are computed by aggregating up the cost to each individual who stands to lose from the proposed policy intervention – the cost to them is their minimum willingness to accept. This minimum willingness to accept is the reservation price of the seller and this maximum willingness to pay is the inverse demand of the buyer; thus, the finding that a proposed policy intervention is cost-beneficial is equivalent to hypothetically assigning a right to the status quo to the losers and them selling that right to those who stand to gain in a market (if transactions costs were sufficiently low for that market to exist).

In practice, when a proposed policy intervention passes a CBA, it then gets implemented but the losers are rarely (if ever) compensated. Although such compensation schemes can present a plethora of rent seeking complications, that compensation is necessary in order for the policy intervention to yield a Pareto improvement. Taking a property right from a seller in a market without compensating the seller constitutes theft, which among other things, is bad because it makes the seller worse off. The practice of not compensating the losers has been justified by the depression-era work of Kaldor (1939) and Hicks (1939). The basic rationale is that the uncompensated losses should average out across policy interventions, with any remaining balance rectified with income taxation policy (i.e. using policies as close to lump-sum transfers as possible). Decades of research in public choice theory, such as in Buchanan (1987), draws such rosey assumptions into question.

The political economy problem with the rationale for Kaldor-Hicks CBA is that the averaging out of uncompensated losses is far less likely when the agenda of proposed policy interventions is not set purely at random; likewise, income taxation policy is also heavily influenced by the lobbying of interest groups. Any conventional model of interest group lobbying, such as Persson and Tabellini (2000), will predict that interest groups with superior resources will tilt the agenda in their favor. Rather than graft a full-blown lobbying model as a layer on top of our otherwise parsimonious model, we simply take it for granted that the wealthy will wield a disproportionate influence – where disproportionate is relative to their head count, implying that the preferred policy intervention of the median voter is proportionate (in our model, the median voter is poor due to our assumption that $\mu(P) > \mu(W)$).

Proposition 4. Given that the wealthy set the policymaking agenda, successive rounds of implementing environmental policy justified by Kaldor-Hicks CBA makes the poor worse off (i.e. does not generate Pareto improvements) by ratcheting upwards environmental quality to levels that are in excess of the levels that the poor deem optimal for their resources.

Proof: *Suppose that we begin with the ex ante levels of environmental quality (Q_k) so that $t_k = 0$ $\forall k$. If the wealthy begin by setting a policymaking agenda at t_P^*, i.e. the level of environmental policy intervention favored by the poor as described in Proposition 2, then that easily passes a CBA by unanimity – the wealthy's preferred level of policy intervention is even higher ($t_W^* > t_P^*$). Beyond that level, any Kaldor-Hicks improvement in environmental quality would make the wealthy better off at the expense of making the poor worse off. Yet, a Kaldor-Hicks CBA would pass any candidate intervention (uniquely identified by the value of t) where the aggregate benefits exceed the aggregate costs:*

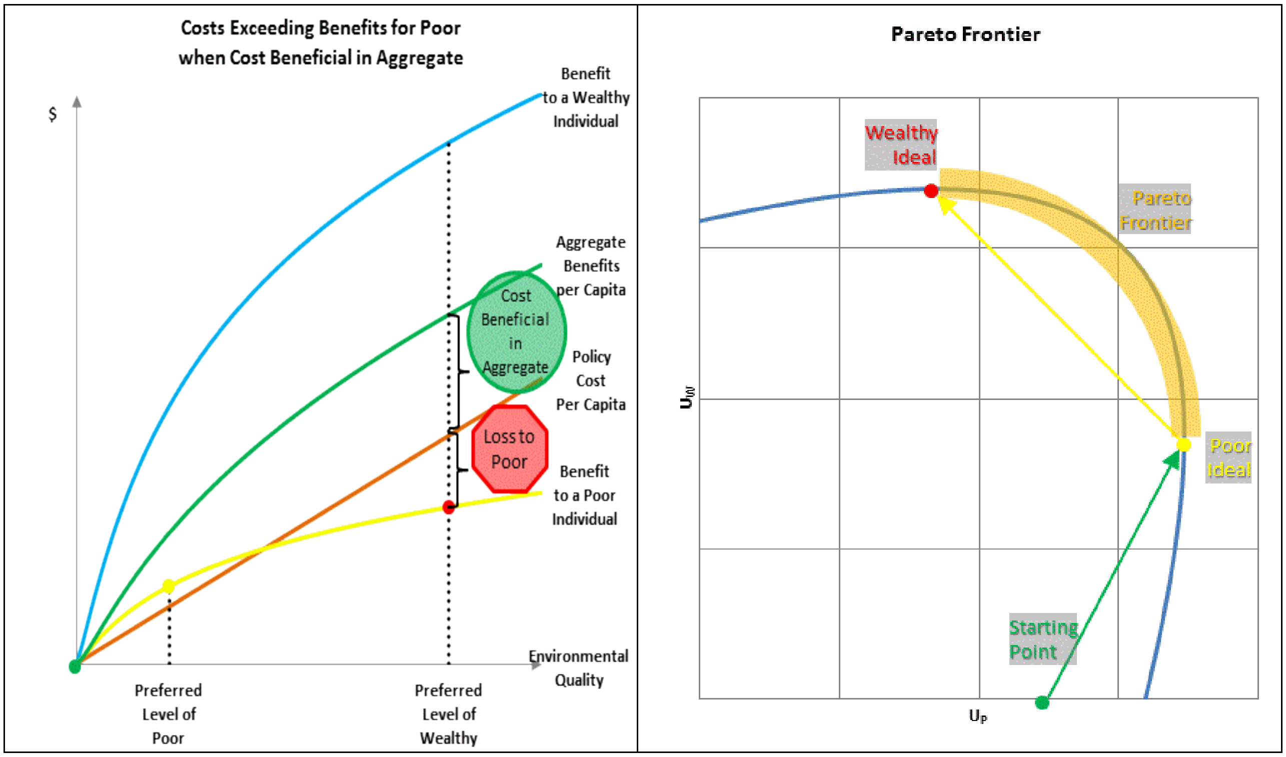
$$\mu(W)\left[WTP\left(Q_1 + g\left(\mu(W)\left[t - \underline{T}\right]\right), \overline{M} - [c_1 + t_P^*]\right) - (t - t_P^*)\right] \\ \geq \mu(P)\left[WTA = (t - t_P^*) - WTP\left(Q_2 + g\left(\mu(P)\left[t - \underline{T}\right]\right), \underline{M} - [c_2 + t_P^*]\right)\right]$$

