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Batabyal, Amitrajeet and Beladi, Hamid

Rochester Institute of Technology, University of Texas at San
Antonio

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A Political Economy Model of the Ganges Pollution Cleanup Problem¹

by

AMITRAJEET A. BATABYAL²

and

HAMID BELADI³

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²

Department of Economics, Rochester Institute of Technology, 92 Lomb Memorial Drive, Rochester, NY 14623-5604, USA. Internet aabgsh@rit.edu

³

Department of Economics, University of Texas at San Antonio, One UTSA Circle, San Antonio, TX 78249-0631, USA. Internet Hamid.Beladi@utsa.edu

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Problem

Abstract

We study pollution cleanup in the Ganges in Varanasi, India. Voters elect politicians and elected politicians decide how much pollution to clean up. Between the two time periods, there is an election. Politicians are sincere or insincere. The marginal cost of public funds ζ measures how efficiently elected politicians transform tax receipts into pollution cleanup. Voters have identical per period utility functions. We ascertain the equilibrium outcome and per period voter welfare. Second, we show that an increase in ζ reduces the equilibrium pollution cleanup and voter welfare. Third, an insincere politician can delay the revelation of his insincerity. We show that a critical value of ζ, ζ^* , exists such that the insincere incumbent separates and loses the election if and only if $\zeta > \zeta^*$ and that he pools and is re-elected otherwise. Finally, we note that an increase in ζ can raise voter welfare when politicians are more likely to be insincere.

Keywords: Ganges River, Politician, Pollution Cleanup, Uncertainty, Voting

JEL Codes: D72, Q52

Recommendations for Resource Managers

1. Successful cleanup policies depend on whether elected politicians are sincere or insincere about pollution cleanup.
2. When cleanup is publically financed, the marginal cost of public funds greatly influences how much pollution is cleaned up.
3. In some circumstances, insincere politician can get elected and do very little to clean up pollution.

1. Introduction

The Ganges (Ganga in Hindi) river is the longest river in India. In addition, this river occupies a central place in the Hindu religion. As noted by Hammer (2007) and Conaway (2015), Hindus generally consider the Ganges to be sacred. As such, millions of them standardly visit the holy city of Varanasi in the state of Uttar Pradesh to perform a purification ritual that involves, among other things, bathing in the river. The city of Varanasi is significant not only for what Rinschede (1992) calls “religious tourism,” but also because it is one of the oldest inhabited cities in the world. Alley (1992), Chitravanshi (2014), and Conaway (2015) point out that in contemporary times, in addition to being a major center for both domestic and foreign tourists, Varanasi is also prominent for its art, culture, and music.

Unfortunately, as noted by Markandya and Murty (2004) and others, the single feature of the Ganges that now generates the greatest amount of news relates to its extremely polluted status. Black (2016) points out that millions of gallons of industrial pollutants and raw sewage drain into the Ganges every day. In addition, in Varanasi, one can find animal carcasses, partially cremated corpses, and the material offerings of Hindu devotees in the river. In this regard, Dhillon (2014) contends that 32,000 bodies are cremated every year in Varanasi and that this process results in 300 tons of ash and 200 tons of half burnt human flesh being deposited into the Ganges. Given this extremely insalubrious state of the river, there is global concern about whether the Ganges can continue to provide water to and more generally support ten percent of the world’s population (Conaway 2015). In addition, Batabyal and Beladi (2017, 2019) and Xing and Batabyal (2019) point out that questions are now also being asked about the sustainability of the tourism industry in Varanasi.

Markandya and Murty (2000), Conaway (2015), and Black (2016) tell us that the first

serious attempt to clean the Ganges began in 1986 when Prime Minister Rajiv Gandhi launched the so called “Ganga Action Plan.” Despite his good intentions, cleaning efforts were haphazard and therefore the Plan accomplished little. In 1993, Prime Minister P.V. Narasimha Rao supplemented the efforts of his predecessor by adding many water treatment plants and other pollution abatement projects. These actions were followed up in 2009 by the creation of the “National Ganga River Basin Authority” by Prime Minister Manmohan Singh. It is fair to say that all of these initiatives undertaken by the politicians named above have, at best, enjoyed partial success. Hence, there has been *no* dramatic change in the cleanliness of the water in the Ganges in key locations such as the city of Varanasi.

