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On Unitization as a Way of Addressing Water Pollution in the Ganges in Kanpur, India [1]

by

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Abstract

We study water pollution in the Ganges River caused by tanneries in Kanpur, India. We analyze the merits of a recent claim that unitizing or merging the polluting tanneries can improve water quality in the Ganges. We first describe the $n \geq 2$ polluting tanneries in Kanpur as a Cournot oligopoly and derive the equilibrium output of leather and profits. Second, we permit $m < n$ tanneries to merge and determine the cost function, when the m tanneries can use their production facilities, and there are no other efficiency gains from unitization. Third, we examine when the m-tannery unitization is profitable to the unitized entity and to the non-unitized tanneries. Fourth, we discuss our conclusions about the profitability of the unitized and the non-unitized tanneries and comment on what our findings mean for improved water quality in the Ganges. Finally, we discuss some key regional dimensions of the Ganges water pollution problem caused by tanneries in Kanpur.

Keywords: Ganges River, Merger, Tannery, Unitization, Water Pollution

JEL Codes: G34, Q25, Q28

1. Introduction

Water pollution in the Ganges (Ganga in Hindi) River, particularly in and around Kanpur, is a severe environmental problem caused by the discharge of untreated industrial waste from tanneries (Khwaja *et al.* 2001; Singh and Gundimeda 2021). Kanpur, often referred to as the "Leather City of India,"[4] houses hundreds of tanneries that process animal hides into leather goods. During this process, large quantities of toxic chemicals such as chromium, sulfides, and arsenic are used (Singh and Rao 2013). Once these chemicals have been used, they are frequently dumped directly into the Ganges River without proper treatment, leading to acute contamination of the water.

The high concentration of heavy metals and toxic chemicals in the Ganges near Kanpur has a significant impact on both the ecosystem and public health (Ory *et al.* 1996). The Ganges River, which is sacred to millions of Hindus and a crucial water source for drinking and irrigation, is severely polluted by the effluents from these tanneries (Das and Tamminga 2012). The chemicals released into the river contaminate the water, making it unsafe for both humans and wildlife. In addition, the presence of toxic substances leads to the destruction of aquatic life, as fish and other organisms cannot survive in such polluted conditions (Singh 2001).

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Go to https://www.kanpuronline.in/guide/kanpur-the-leather-city for additional details. Accessed on 10 June 2025.

Markandya and Murty (2004) point out that despite efforts by the central Indian government and environmental organizations to address the underlying issue, the problem of water pollution in the Ganges persists due to inadequate waste treatment infrastructure and the lack of effective enforcement of environmental regulations. While some tanneries have installed water treatment plants, many do not operate them properly or fail to treat the effluents to the necessary standards (Tare *et al.* 2003). As a result, the continuing pollution of the Ganges near Kanpur remains a pressing public policy problem---also see Section 6 below---that requires a comprehensive solution, involving stricter regulation, improved waste treatment technologies, and greater accountability for industries contributing to the pollution.

Despite the severity of the water pollution problem in the Ganges in Kanpur, there are very few studies in the literature that have rigorously analyzed this problem. Recently, Batabyal (2023) and Batabyal *et al.* (2023) have theoretically studied aspects of the Ganges water pollution problem in Kanpur. Both studies focus on the water pollution caused by two tanneries, one located upstream of the other. Batabyal (2023) concentrates mainly on how leather production is altered by explicitly accounting for water pollution whereas Batabyal *et al.* (2023) are more concerned with how leather production is impacted by the interactions between climate change and water pollution.

A key point that we would like to emphasize now is that both studies contend that one way to ensure higher water quality in the Ganges is by unitizing or merging[5] the two polluting tanneries under study. For instance, Batabyal (2023, p. 1121) says that "a straightforward policy implication of our analysis is that the many, often small, tanneries in Kanpur that both pollute the Ganges and impose costs on each other ought to be merged into larger entities. Inter alia, such an action is likely to ameliorate water quality in the Ganges River."

To the best of our knowledge, the merits of unitization or a merger in the context of polluting tanneries in Kanpur has received *no* attention in the literature thus far. Therefore, our specific objective in this paper is to analyze the merits of the unitization claim made by Batabyal (2023) and Batabyal *et al.* (2023).

