WATER AND GROWTH

So far we have looked at water as input to industrial production.

Now we want to consider the possibility of (an improved supply of) water as a cause of (increased) industrial production and economic growth.

In other words, if one invests in the creation of an additional water supply, will this trigger additional economic growth?

There are numerous ways in which an increment in access to water might produce benefits, whether to those who use the water directly or to others.

A key tool used by economists in formalizing many of these benefits is the concept of a production function.

A production function is conceived as an empirical, causal relationship between the levels of inputs required to produce an output, or an outcome, and the level of output or the outcome that results.

E.g., the production function for an industrial or agricultural output as a function of water and other inputs to the production process

A *health production function* relating inputs (including behavior patterns and levels of resource availability) to the production (attainment) of health status outcomes

An *ecological production function* relating inputs and resource endowments to the production (attainment) of ecosystem outcomes.

However, while the notion of a production function is undoubtedly useful as a conceptual tool for organizing one's thought about these matters, it may work less well as a dependable empirical construct.

The production function may work better on a micro-scale (i.e. at a factory level) rather than at the level of an entire regional economy

It implies a notion of causation that may be oversimplified.

In practice, it can often turn out to be surprisingly difficult to measure a production function on a regional scale or, more generally, to measure the specific increment in benefits associated with an increment in water availability; these difficulties are clearly evident in the literature on water and economic development.

The notion that water supply contributes to economic growth and development seems intuitively obvious. After all, it is known that many of the world's major cities owe their origin to their location along coasts or rivers where water-borne transportation was facilitated.

But, the relevant question is whether an increment in water availability now would generate an increment in economic activity now, and how much.

In the USA, federal water projects have long been advocated for their claimed contribution to regional economic development. However, the actual empirical evidence is less obvious and more negative.

As Howe (1968) noted, in industrial processes, water costs are a relatively small fraction of total production costs even in water-intensive industries, and there are many examples of firms in such industries choosing to locate plants in water deficient areas because of market or non-water input considerations.

In the USA in the late 1960s, there was a flurry of efforts to conduct formal, ex post statistical analyses of the impact of water availability on economic development; the findings were generally quite negative.

The studies were motivated in part by Bower's (1964) hypothesis that the availability of water at the intake end and/or the effluent end is not a major factor in *macro-location* decisions of industry relating to location in major geographical areas or regions, such as river basins, but it can be a major determinant of *micro-location* decisions relating to location within the region or basin.

Ben-David (1966) found that employment in the major water-intensive industries was not significantly related to a measure of water availability in a cross-section regression of USA states, but there was a significant positive impact at the county level in a regression of counties within Pennsylvania.

Howe (1968) extended this analysis to include all the counties in the USA, and found the evidence for such an effect to be extremely limited.

Cox *et al*. (1971) examined counties in the Northeastern USA in which large water projects had been constructed between 1948 and 1958, and found no relationship between project size and economic growth over the period 1950–1960.

By contrast, Garrison & Paulson (1972) examined counties in the Tennessee Valley region and found a significant micro-location relation between water-oriented manufacturing employment and a measure of water availability.

At the macro-location level, Carson *et al*. (1973) sampled counties in geographic sub-regions from all parts of the country, both rural and urban, and found no significant relationship between federal water resource projects and population growth.

Cicchetti *et al*. (1975) extended this study using economic sub-regions as the unit of analysis and found that variables representing federal investment in irrigation facilities had no significant impact on regional income and growth, and only a small and not convincingly significant impact on the value of farm output. There was some relationship between economic growth and federal investments in flood control, hydropower and recreation, but the coefficients were often unstable.

A similar study by Fullerton *et al*. (1975) of counties in seven western states found no relationship between water investment and economic growth.

It seems clear that an investment in water supply does not automatically guarantee economic growth.

But, what conclusion can be drawn? Is there *never* an economic case for investing in water supply?

I want to suggest that part of the problem arises from the inadequate concept of causation that is being utilized by economists in conceptualizing the notion of a production function.

The philosophy literature makes a distinction between necessity and sufficiency: *X* could be a necessary but not sufficient condition for *Y* to occur, or it could be a sufficient but not a necessary condition.

This distinction is generally ignored in the economic literature, including both the theoretical and empirical analyses of the relationship between water and growth.

The production function as conventionally formulated as a relationship along the lines of $Y = f(X, Z, ...)$, implies that *X*, *Z* and the other factors on the right-hand side of the equation are each a *sufficient* condition for producing *Y*: changing any individual element *X* or *Z* is sufficient to induce a change in the value of *Y*.

Similarly, the conventional forms of regression equation used in the statistical literature imply that the regressors are each sufficient conditions for a change in the dependent variable.

However, the true relationship may be different, and perhaps more complicated.

It seems plausible that having an adequate supply of water might be a necessary but not a sufficient condition for economic growth.

While water does not automatically generate growth, it may be the case that areas which persist in lacking an adequate water supply (regardless of whether or not they started out with adequate water) will not flourish economically. For example, one can expect that people will eventually leave those areas and migrate to other areas that do have an adequate water supply. Thus, lack of water could be a sufficient condition for economic decline or, to put it another way, water may be a necessary but not sufficient for economic growth.

But, this is not a relationship that is captured in the existing formulations of production functions and regression equations.

In fact, the relationship between water and growth might be even more complicated. It may be that there are *multiple* possible causal pathways, such that while there is some causal linkage between water and growth, the linkage is sufficiently imprecise and variable that water is neither a necessary nor a sufficient condition for growth. In effect, there is *sometimes* a causal linkage, but not always. If this is so, it would require a new formalism to express this type of relationship.