Algebraic manipulation shows that a sufficient condition for passing a Kaldor-Hicks CBA is $t \in (0, t_A^*)$, where $t_A^* > t_P^*$ is the highest value of t that could support a Pareto improvement in aggregate (with transfers):

$$\left[\frac{\mu(W)}{\mu(W) + \mu(P)}\right] WTP\left(Q_1 + g\left(\mu(W)\left[t_A^* - \underline{T}\right]\right), \overline{M} - [c_1 + t_P^*]\right) \\ + \left[\frac{\mu(P)}{\mu(W) + \mu(P)}\right] WTP\left(Q_2 + g\left(\mu(P)\left[t_A^* - \underline{T}\right]\right), \underline{M} - [c_2 + t_P^*]\right) = t_A^* - t_P^*$$

Note that the left hand side is the average willingness to pay, which is the reason for choosing A as the subscript for t's maximum supportable value, t_A^*. Whether t_A^* exceeds t_W^* depends on whether the gains to the wealthy in route to their optimum (t_W^*) would be sufficient to offset the losses of the poor, which in turn depends on parameters such as the size of these groups and their wealth.

This result resonates with a growing complaint that recently proposed environmental policy interventions (such as a climate change policy) would sacrifice more economic wealth than many are willing to pay, which should be particularly problematic for the poor. The age-old problem is amplified by the growing gap in wealth between the wealthy and poor. Although this finding is fairly simple and intuitive, its policy implications are no less profound. The following diagram encapsulates why using Kaldor-Hicks CBA leads to problematic outcomes when the wealthy set the agenda of proposed policy interventions:



C. Uniformity Constraints in Ex Post Environmental Quality

Concerns over fairness have sometimes driven EJ advocates to call for equal environmental outcomes for the poor. The resulting constraint takes the following form:

$$q_k = q_{-k}$$

Not only does this constraint fail to reach Pareto efficiency, we can show that it can have unintended consequences that perversely make the poor worse off.

Proposition 5. Uniformity Constraints in Environmental Quality may be Pareto inefficient and result in lower welfare for the poor.

Proof: *In this model, it is trivial to show that this equal environmental outcomes constraint is infeasible for broad subspaces of the combination of endowments of market goods g() and Q_k, which need not be unrealistic; when one must move mountains, pipe in water bodies, and replace ecosystem services then equating environmental quality across all locations is clearly beyond our production possibilities frontier. Even when it is feasible for the poor location to attain the same level of environmental quality, then this constraint makes individuals worse off than the constraint of equal improvements – either the poor must attain levels of environmental quality in excess of what they have deemed as optimal for their resources, the wealthy are forced to attain levels of environmental quality beneath what is optimal for them, or* *both. Except in the extreme case when the wealthy adopt the level of environmental quality that the poor find optimal, the poor are made worse off by this constraint. When environmental quality is a poor substitute for market goods, then this burden on the poor is even worse – near perfect complements implies that even small improvements in environmental quality to match the wealthy can have catastrophic impacts on the welfare of the poor.*