That said, the Ganges now appears to have a champion in a new politician and that politician is Mr. Narendra Modi. Mr. Modi is a devout Hindu and also the current Prime Minister of India. In fact, Mr. Modi’s Bharatiya Janata Party (BJP) recently won a second five-year term in the 2019 national elections⁴ and it is important to understand that his parliamentary constituency in 2014---the earlier year in which a national election was held---and in 2019 was Varanasi. Therefore, it is perhaps not surprising to note that Mr. Modi has launched an ambitious plan to clean the Ganges---the so called “Namami Gange Project”---and that he has also promised to convert Varanasi into a vibrant city for religious and other tourists.

Despite the specific significance of Prime Minister Modi’s project from both environmental and touristic perspectives and the more general salience of the interaction between voters and elected politicians in determining how much pollution in the Ganges is actually cleaned up, to the best of our knowledge, there are *no* studies in the extant literature that analyze the Ganges pollution

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See Gettleman *et al.* (2019) and Slater and Masih (2019) for additional details on this election victory.

cleanup problem from a *political economy* perspective. Given this lacuna in the literature, we provide what we believe is the *first* political economy analysis of pollution cleanup in the Ganges that arises as a result of the interaction between voters and politicians who promise to undertake all manner of pollution cleanup measures.

The remainder of this paper is organized as follows. Section 2 describes the two-period, political economy model of pollution cleanup in the Ganges in Varanasi.⁵ In this model, voters elect politicians to office in each time period and elected politicians decide how much pollution to clean up. Between the two time periods, there is an election. Politicians are either *sincere* which means that they are genuinely interested and hence efficient in cleaning pollution or *insincere* which means that they are less interested and thus inefficient in cleaning pollution. The marginal cost of public funds $\zeta \geq 1$ (on which more below) measures how *efficiently* elected politicians transform tax receipts into pollution cleanup. All voters have identical per period utility functions. Section 3 computes the equilibrium outcome and per period voter welfare. Section 4 demonstrates that an increase in ζ reduces the equilibrium cleanup of pollution and voter welfare. Section 5 permits an insincere politician to borrow funds and thereby delay the revelation of his inefficiency. In this setting, an insincere politician can appear sincere and this influences his chance of getting elected to office. This section solves for the equilibrium outcome and then shows that there exists a critical value of ζ, ζ^* , with the property that the insincere incumbent separates and loses the election if and only if $\zeta > \zeta^*$ and that he pools and is re-elected otherwise. Section 6 points out

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We have chosen to focus on the Ganges pollution cleanup problem in a particular location, i.e., in Varanasi, because of two reasons. First, the importance of Ganges-based religious and non-religious tourism in this city cannot be overstated. Second, by focusing on a particular parliamentary constituency, the nature of the interaction between voters and politicians can be studied in a transparent manner. That said, we recognize that, in principle, the Ganges pollution control problem is a complex, non-point source pollution control problem.

that an increase in ζ can raise voter welfare when politicians are more likely to be insincere. Section 7 concludes and then suggests two ways in which the research delineated in this paper might be extended.

2. The Theoretical Framework

Consider the interaction between voters and politicians seeking to represent the city of Varanasi centrally, i.e., in the Indian parliament (known as the Lok Sabha). We shall think of Varanasi as a single parliamentary constituency. There are two time periods in our model. Between the first and the second time period, there is an election to determine which politician will be put in office in the second period. Politicians differ in terms of how *sincere* they are in genuinely wanting to cleanup pollution in the Ganges. These politicians also differ in terms of the *efficiency* with which they are able to convert tax revenues into actual pollution cleanup. Voters are uncertain about the sincerity of the politicians and this uncertainty is unidimensional in nature. Looked at a little differently, they are uncertain about how efficient politicians are in cleaning up pollution in the Ganges.