Section 2 below first describes the $n \geq 2$ polluting tanneries in Kanpur as a Cournot oligopoly and then derives the equilibrium output of leather and profits. Section 3 permits $m < n$ tanneries to merge and determines the cost function of the unitized entity, assuming that the m tanneries can use their production facilities and that there are no other efficiency gains from unitization. Section 4 examines when the m-firm unitization is

[5] We shall use the terms "unitization" and "merger" interchangeably in the remainder of this paper. See Hartwick and Olewiler (1998, p. 194) for a textbook discussion of unitization in the natural resource and environmental economics literature.

profitable to the unitized entity and to the non-unitized tanneries. Section 5 discusses the rationale for our conclusions regarding the profitability of the unitized and the non-unitized tanneries and then points out what our findings mean for improved water quality in the Ganges. Section 6 discusses some key regional dimensions of the Ganges water pollution problem caused by the tanneries in Kanpur that we have focused on in our paper. Section 7 concludes and then suggests two ways in which the research delineated in this paper might be extended.

2. The Cournot Oligopoly

According to Sahu (2019), there are more than 400 tanneries in the Jajmau area of Kanpur and many of these tanneries are responsible for water pollution in the Ganges. Therefore, to meaningfully address the usefulness of unitization, we shall depart from the focus of Batabyal (2023) and Batabyal *et al.* (2023) on $n = 2$ tanneries and consider a stylized version of the Jajmau economy in which there are $n \geq 2$ tanneries.

We suppose that these $n \geq 2$ tanneries collectively can be thought of as a Cournot oligopoly.[6] This means that the various tanneries "playing" the underlying Cournot game choose quantities or how much leather to produce and not what price to charge for the

[6] See Tirole (1988, pp. 218-221) for a textbook discussion of a Cournot oligopoly.

leather that they have produced. The reader should note that the Cournot game-theoretic model that we are analyzing is static in nature.

The quantity of leather produced by the *ith* tannery is $q_i, i = 1, \ldots, n$. Aggregate production of leather is given by $Q = \sum_{i=1}^{n} q_i$ and it is understood that $Q \geq 0$. The demand for leather in our n tannery leather manufacturing industry is given by $P(q) = a - bQ$, where $a > 0$ and $b > 0$.

An individual tannery incurs two kinds of costs in producing leather. The first cost is the direct cost of producing leather which is described by the quadratic and strictly convex cost function $\alpha q^2, \alpha > 0$. The second or indirect cost stems from the *requirement* that tanneries treat the waste they generate (Hussain 2024). Let us describe this cost with the quadratic and strictly convex cost function $\beta q^2, \beta > 0$. Therefore, the total cost of producing leather confronting an arbitrary tannery is $C(q) = \alpha q^2 + \beta q^2 = (\alpha + \beta) q^2 = \gamma q^2$ where $\alpha + \beta = \gamma$ and $\alpha \neq \beta$. With this description of the theoretical framework in place, our next task is to determine the Cournot equilibrium output of leather and the profits earned by an arbitrary tannery.

Tannery i chooses its output of leather q_i to maximize its profits. This *ith* tannery's profit function is

$$\pi_i = P(\sum_{i=1}^{n} q_i) q_i - \gamma q_i^2 = \left\{a - b\left(q_i + \sum_{j \neq i}^{n} q_j\right)\right\} q_i - \gamma q_i^2. \tag{1}$$

This maximization is undertaken, given the leather output choices of all the other tanneries. The first-order necessary condition to the above profit maximization problem tells us that we must have

$$\frac{\partial \pi_i}{\partial q_i} = a - 2bq_i - b\sum_{j \neq i}^{n} q_j - 2\gamma q_i = 0. \tag{2}$$

Rewriting equation (2), we can state the *ith* tannery's best response or reaction function. This function is given by

$$q_i = \frac{a - b\sum_{j \neq i}^{n} q_j}{2(b+\gamma)}. \tag{3}$$

In a symmetric Cournot equilibrium, we must have $q_i = q, \forall i$. Using this last condition, the best response function in equation (3) can be written as

$$q = \frac{a - b(n-1)q}{2(b+\gamma)}. \tag{4}$$

At this stage, it is worth highlighting some of the key differences between a *symmetric* and an *asymmetric* Cournot equilibrium. In a symmetric Cournot equilibrium, the tanneries being analyzed are, for all practical purposes, identical in terms of their cost structures and strategic behavior, leading them to produce the same quantity of leather and earn the same profits in equilibrium. In contrast, in an asymmetric Cournot equilibrium, the various tanneries would differ—typically in terms of their cost functions and/or their production capacities—which would result in unequal output levels and profits across the tanneries. While both types of equilibria satisfy the condition that each tannery maximizes its profit given the output of the other tanneries, the symmetric equilibrium assumes homogeneity among the competing tanneries, whereas the asymmetric equilibrium focuses on the heterogeneity between the different tanneries.