For EJ advocates, the ultimate focus should be on the welfare of the poor instead of an argument that enters their utility function. Although it may sound like a tautology, the primary problem for the poor is that they are poor – not that they have low environmental quality. Low environmental quality is the consequence of few resources, not the cause. If the wealthy financed the environmental improvements for the poor so that both had equal outcomes, then clearly the poor would be better off but the pivotal factor is the implicit transfer of wealth from wealthy to poor. If environmental quality is weak substitute for market goods, then it would be much more cost-effective for the wealthy to just transfer some market goods to the poor instead of using a weaker policy instrument to make them better off by improving their environmental quality.[12]

IV. Conclusion

We have presented a simple model that illustrates a collection of concerns that other economists have raised about the equity effects of current practices in environmental policymaking. We have shown that individuals will be Tiebout sorted into locations with the wealthy enjoying superior environmental quality. We should note that Tiebout sorting over environmental quality is not just a theoretical possibility; Banzhaf and Walsh (2008) have found compelling evidence that the environmental quality of a location is a consideration when individuals choose their location. This apparent lack of EJ can become even more pronounced when well-intentioned policy is regressive and/or constrained to second-best outcomes. Even when policymakers strictly operate within [viscerally appealing] EJ constraints, an unintended consequence can be that the poor are made worse-off. As with any theoretical model, these findings are proved with propositions that follow logically from the assumptions; hence, a sufficient alteration of the assumptions can greatly affect the qualitative findings. We hope that our assumptions appear fairly reasonable; however, we can also speculate about the effects of adopting alternative assumptions that also seem to be reasonable.

In this model, we have implicitly assumed that all revenue raised for improving environmental quality is constrained to be spent in the location where it is raised. Yet the United States' federal government is subject to no such constraint. If that constraint were relaxed in the model, then it might be possible to improve environmental quality in impoverished locations using funds raised elsewhere without making

[12] It is noteworthy that the importance of substitutability has been made in a closely related context: Hanemann (1991) argues that not only can an individual's willingness to accept (WTA) in exchange for selling some right to environmental quality be larger than their willingness to pay (WTP) to acquire such a right due to the fact that WTP is bounded by income whereas WTA is not, but we should expect them to diverge when the market goods used as compensation are poor substitutes to environmental quality.

their residents worse off. However, this would represent a pure transfer from wealthy to poor and the agenda-setting wealthy has no incentive to engage in such behavior. This begs the question as to why we didn't allow individuals to have preferences over equity; preferences over the distribution of outcomes are, by definition, interdependent and that can greatly complicate theoretical models beyond the scope of our objective in constructing this study. Nonetheless, we hypothesize that the combination of agenda setting and Kaldor-Hicks CBA would still lead to the wealthy's ideal outcome but that ideal would be more equitable; depending on how the preferences are constructed, the poor's ideal might be nearly unchanged if altruism is a luxury good. If the wealthy did care about the poor, the most direct means of enhancing their welfare would be through a direct transfer of market goods that the poor could freely use in whatever way is optimal for them (with the bulk spent on food, clothing, and shelter but perhaps some spent on environmental quality). One might wonder if the poor's revealed preferences are clouded by poor information on public health risks. This might justify an environmental policy intervention, or at least a public information campaign.

Indeed, many environmental problems can involve complicated science and thus raise the costs to individuals of updating their beliefs with better information. The poor could attempt to mimic the wealthy but that is more difficult when Tiebout sorting results in them inhabiting separated locales. Once again, public information and education might be in order. With a high fixed cost component but a low variable cost component, there are significant economies of scales in ingesting and disseminating information on how environmental quality affects public health. As shown in Banzhaf and Chupp (2012), economies of scale in the improvement of environmental quality (broadly defined to include information) can tip the scale away from fiscal federalism toward federal action. This importance of scale economies is somewhat disappointing because Environmental Federalism is an attractive policy option, particularly for those who already favor devolution of government to a more local level. Yet environmental federalism is not a panacea.

As we have shown, when pollutants cross borders then a local government does not have sufficient jurisdiction to adequately address the externality. The second-best solution may be for the wealthy to compensate the poor in the form of some kind of relief from the poor's tax burden (such as the Earned Income Tax Credit, a reduction in Social Security payroll taxes, or trying to make income taxation even more progressive). Global climate change from greenhouse gas emissions makes a nice exemplar here – carbon policy should be set at the highest level of government and is widely expected to be regressive.[13] Moreover, there is some evidence (Cai et al. 2007) that individuals' willingness to pay for carbon policy depends on how regressive that carbon policy might be, suggesting that individuals may well prefer equitable outcomes (at least in the realm of climate change policy). Levying a carbon tax might pass an aggregate CBA if the willingness to pay of a wealthy constituency is sufficiently high but still make the poor worse-off. Whatever sort of policy intervention we ultimately adopt for climate change, it is likely to be both more efficient and more just if it is built on cutting-edge tools in new or reformed environmental laws (designed for this purpose) instead of the holdovers from the 1970s.

[13] There is some debate between researchers as to how regressive carbon policy might be. See Rausch et al (2011) for a careful analysis of the distributional effects.

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