A Note on Public Goods Dependency*

By

Ravi Kanbur[#] and David Pottebaum[+]
Cornell University

January, 2002

Abstract. — Why are rich countries rich? One factor, which has support in the empirical literature, is that they have more public goods like infrastructure, which allows more productive patterns of production and distribution. However, it has rarely been remarked that precisely because their activities have adjusted to the higher supply of public goods, richer economies may be more dependent on them and therefore more vulnerable to their destruction. This paper develops a formal model to capture this basic intuition, and to derive testable implications of this perspective on public goods dependency—predictions which, we argue, have empirical support.

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[#] sk145@cornell.edu
[+] dap12@cornell.edu

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1. Introduction

Why are rich countries rich? One factor, which has support in the empirical literature, is that they have more public goods like infrastructure, which allows more productive patterns of production and distribution. Aschauer's (1989) influential study showed that U.S. productivity growth was largely determined by, *inter alia*, a core infrastructure of roads, airports, sewage, and water systems. Easterly and Rebelo (1993), in a cross-national study of data from more than 100 countries, found that investments in transport and communications were consistently correlated with economic growth. Canning, Fay and Perotti (1994, p. 144) found that infrastructure, particularly telephones and electricity, have a significant positive effect on growth rates.

Thus, public goods can be argued to be the foundation of the wealth of nations. However, it has rarely been remarked that precisely because their activities have adjusted to the higher supply of public goods, richer economies may be more dependent on them and therefore more vulnerable to their destruction. This paper develops a formal model to capture this basic intuition, and to derive testable implications of this perspective on public goods dependency.

Section 2 presents a model of two economies identical in every way except that one has solved the collective action problem in provision of public goods, which makes it richer directly but also indirectly through production patterns adjusting to the higher provision of public goods. Section 3 contemplates a catastrophe such as natural disaster or war which destroys public goods. The vulnerability of the two economies to this event

is assessed, and it is shown that under certain conditions the richer economy will lose more in absolute and in relative terms. Section 4 concludes with a discussion of the implications of these findings.

2. Model

Think of an island economy of farmers who have a choice between growing a food crop and a cash crop. The cash crop is grown because it can be exchanged for food and other goods by trade with the outside world. However, transporting the cash crop to the outside world is costly, especially if there are no modern port facilities. With a modern port the costs would fall, bringing increased net profit to producers. However, building the port requires up-front investment, which involves solving the collective action problem. If the economy manages to solve the collective action problem it can build the port, in which case it will adjust production to producing more cash crops, and become richer as a result. But if for some reason the port were to be destroyed, and the production patterns were difficult to change in the short run, then this economy would suffer a disproportional setback compared to an economy which did not have a port at all. It is these intuitions that our formal model is constructed to capture.

The model assumes that both food and cash crop production require a single input—land—which is available in fixed quantity. Let the farmers' food crop production function be $F(l_f)$ and the cash crop production function be $K(l_k)$, where total land allocated is $l = l_f + l_k$, and $F(l_f)$ and $K(l_f)$ have standard properties. Let food be the numeraire, and let q be the world price of the cash crop minus transportation costs (i.e., the net cash crop price received by the farmers).

Each farmer is assumed to maximize income:

$$\text{Max } y = F(l_f) + q\,K(l\text{-}l_f) \qquad [1]$$
$$l_f$$

with first order condition:

$$F'(l_f) - qK'(l - l_f) = 0 \qquad [2]$$

The standard properties of the production function ensure that the second order

conditions are met. Equation [2] defines the land allocation $l(q)$ as a function of q which

in turn gives us maximized income as a function of q, $y(q)$. Simple calculation

establishes that:

$$\frac{\partial l_f}{\partial q} = \frac{K'}{F''+qK''} < 0 \qquad [3]$$

$$\frac{\partial y(q)}{\partial q} = K(l - l_f(q)) > 0 \qquad [4]$$

Thus, an increase in the farm-gate price of the cash crop increases the land allocated to

the cash crop, and it increases farmer income as well.

Consider now the possibility of undertaking an investment in a port which, by

reducing transport and transactions costs, increases the farm-gate price of the cash crop.

Let the flow costs of the investment be denoted I, and let the higher farm-gate price be

$q_I > q$. We suppose that I is so large that no single farmer can afford it, but that if the N

farmers banded together to share costs, it would be worthwhile for every farmer. In other

words:

$$y*^{\text{r}}_{\text{n}} = y(q_{\text{I}}) - \frac{\text{I}}{\text{N}}$$

$$> y*^{\text{p}}_{\text{n}} = y(q) \qquad\qquad [5]$$

$$> y(q_{\text{I}}) - \text{I}$$

where $y*^{\text{r}}_{\text{n}}$ and $y*^{\text{p}}_{\text{n}}$ are incomes of farmers on the rich and poor islands net of public goods costs, in "normal" times (denoted by subscript n).

Thus, the wealthier island is wealthy because it has managed to solve the collective action problem in providing the public good. But what would happen if this public good were to be destroyed overnight?

3. Dependency

To formulate the notion of dependency, consider some sort of catastrophe which destroys production capability *and* the public good. What are the effects on producers on these two islands? First, farmers on both the rich and poor islands incur direct costs due to the catastrophe. For simplicity we assume that this is a fixed amount, denoted θ, and both wealthy and poor farmers incur the same loss. But, the catastrophe also destroys each island's stock of public goods. As a result, the net cash price received by farmers on the rich island is reduced from q_I to q, but we assume that they cannot quickly change their production decisions to match changing market conditions. In contrast, farmers on the poor island do not suffer this consequence: they are poor because they do not have public goods, but for this very reason they are less vulnerable to their destruction.