Equation (4) can be simplified to give us the equilibrium output of leather produced by an arbitrary tannery. We get

$$q = \frac{a}{(1+n)b+2\gamma}. \tag{5}$$

Knowing the equilibrium output of leather, it is straightforward to compute the equilibrium price and profits. The equilibrium price in our leather producing industry is given by

$$P = a - bnq = a\left\{\frac{b+2\gamma}{(1+n)b+2\gamma}\right\}. \tag{6}$$

Finally, using the equilibrium output of leather and the price given in equations (5) and (6), we can compute an arbitrary tannery's profits. We get

$$\pi = Pq - \gamma q^2 = \frac{a^2(b+\gamma)}{\{(1+n)b+2\gamma\}^2}. \tag{7}$$

We can use equations (5)-(7) to shed light on how the water pollution in the Ganges generated as a byproduct of leather production affects an arbitrary tannery's equilibrium output, price, and profits. Looking at the coefficient of the total cost function γq^2, we know that $\gamma = \alpha + \beta$. Now, *ceteris paribus*, suppose that there is an increase in water pollution in the Ganges. Then this leads to a greater amount of required tannery waste treatment. In turn, this increase can be expected to raise the cost of this treatment or βq^2.

This last effect can be captured by postulating a rise in the coefficient β. In symbols, $\beta \uparrow \Rightarrow \gamma \uparrow$.

Inspecting equation (5), we see that $\gamma \uparrow \Rightarrow q \downarrow$. In other words, *ceteris paribus*, a rise in water pollution increases the total cost of producing leather and this reduces the equilibrium output of leather in our stylized Jajmau economy. Next, consider the equilibrium price in equation (6). Using the quotient rule for differentiation, simple calculus reveals that $\partial P/\partial\gamma > 0$. Put differently, all else being equal, an increase in water pollution in the Ganges raises the equilibrium price received by the leather producing tanneries in our model. Note that this is to be expected because we just determined that an increase in water pollution reduced the equilibrium output of leather. Finally, let us consider the impact of rising water pollution in the Ganges on tannery profits. Partially differentiating both sides of equation (7) with respect to the parameter γ, we get

$$\frac{\partial\pi}{\partial\gamma} = \frac{[\{(1+n)b+2\gamma\}a]^2 - \{(b+\gamma)a^2\}[4\{(1+n)b+2\gamma\}]}{\{(1+n)b+2\gamma\}^4}. \qquad (8)$$

The denominator on the right-hand-side (RHS) of equation (8) is clearly positive but the numerator cannot be signed unambiguously. This tells us that an increase in water pollution in the Ganges leads to an indeterminate effect on the profits of the tanneries under study.

Out next task is to analyze the case where $m < n$ tanneries are unitized or merged. Specifically, we wish to derive the cost function of the unitized entity, on the assumption that the m tanneries can continue to use their production facilities and that there are no other efficiency gains from unitization.

3. Cost Function of the Unitized Entity

Let q_u denote the total output of leather from the unitized tanneries. Since the cost function $C(q) = \gamma q^2$ is strictly convex, it follows that the marginal cost is increasing in the output of leather. This, in turn, tells us that it would be cost minimizing to divide the production of leather among all the available production facilities.

Now observe that after the unitization is complete, all the m production facilities will be utilized for leather production with each facility producing q_u/m units of leather. From this, it straightforwardly follows that the total cost of leather production by the merged tanneries is given by

$$\gamma m(\tfrac{q_u}{m})^2 = \gamma \left(\tfrac{q_u^2}{m}\right). \tag{9}$$

With the derivation of this cost function out of the way, let us study the conditions under which this m-firm unitization is profitable to the unitized entity and to the non-unitized tanneries.