We suppose that politicians are sincere with probability $p > 0$ and that they are insincere with complementary probability $(1 - p) > 0$.⁶ We assume that a sincere politician is also efficient in cleaning up pollution and that an insincere politician is relatively inefficient in cleaning up pollution in the Ganges.⁷ We model this efficiency aspect of the story by supposing that a

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We are introducing the probability $p > 0$ in this second section because the probability of a politician being sincere or efficient is a theme that runs through sections 3 through 6 of the paper. Voters know this probability. That said, the reader should note that we are *not* beginning our analysis with some “perfect information assumption” and that politicians do *not* know the “behavior of their constituencies.” What politicians hope to do is to *influence* the voting behavior of their constituents by signaling to them that they are sincere or efficient in cleaning up pollution.

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Instead of thinking of the notion of “sincerity” as a binary concept, in principle, it is also possible to think of and model “sincerity” as a continuous concept.

sincere or efficient politician “produces” public pollution cleanup at *low* cost. Similarly, an insincere or inefficient politician “produces” public pollution cleanup at *high* cost.⁸ In symbols, a sincere politician “produces” pollution cleanup at unit cost $\lambda_L > 0$, an insincere politician “produces” pollution cleanup at unit cost λ_H , and we have $\lambda_H > \lambda_L$.

The idea behind the sincere versus insincere and the efficient versus inefficient dichotomies is to capture and model the idea that there are *two types* of politicians that voters in Varanasi have to interact with. One type is genuinely *more* interested than the other type in cleaning up pollution in the Ganges. To account for this difference in a straightforward manner we are referring to the type of politician who is more (less) interested in cleaning up pollution in the Ganges as a sincere (insincere) politician. Since a sincere politician is more interested in pollution cleanup in the Ganges, we believe that it makes sense to think of such a politician as being *more* efficient at this task as compared to a less interested or insincere politician. Therefore, we are linking the notion of sincerity (insincerity) with the notion of efficiency (inefficiency). Finally, one way to model the notion of efficient behavior is to think of this kind of behavior as resulting in *lower* costs relative to inefficient behavior which can reasonably be expected to give rise to higher costs. This explains why the unit cost λ is *lower* for a sincere or efficient politician or, in symbols, why we have $\lambda_H > \lambda_L$.

The Ganges pollution cleanup problem that we are studying in this paper is a *partial equilibrium* analysis of a salient environmental problem in contemporary India. This means that other aspects of the Varanasi---and more generally the Indian---economy can be *set aside* so as to concentrate on the specific problem that is of interest to us for the reasons given in section 1. So,

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See Beladi *et al.* (2013) for more on the public aspects of pollution abatement.

even though we are casting and analyzing the election and re-election of politicians in terms of how credible they are to voters when they promise to clean up pollution once in office, nothing in our subsequent analysis should be construed to mean that we believe the Ganges pollution cleanup issue is the only issue that confronts voters in Varanasi. We acknowledge that voters typically care about *many* issues when determining which politicians to vote for and it is possible that some Varanasi voters may care less about pollution in the Ganges and more about other issues. That said, we reiterate that because of the partial equilibrium nature of our analysis, we are able to set aside other issues and focus on the particular problem of interest to us. In this regard, the reader should understand that if were to model *all* the issues that voters care about then our model would become *intractable*. Finally, we note that a politician who is inefficient in cleaning up pollution need *not* be inefficient at other tasks as well. In fact, most politicians we are aware of are better at performing some tasks relative to others.

All voters in Varanasi have an identical per period quasi-linear utility function and this function is given by

$$U(C, T) = G(C) - \zeta T, \tag{1}$$

where the function $G(\cdot)$ is differentiable, increasing, and concave, C denotes pollution cleanup, T denotes taxes, and $\zeta \geq 1$ represents the marginal cost of public funds.⁹ The reader may want to think of C as the physical amount of pollution that is removed from the Ganges in the Varanasi constituency that we are studying. Because the parameter ζ can be thought of as a measure of the scarcity of public resources in Varanasi, an increase in ζ means that it is now *more* difficult for

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The utility function in equation (1) is not homogeneous of degree one because even though $U(\cdot, \cdot)$ is linear in T , it is not linear in C because the function $G(\cdot)$ is concave and not generally intended to be linear.

politicians to raise tax revenues to fund the cleanup of pollution in the Ganges. Without loss of generality and to keep the subsequent mathematical analysis transparent, we suppose that there is no discounting between the two time periods. Finally, $B > 0$ denotes the private benefit to politicians from holding elected office.