The incomes of farmers on the poor and wealthy islands after the catastrophe (denoted by subscript w for "war") are therefore:

$$y^{*p}_{w}(q) = F(l_f(q)) + qK(l - l_f(q)) - \theta \qquad [6]$$

$$y^{*r}_{w}(q) = F(l_f(q_I)) + qK(l - l_f(q_I)) - \frac{I}{N} - \theta \qquad [7]$$

Note that the incomes of farmers on the wealthy island are reduced not only by the direct impact of war as indicated by θ, but also indirectly by the reduction in price from q_I to q. The impact of war on producers on each island can be calculated by subtracting income during the war period from income during normal periods:

$$\Delta^{p}_{n,w} = y^{*p}_{n}(q) - y^{*p}_{w}(q) = \theta \qquad [8]$$

$$\Delta^{r}_{n,w} = y^{*r}_{n}(q_I) - y^{*r}_{w}(q) = (q_I - q)K(l - l_f(q_I)) + \theta \qquad [9]$$

Equations [8] and [9] say that the costs of war are greater in absolute terms for farmers on the wealthy island than for those on the poor island. Is the impact of war proportionately greater for farmers on the wealthier island as well? From [8] and [9]:

$$\frac{\Delta^{r}_{n,w}}{y^{*r}_{n}} \gtreqless \frac{\Delta^{p}_{n,w}}{y^{*p}_{n}}$$

$$<=>\qquad [10]$$

$$\frac{(q_I - q)'K(l - l_f(q_I))}{\theta} \gtreqless \left[\frac{y^{*r}_{n} - y^{*p}_{n}}{y^{*p}_{n}} \right]$$

Thus, if the indirect loss of income to the rich country, through loss of the public good, is significantly larger than the direct cost of the catastrophe, rich economies will lose proportionately more.

Pottebaum and Kanbur (2001) present evidence that supports the conclusion that poorer countries lose less during war, absolutely and proportionally, than do wealthier countries. In their study of socio-economic data for 102 countries (43 of which were affected by civil war) between 1960 and 1999, Pottebaum and Kanbur found that infant survival, life expectancy, school enrollment, literacy and real per capita income fell further during war in middle-income countries than in low-income countries. The results of regression analysis provided additional support: a *conflict* variable interacted with per capita income was found to be a significant and negative determinant of social welfare. That is, the wealthier the country in terms of per capita income, the greater the losses in social welfare during war.

What does this model tell us about how producers on wealthy and poor islands might respond in the aftermath of war or natural catastrophes? Clearly, the incomes of farmers on both islands will increase by Θ when war concludes. But in the short run public goods cannot be built up quickly. The incomes of rich and poor countries will reflect this. This is shown by the following income equations of the poor and wealthy nations (with the subscript pc denoting post-catastrophe or post-conflict):

$$y^{*p}_{pc}(q) = F(l_f(q)) + qK(l - l_f(q)) \qquad [11]$$

$$y^{*r}_{pc}(q) = F(l_f(q_I)) + qK(l - l_f(q_I)) - \frac{I}{N} \qquad [12]$$

The change in income from war to post-conflict is:

$$\Delta^{p}_{w,pc} = y^{*p}_{pc}(\Pi) - y^{*p}_{w}(\Pi) = \theta \qquad [13]$$

$$\Delta_{w,pc}^{r} = y_{pc}^{*r}(\Pi) - y_{w}^{*r}(\Pi) = \theta \qquad [14]$$

From [13] and [14], the nominal change is identical for farmers on both wealthy and poor islands. In this case, the proportional change (improvement) is clearly greater for farmers on the poor island because they are starting at a lower base (i.e.,

$y_{w}^{*r}(q) > y_{w}^{*p}(q)$).

Pottebaum and Kanbur (2001) again provide evidence to support this prediction for the case of civil war. Using the same 102 country data set, they find that *after war* wealthier countries tend to rebound more slowly, both absolutely and proportionately, than do poorer countries. Again, the results of analyses using indices for infant survival, life expectancy, literacy, school enrollment, and per capita income provide strong support for this conclusion. The results of regression analysis found that a *conflict history* variable interacted with per capita income is a significant and negative indicator of social welfare. That is, after war, conflict history weighs more heavily on social welfare in wealthier than in poorer countries. In addition, Pottebaum and Kanbur (2001) find that the longer the war, the greater the difference in post-war social welfare performance between average low- and middle-income countries.

4. Conclusion

The model is this note captures a basic intuition that those economies whose wealth is founded on public goods will also be more vulnerable to their destruction. One testable implication of this perspective is that in the event of a catastrophe like natural disaster or war, richer economies will suffer more in absolute and proportional terms. A

second testable implication is that the short term rebound from the catastrophe will be stronger in the poorer economy—the one less dependent on public goods. These predictions are indeed confirmed empirically by data on the consequences of civil war (Pottebaum and Kanbur 2001).

At the theoretical level, our model raises an intriguing question. If choosing a higher level of public goods brings vulnerability along with greater wealth, will not societies take this into account in their initial decision? Moreover, if the likelihood of catastrophe can itself be reduced by appropriate investment, we have a joint problem of choosing public goods and the optimal degree of vulnerability to them. Formal modeling of this interaction could be useful, for example, in understanding the stylized fact that richer economies have fewer civil wars than do poor ones. This is a topic for further research.

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