4. Profitability from Unitization

In Cournot competition, the unitized entity will select output q_u to maximize its profits given the leather production choices of all the other tanneries. This profit function $\pi_u(\bullet)$ can be written as

$$\pi_u = \{a - b(q_u + \sum_{i=1}^{n-m} q_i)\}q_u - \frac{\gamma}{m} q_u^2. \tag{10}$$

The first-order necessary condition for a maximum is

$$\frac{\partial \pi_u}{\partial q_u} = a - 2bq_u - b\sum_{i=1}^{n-m} q_i - 2q_u \frac{\gamma}{m} = 0. \tag{11}$$

Equation (11) can be used to ascertain the best response function of the unitized entity. After some algebra, we get

$$q_u = \frac{a - b\sum_{i=1}^{n-m} q_i}{2(b+\gamma/m)}. \tag{12}$$

Now, let us consider the non-unitized tanneries. Each non-unitized tannery also maximizes its profits. The relevant profit function $\pi_i(\bullet)$ can be written as

$$\pi_i = \left\{a - b\left(q_i + \sum_{j\neq i}^{n-m} q_j + q_u\right)\right\} q_i - \gamma q_i^2. \tag{13}$$

The first-order necessary condition for an optimum to the above maximization problem can be used to state this non-unitized tannery's best response function. After several algebraic steps, we get

$$q_i = \frac{a - b\left(\sum_{j\neq i}^{n-m} q_j + q_u\right)}{2(b+\gamma)}. \tag{14}$$

As in section 2, we focus on a symmetric equilibrium in which we must have $q_i = q, \forall i$, i.e., for all the non-unitized tanneries. Using this last condition, the equilibrium output of leather by the non-unitized tanneries is

$$q = \frac{a - b\{(n-m-1)q + q_u\}}{2(b+\gamma)}. \tag{15}$$

Using equation (15), we now want to find expressions for the equilibrium output of leather produced by the non-unitized tanneries, given by q, and the unitized entity, given by q_u. After some algebraic steps, we obtain

$$q = \frac{a-bq_u}{(n-m+1)b+2\gamma}, \tag{16}$$

and

$$q_u = \frac{a-b(n-m)q}{2(b+\gamma/m)}. \tag{17}$$

Equations (16) and (17) together constitute a system of two equations in the two unknowns q and q_u. Solving these two equations simultaneously, we obtain the equilibrium output levels of leather for the unitized entity and the non-unitized tanneries. These output levels are given by

$$q = \frac{a(mb+2\gamma)}{m(n-m+2)b^2+2(n+m+1)b\gamma+4\gamma^2} \tag{18}$$

and

$$q_u = \frac{a(b+2\gamma)m}{m(n-m+2)b^2+2(n+m+1)b\gamma+4\gamma^2}. \tag{19}$$

Using equations (18) and (19), we can determine the equilibrium price of leather in our stylized Jajmau tannery industry. Modifying the demand function specified in section 2, we get $P = a - b\{q_u + (n-m)q\}$. Substituting for q and q_u from equations (18) and (19) into the preceding demand function, we get, after several algebraic steps, the demand function we seek and that is

$$P = a\frac{mb^2+2(m+1)b\gamma+4\gamma^2}{m(n-m+2)b^2+2(n+m+1)b\gamma+4\gamma^2}. \tag{20}$$

Finally, we are now able to compute the profits of the two categories of tanneries in the leather manufacturing industry under study. The equilibrium profit of a non-unitized tannery is given by $\pi = Pq - \gamma q^2$. Substituting for q and P from equations (18) and (20) into the preceding profit function and then simplifying gives us the expression for the profit that we seek. That expression is

$$\pi = \frac{a^2\{mb^2+(m+2)b\gamma+2\gamma^2\}(mb+2\gamma)}{\{m(n-m+2)b^2+2(n+m+1)b\gamma+4\gamma^2\}^2}. \tag{21}$$

Using a similar line of reasoning, the equilibrium profit of the unitized entity is $\pi_u = Pq_u - (\gamma/m)q_u^2$. Substituting for q_u and P from equations (19) and (20) into the previous profit function and then simplifying, we obtain

$$\pi_u = ma^2\frac{\{mb^2+(2m+1)b\gamma+2\gamma^2\}(b+2\gamma)}{\{m(n-m+2)b^2+2(n+m+1)b\gamma+4\gamma^2\}^2}. \tag{22}$$