With this description of the theoretical model out of the way, we are now in a position to solve for the equilibrium outcome resulting from the interaction between voters and politicians in Varanasi and to then determine the per period welfare of the voters.

3. The Equilibrium Outcome and Voter Welfare

Let i denote the type of incumbent politician in office in Varanasi in time period 1. Then, the amount of pollution cleanup provided in this time period is given by the solution to the maximization problem

$$\max_C G(C) - \zeta \lambda_i C. \quad (2)$$

The first-order necessary condition for an interior solution to the above problem is given by the condition

$$G'(C^*) = \zeta \lambda_i, \quad (3)$$

where C^* is the optimal amount of pollution cleanup.¹⁰ We know that the $G(C)$ function is increasing and concave. From this it follows that the derivative $G'(C)$ is positive and decreasing in C . Using this last point, we deduce that

$$C_L^* \equiv C^*(\lambda_L) > C^*(\lambda_H) \equiv C_H^*. \quad (4)$$

The inequality in (4) tells us that the amount of pollution cleanup provided by the sincere or low cost incumbent is *greater* than the amount provided by an insincere or high cost incumbent.

¹⁰

Note that because the $G(\cdot)$ function is concave, the second-order sufficiency condition $G''(\cdot) \leq 0$ is satisfied.

Varanasi voters observe the amount of pollution cleanup provided in the first time period and then they re-elect the sincere incumbent and get rid of the insincere incumbent in which case a new incumbent is elected to replace the insincere incumbent in office.

If an insincere politician is removed from office then the new incumbent will be sincere or efficient with probability $p > 0$ and insincere or inefficient with probability $(1 - p) > 0$. As such, suppose that in the first time period, the incumbent in office is sincere. Then, after observing the amount of pollution in the Ganges that is cleaned up, voters in Varanasi will re-elect this incumbent. In this case, an arbitrary Varanasi voter's per period welfare is

$$U = G(C_L^*) - \zeta\lambda_L C_L^*, \quad (5)$$

and therefore this individual's total welfare is simply the sum of the two per period expressions given in equation (5) or $2U$.

On the other hand, if the incumbent politician in the first time period is insincere or inefficient then this incumbent will be removed from office. In this case, an arbitrary Varanasi voter's welfare in the first time period is

$$U_1 = G(C_H^*) - \zeta\lambda_H C_H^*. \quad (6)$$

This same voter's welfare in the second time period depends on whether the elected politician turns out to be sincere (this happens with probability p) or insincere (this happens with probability $(1 - p)$). Accordingly, this arbitrary Varanasi voter's second period welfare is given by a weighted sum and that sum is

$$U_2 = p\{G(C_L^*) - \zeta\lambda_L C_L^*\} + (1 - p)\{G(C_H^*) - \zeta\lambda_H C_H^*\}. \quad (7)$$

Therefore, in this second case, an arbitrary Varanasi voter's total welfare is given by the sum of the two expressions given in equations (6) and (7) or $U_1 + U_2$. We now proceed to show that an

increase in the marginal cost of public funds or ζ reduces both the equilibrium amount of pollution that is cleaned up and the welfare of voters in Varanasi.