We can now answer the question about the profitability from unitization. Some thought ought to convince the reader that unitization is profitable to the unitized entity if and only if the post-unitization profits of the merged entity are greater than the profits of the unitized tanneries prior to unitization. Using a modified equation (7) and equation (22), the condition for the profitability from unitization that we seek is

$$ma^2\frac{\{mb^2+(2m+1)b\gamma+2\gamma^2\}(b+2\gamma)}{\{m(n-m+2)b^2+2(n+m+1)b\gamma+4\gamma^2\}^2} > m\frac{a^2(b+\gamma)}{\{(1+n)b+2\gamma\}^2}. \tag{23}$$

The inequality in (23) can also be re-written so that the condition for the profitability from unitization is expressed in terms of the number of merged tanneries or m. Doing this, unitization is profitable when the number of tanneries being unitized or m satisfies

$$\frac{mb^2+(2m+1)b\gamma+2\gamma^2}{\{m(n-m+2)b^2+2(n+m+1)b\gamma+4\gamma^2\}^2} - \frac{(b+\gamma)}{(b+2\gamma)\{(1+n)b+2\gamma\}^2} > 0. \tag{24}$$

Using a similar line of reasoning and equations (7) and (21), the m-firm unitization is profitable for the non-unitizing tanneries if and only if

$$\frac{a^2\{mb^2+(m+2)b\gamma+2\gamma^2\}(bm+2\gamma)}{\{m(n-m+2)b^2+2(n+m+1)b\gamma+4\gamma^2\}^2} - \frac{a^2(b+\gamma)}{\{(1+n)b+2\gamma\}^2} > 0. \tag{25}$$

As in the case of the inequality in (23), the inequality in (25) can also be re-written so that the condition for the profitability from unitization for the non-unitizing tanneries is expressed in terms of the number of merged tanneries or m. Doing this, unitization is profitable to the non-merging tanneries as long as m satisfies

$$\frac{\{mb^2+(m+2)b\gamma+2\gamma^2\}(mb+2\gamma)}{\{m(n-m)b^2+2(n+m+1)b\gamma+4\gamma^2\}^2} - \frac{b+\gamma}{\{(n+1)b+2\gamma\}^2} > 0. \tag{26}$$

We are finally in a position to determine the impact of unitization on the profitability of the two categories of tanneries and on water pollution in the Ganges in Kanpur.

5. Unitization, Profitability, and Water Pollution

The two inequalities of interest are given in (24) and (26). Let us focus on (24) first. Numerical analysis with the inequality in (24) yields three findings. First, the difference on the left-hand-side (LHS) of (24) is equal to zero when $m = 1$. Second, this difference is negative for small m. Third, this difference is positive for large m. Next, let us consider (26). Numerical analysis with the LHS of (26) yields two results. First, the difference on the LHS of (26) is zero when $m = 1$. Second, this difference is positive for $m > 1$.

The findings in the preceding paragraph tell us that when $m < n$ tanneries are unitized, this unitization is *unambiguously profitable* for the non-unitized tanneries. This is because the smaller number of tanneries post-unitization means that competition in the leather manufacturing industry declines and this results in a decrease in the Cournot competition output of leather and an increase in its price.

On the other hand, the unitized entity finds unitization profitable only if the number of merging tanneries is *large enough*. This result arises because of the presence of strictly convex total costs in our model. With such costs, the unitized entity finds it profitable to split the production of leather among the large enough number of production facilities. This discussion tells us that from a profitability standpoint, unitization works for both unitized and non-unitized tanneries only when the unitized entity is large enough. That said, what is "large enough" will depend on the trinity of number of tanneries involved or n and the demand and cost parameters b and γ. Our computations show that, for instance, when $n = 10$ and $b = \gamma = 0.1$, unitization is profitable for the unitized tanneries when at least 6 tanneries are unitized.

Finally, coming to the Batabyal (2023) and Batabyal *et al.* (2023) claim about unitization likely leading to a decline in water pollution in the Ganges in Kanpur, let us suppose, as these two papers implicitly do, that water quality (water pollution) in the Ganges is an increasing (decreasing) function of the number of unitized tanneries m in

Kanpur. This means that as the unitized entity becomes large, water quality in the Ganges improves or, put differently, water pollution lessens. If this supposition is valid then policy makers have an incentive to create a large, unitized entity because such an action can be justified on commercial grounds because it increases the profits of both the unitized and the non-unitized tanneries *and* on environmental grounds because it lowers water pollution in the river under consideration.

If the above supposition is invalid, then commercial and environmental considerations are in *conflict*. Specifically, commercial or profitability considerations alone would suggest that a policy maker create a large, unitized entity but environmental considerations would suggest that this policy maker not engage in unitization. We now talk about some salient regional dimensions of the Ganges water pollution problem caused by the tanneries in Kanpur.