4. An Increase in the Marginal Cost of Public Funds

We begin by totally differentiating the first-order necessary condition for an optimum given in equation (3). This gives us

$$G''(C^*)dC^* = \lambda_i d\zeta. \quad (8)$$

We now use the concavity of the $G(\cdot)$ function---which means that the second derivative of this function is negative---to obtain an expression that can be signed. That expression is

$$\frac{dC^*}{d\zeta} = \frac{\lambda_i}{G''(C^*)} < 0. \quad (9)$$

Equation (9) shows that when the marginal cost of public funds or ζ rises, the equilibrium amount of pollution in the Ganges that is cleaned up *declines*. This result arises because an increase in ζ means that it is now *more* difficult to raise the tax revenues that will be used to fund the cleanup of pollution in the Ganges.

To demonstrate the validity of a similar claim for the welfare of voters in Varanasi, we use a standard result in microeconomic theory, namely, the envelope theorem.¹¹ Now, recalling equation (1) and then using the envelope theorem, we get

$$\frac{dU(C_i^*)}{d\zeta} = \frac{\partial U(C_i^*)}{\partial \zeta} = -\lambda_i C_i^* < 0. \quad (10)$$

¹¹

See Varian (1992, pp. 490-492) for a standard textbook account of the envelope theorem.

The right-hand-side (RHS) of equation (10) clearly tells us that an increase in the marginal cost of public funds or ζ *lowers* the welfare of voters in Varanasi in *both* time periods and for *both* possible types of incumbent politicians (sincere or insincere). This negative finding reinforces the previous finding in equation (9) that an increase in ζ lowers the equilibrium cleanup of pollution C^* . In particular, since the RHS of equation (10) depends on C^* which is lower, it follows that the welfare of voters in Varanasi is also lower. We now proceed to study the case in which an insincere politician is able to hide the fact that he is insincere by borrowing funds and thereby delaying the revelation of his inefficiency to Varanasi voters.

5. An Insincere Politician Appearing to be Sincere

The basic modeling framework now is essentially the same as the framework delineated in section 2 but there is one noteworthy difference. Specifically, an insincere incumbent can *delay* the revelation of his insincerity or inefficiency by borrowing funds denoted by $F > 0$. This borrowing is observable to Varanasi voters only after the election at the end of the first time period. In addition, this borrowing by an insincere incumbent permits him to appear sincere because he can act as if the unit cost of pollution cleanup is low when it is, in fact, high. Observe that this course of action also results in the creation of a budget deficit in an election year.

In time period 1, the incumbent politician observes the unit cost $\lambda \in \{\lambda_L, \lambda_H\}$. He then selects the amount of pollution cleanup C to “produce” and the amount of funds F that he would like to borrow. These two actions lead to a total tax bill given by $T = \lambda C - F$. Next, Varanasi voters observe the choices of C and T before the election. On the basis of these two observations, voters draw a conclusion about the incumbent politician’s type. The incumbent is re-elected if he is at least as likely to be sincere as a rival who is sincere with prior probability $p > 0$ and insincere

with prior probability $(1 - p) > 0$. In the second time period, the politician then in office again selects C given λ and he repays the funds F he borrowed in the first time period. These two actions give rise to a tax bill denoted by $T = \lambda C_\lambda + F$. No further elections take place in our model.

There are now two tasks to complete. First, we would like to compute the equilibrium outcome that arises in the interaction between Varanasi voters and politicians. Second, we want to demonstrate that there exists a critical value of ζ, ζ^* , with the property that the insincere incumbent *separates* and loses the election if and only if $\zeta > \zeta^*$ and that he *pools* and is re-elected otherwise.¹²

We begin by pointing out that voters do *not* observe either the incumbent's type λ or the funds F that he has borrowed before the election. Therefore, in a pooling equilibrium, the following equality

$$\lambda_H C_L^* - F = \lambda_L C_L^* \tag{11}$$

must hold. An implication of equation (11) is that in order to confuse voters into thinking that he is sincere, an insincere incumbent politician will borrow

$$F = (\lambda_H - \lambda_L) C_L^* \tag{12}$$

in the first time period. Since these borrowed funds must be paid back in the second time period, an insincere incumbent will choose to pool and be re-elected if and only if the borrowed amount

¹²

The kind of game we are analyzing in this paper is a so called "signaling game" which is itself one kind of dynamic game of incomplete information. Standard equilibria to study in signaling games are the so called "pooling" and "separating" equilibria. Now, as in this paper, consider a signaling game with two categories of players---politicians and voters. In a pooling equilibrium, all *types* (sincere or insincere) of a particular category of player (in our case politicians) send the *same* message or signal to the other category of player (in our case voters). This interaction between politicians and voters leads to a pooling equilibrium. In contrast, when the different types of politicians (sincere or insincere) send *different* messages or signals to the voters, the resulting interaction between politicians and voters leads to a separating equilibrium. For more on these concepts, the reader ought to consult standard game theory texts such as Fudenberg and Tirole (1991) or Gibbons (1992).

F is no larger than $2B$ which is his private benefit from being in office for two time periods. In symbols, we must have

$$(\lambda_H - \lambda_L)C_L^* \leq 2B. \quad (13)$$

Now, assuming that the relationship in (13) holds with equality, we get

$$C_L^*(\zeta^*) = \frac{2B}{\lambda_H - \lambda_L}. \quad (14)$$

Using equation (3), we can simplify the expression in equation (14) and, at the same time, deduce the critical value of ζ, ζ^* , that we seek. We obtain

$$\zeta^* = \frac{1}{\lambda_L} G' \left(\frac{2B}{\lambda_H - \lambda_L} \right). \quad (15)$$

We have already shown in section 4 that the optimal pollution cleanup amount C_L^* is *decreasing* in the marginal cost of public funds ζ . This tells us that when ζ increases, the left-hand-side (LHS) of (13) decreases. This last finding implies that for all $\zeta > \zeta^*$, (13) holds as a strict inequality and therefore we obtain a separating equilibrium. In this equilibrium, an insincere incumbent politician will choose to separate and lose the election at the end of the first time period. In contrast, when $\zeta \leq \zeta^*$, this incumbent politician will successfully pool and be re-elected to office in the second time period.

Before proceeding further, let us emphasize three points about our analysis thus far. First, the fact that the inefficient incumbent politician can borrow F does *not* make it certain that he will be re-elected in the election after the first time period. The purpose of borrowing F is to confuse

voters into thinking that an inefficient politician is efficient. If voters believe this attempt to confuse them then this makes re-election *more likely* but not certain for the inefficient incumbent politician. Second, the $2B$ on the RHS of (13) makes sense because the per period private benefit from holding elected office is the *non-random* B and we are accounting for this private benefit over *both* time periods in (13). In this regard, there is no expectation operator around the $2B$ term because B is *not* random. Finally, in general, there is nothing illegal about an elected politician borrowing money, promising to pay back in a subsequent time period, and thereby creating a budget deficit. This happens quite frequently and this fact has now given rise to a literature---see Waknis (2014) and Ferris and Dash (2019)---on the so called “political budget cycle.” Our last task in this paper is to show that an increase in ζ can raise voter welfare when politicians are more likely to be insincere.

6. An Increase in the Marginal Cost of Public Funds Once Again

Some thought ought to convince the reader that in the pooling equilibrium that we have been discussing, the welfare of voters differs only in the second time period. Therefore, before the resolution of uncertainty about λ and F , voter welfare in the two time periods under study is given by

$$U_1 = G(C_L^*) - \zeta \lambda_L C_L^* \quad (16)$$

and

$$E[U_2] = p\{G(C_L^*) - \zeta \lambda_L C_L^*\} + (1 - p)\{G(C_H^*) - \zeta(\lambda_H C_H^* + F)\}, \quad (17)$$

where $E[\cdot]$ is the expectation operator.

To ascertain the impact of the marginal cost of public funds ζ on intertemporal voter welfare in Varanasi, we differentiate the sum $U_1 + E[U_2]$ with respect to ζ . This gives us

$$\frac{d\{U_1+E[U_2]\}}{d\zeta} = -(1+p)\lambda_L C_L^* - (1-p)(\lambda_H C_H^* + F) - (1-p)\zeta \frac{dF}{d\zeta}. \quad (18)$$

In order to sign the expression on the RHS of equation (18), we need to first sign the derivative $dF/d\zeta$. To do this, let us differentiate equation (12), keeping in mind the dependence of C_L^* on ζ . This gives us

$$\frac{dF}{d\zeta} = (\lambda_H - \lambda_L) \frac{dC_L^*}{d\zeta} < 0 \quad (19)$$

and the sign of the expression on the RHS of equation (19) follows from the fact that C_L^* is decreasing in ζ .