6. Regional Dimensions

The problem of water pollution in the Ganges River due to the tannery industry in Kanpur has significant regional dimensions that extend well beyond the city itself. Kanpur, one of India's largest leather manufacturing hubs, is home to more than 400 tanneries that discharge toxic effluents—including chromium, sulfides, and other hazardous chemicals—into the Ganges. This pollution not only contaminates the river locally but also impacts downstream communities across the state of Uttar Pradesh and further into the states of

Bihar and West Bengal, where millions depend on the Ganges for drinking water, irrigation, and religious rituals. The sheer scale of the inter-state *dependence* on the river means that the effects of Kanpur's industrial pollution ripple far across northern India.

The analytical framework employed in the present paper is unsuitable for studying this dependence. That said, models, richer than the one utilized in this paper, would emphasize this dependence by explicitly modeling, potentially as in Batabyal (2024) and in Batabyal and Beladi (2024), both the intra-state and the inter-state *spatial spillovers* stemming from the cleanup of Ganges water pollution caused by tanneries in Kanpur. The magnitude of the spatial spillover terms would give us a sense for how large an impact the water pollution in Kanpur has on locations and regions that are spatially some distance away from this city.

This means that comprehensive efforts to address the water pollution problem must be regional in scope, involving coordination among state governments, local municipal authorities, and central agencies like the National Mission for Clean Ganga (Alley *et al.* 2018). While local enforcement in Kanpur has seen some success—such as mandating Common Effluent Treatment Plants (CETPs) and relocating tanneries—many units continue to operate illegally or bypass regulations. This regulatory laxity is compounded by jurisdictional fragmentation and inconsistent political will across states in India. Effective water pollution control thus requires not just technical solutions but also intraand inter-state cooperation and joint monitoring systems that ensure pollutants from Kanpur do not undermine water quality further downstream.

As pointed out by Richards and Singh (2002), analytical models of the above-mentioned phenomena will need to distinguish between situations where cooperation is possible, and situations of pure conflict, where a search for a negotiated solution may well be futile. In other words, in conflict scenarios, a quick move to arbitration or adjudication may be more efficient. Here, models of the sort discussed by Gibbons (1988) are likely to be useful in comprehending such conflict laden scenarios.

Finally, the regional economy and ecology are intertwined with the health of the Ganges River. Farmers in adjacent districts face declining crop yields due to polluted irrigation water, and fishermen downstream report falling fish stocks, affecting livelihoods and food security. Religious tourism, especially in cities like Varanasi, also suffers from the river's degraded condition. Addressing water pollution caused by tanneries in Kanpur, therefore, is not a local environmental issue but a regional development imperative (Das and Tamminga 2012; Srinivas *et al.* 2020). This means that analytical models of sustainable cleanup operations will need to integrate industrial regulation with regional planning, community participation, and continued financial and technical support from both state and central governments. This completes our discussion of unitization as a way of addressing water pollution in the Ganges in Kanpur, India.

7. Conclusions

In this paper, we theoretically examined the merits of a claim made recently in the literature that unitizing the tanneries that cause water pollution in the Ganges, can improve water quality in this same river. We first delineated the $n \geq 2$ polluting tanneries in Kanpur as a Cournot oligopoly and derived the equilibrium output of leather and profits. Second, we unitized $m < n$ tanneries and ascertained the cost function, assuming that the m tanneries could use their production facilities and that there were no other efficiency gains from unitization. Third, we examined when the m-firm unitization was profitable to the unitized entity and to the non-unitized tanneries. Fourth, we discussed the implications of unitization for the profitability of the two categories of tanneries and water pollution in the Ganges. Finally, we commented on some of the significant regional dimensions of the Ganges water pollution problem triggered by the tanneries in Kanpur.

The analysis in this paper can be extended in several ways. Here are two examples. First, it would be interesting to see how the results of this paper compare with the results obtained from an alternate model in which the total cost of production is not quadratic but linear with fixed and variable cost components. Second, it would be instructive to analyze whether the usefulness of unitization depends on the magnitude of the combined market share of the tanneries that a policy maker is seeking to unitize. Studies that analyze these aspects of the underlying problem will provide additional insights into the effects of unitization on the profitability of the merged and the non-merged tanneries and water quality in the vitally important Ganges River in India.

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