We now use the result in equation (19) to determine the sign of the derivative in equation (18). After several steps of algebra, we deduce that the welfare of voters in Varanasi *may* rise with an increase in ζ as long as the inequality

$$-\zeta \frac{dF}{d\zeta} > \frac{1+p}{1-p} \lambda_L C_L^* + \lambda_H C_H^* + F \quad (20)$$

holds. Inspection reveals that the RHS of the inequality in (20) is *increasing* in the probability p . Hence, the chance that the condition in (20) will hold is stronger when p is *small*. In turn, this last sentence tells us that the condition in (20) will hold more often than not when $(1-p)$ is large and this means that the politician under consideration is more likely to be insincere.

To understand this somewhat counterintuitive result, note that we generally expect sincere

politicians to “produce” more pollution cleanup than insincere politicians. *Ceteris paribus*, this increased cleanup of pollution in the Ganges makes Varanasi voters better off. However, in order to fund this increased pollution cleanup, politicians need to raise tax revenues and taxation affects voter welfare negatively. Recall that the marginal cost of public funds or ζ measures how difficult it is for politicians to raise tax revenues. In such a scenario, when we permit insincere politicians to appear sincere, there is a range of values for ζ ($\zeta \leq \zeta^*$) where insincere politicians successfully appear sincere. Now, the interaction of this “range of values for ζ ” with the magnitude of the probability p creates circumstances in which the activities of insincere politicians *may* raise the welfare of voters in Varanasi. This completes our analysis of a political economy model of the Ganges pollution cleanup problem.

7. Conclusions

In this paper, we studied a two-period, political economy model of pollution cleanup in the Ganges river in Varanasi. Voters elected politicians to office in each period and the elected politicians determined the extent of pollution cleanup. Between the first and the second time periods, there was an election. Politicians were either sincere or insincere. The marginal cost of public funds ζ measured how efficiently elected politicians transformed tax receipts into pollution cleanup. All voters had identical per period utility functions. First, we ascertained the equilibrium outcome and per period voter welfare. Second, we showed that an increase in ζ reduced the equilibrium cleanup of pollution and voter welfare. Third, we allowed an insincere politician to borrow funds to delay the revelation of his inefficiency to voters. Thus, an insincere politician could appear sincere and this affected his chance of getting elected to office. We solved for the equilibrium outcome and showed that there existed a critical value of ζ, ζ^* , with the property that

the insincere incumbent separated and lost the election if and only if $\zeta > \zeta^*$ and that he pooled and was re-elected otherwise. Fourth, we pointed out that an increase in ζ could raise voter welfare when politicians were more likely to be insincere. Finally, we would like to point out that the theoretical framework utilized in this paper is fairly general and not applicable only to the Ganges pollution cleanup problem. As such, this framework can be used to analyze the behavior of politicians who would like to be re-elected to office by promising to, for instance, cleanup garbage and waste, reduce ambient pollution, and lower crime, in appropriate jurisdictions.

Here are two suggestions for extending the research described in this paper. First, it would be useful to distinguish between different kinds of pollution in the Ganges and to then see what impact different kinds of pollution cleanup and the associated costs have on the electability of politicians and on the welfare of voters in a city like Varanasi. Second, it would also be helpful to study a scenario in which elected officials in a city like Kanpur---where tanneries are responsible for a significant amount of industrial pollution---cooperate with elected officials in Varanasi to jointly deal with the problem of cleaning up pollution in the Ganges. Studies of the cleanup of pollution in the Ganges that incorporate these aspects of the problem into the analysis will provide further insights into how what has been referred to by Conaway (2015) as a “river of death” can gradually be converted into a “river of life.”

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