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IMPLICATIONS FOR ECONOMIC AND POLICY ANALYSIS**

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Sunk Costs and Resource Mobility: Implications for Economic and Policy Analysis

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Abstract: The implications of sunk costs for many key questions in agricultural economics have yet to be explored. This paper uses a dynamic model of investment behavior to explore how sunk costs can shape market outcomes in ways that might not match predictions of standard competitive models. Applying the model to several key issues in agricultural markets and international trade offers new perspectives that challenge conventional wisdoms. Institutional and policy innovations are also examined for their potential to improve welfare outcomes when sunk costs impede factor mobility.

Key words: Sunk costs, irreversibility, uncertainty, investment, entry, exit, market performance

SUNK COSTS AND RESOURCE MOBILITY: IMPLICATIONS FOR ECONOMIC AND POLICY ANALYSIS

Unfettered resource mobility is crucial in obtaining a Pareto optimal allocation of resources in a Walrasian economy. Accordingly, government interventions in markets are often seen as distorting or restricting the fluid movement of resources, thereby limiting the effectiveness of competitive markets to achieve an efficient allocation. Recently, the inherent mobility of a broad class of resources, including many investments in physical and human capital, has been questioned by a large body of theoretical and empirical research on sunk costs and market performance (Baldwin and Krugman; Chavas; Dixit and Pindyck; Pindyck; Sutton; Tirole). Sunk costs occur whenever investment costs cannot be fully recovered in the case of later disinvestment. The resulting immobility of capital resources raises questions about the efficiency of markets and the role of private and public institutions in mitigating the ill effects of sunk costs.

The effects of sunk costs and imperfect resource mobility on the agricultural and food sector warrant more attention than they have received to date. While Johnson and Quance's seminal work on "asset fixity" raised the issue, the implications of sunk costs for many key questions in agricultural economics remain unexplored. This paper focuses on agricultural markets and trade policy, showing how sunk costs can distort economic outcomes and how institutional and policy innovations might improve welfare outcomes when sunk costs impede factor mobility.

Section II reviews the causes of sunk costs and, in the process, suggests why they may be more prevalent than commonly perceived by economists. Section III presents a dynamic model of investment behavior in the presence of sunk costs. The outcomes are distinct from those of a standard competitive model. Section IV considers when sunk costs are, and are not, subject to

management by private or public agents. Sections V and VI explore how sunk costs could affect agricultural market performance and trade policy. Section VII concludes.

II. The Meaning and Origins of Sunk Costs

An investment is considered sunk, when once undertaken it cannot be fully recovered through transfer or sale. The extent of sunk costs therefore depends on the difference between the value of the original investment (minus any depreciation) and its salvage value - resale or transfer price. What factors increase original investment costs or reduce salvage values?

(1) Physical characteristics of investments that make it specific to a given site, time, firm, or industry are perhaps the most well known cause of sunk costs.

- (a) An investment is site-specific when its physical features make it costly to install, remove, or relocate as is the case for structures and infrastructure.
- (b) An investment is time-specific when its value deteriorates sharply after a given time period (e.g., perishables, or inputs with time-sensitive productivity).
- (c) An investment is firm or industry-specific when its features make it costly to retrofit or transfer it to other firms or industries. In many cases, even slight adjustments of the product or service produced by a given investment may require major adjustment costs that reduce its salvage value.

(2) Transaction costs are an important source of sunk costs, as they can increase original outlays and reduce salvage values. Examples are: worker hiring, training, and retention, negotiating transfers, transportation costs, informational asymmetries among buyers and sellers, and accumulated experience or goodwill with suppliers or buyers.

(3) The Investment Package Effect arises when a given investment is vital to the salvage value of other investments. Thus, even if it can be transferred at a high salvage value, its mobility may be limited by its role in the salvage value of other investments.

(4) The Same Boat Effect occurs when the simultaneous efforts of economic agents to sell off similar investments drive down salvage values, thereby increasing sunk costs. This effect is most likely when down-side risks in an industry or region are widely felt, and prompt agents to sell off what might otherwise be readily transferable investments.

The likely presence of positive gaps between the original value and salvage value of investments makes sunk costs a more common feature than is often recognized in economic analysis. The effects of sunk costs on resource allocation are explored next.

III. The Economics of Sunk Costs

Consider an agent involved in an economic activity requiring an investment decision. Let x_t be the amount of investment made by the agent at time t . This investment contributes to increasing the amount of capital controlled by the agent, as given by the following state equation:

$$y_t = (1-\delta) y_{t-1} + x_t \geq 0, \quad (1)$$

where y_t is the amount of capital at time t , and δ is the depreciation rate of capital. In the case where capital y_t is a necessary input for a given economic activity, then $y_t > 0$ ($= 0$) means that the agent participates (does not participate). Then, the agent enters at time t whenever $y_{t-1} = 0$ and $y_t = 1$. Alternatively, the agent exits at time t when $y_{t-1} > 0$ and $y_t = 0$. Understanding the agent's investment behavior provides all the information needed to understand his/her entry-exit behavior.

At time t , the agent generates profit $\pi_t = R(y_t, e_t) - C(x_t)$, where $R(y_t, e_t)$ denotes revenue, e_t is a random vector reflecting revenue uncertainty faced by the agent at time t , and $C(x_t)$ denotes cost. Substituting equation (1) into the cost function yields $\pi_t = R(y_t, e_t) - C(y_t - (1-\delta) y_{t-1})$. The agent's budget constraint is:

$$w_t = A(w_{t-1}) + R(y_t, e_t) - C(y_t - (1-\delta) y_{t-1}) - z_t, \quad (2)$$

where w_t is the agent monetary wealth at time t , $A(w_{t-1})$ is the return at time t on wealth w_{t-1} , and z_t is a consumption good assumed to have unit price.

Let the objective function of the agent at time $t = 0$ be represented by the expected utility $E_0 \sum_{t=1}^T \beta^t U_t(z_t)$, where E_0 is the expectation operator based on the information available at time $t = 0$, T is the length of the planning horizon, β is the time-preference discount factor ($0 < \beta < 1$),

and $U_t(z_t)$ is the agent's von Neumann-Morgenstern utility function at time t . The agent's economic rationality is then represented by the optimization problem

$$V_0(w_0, y_0) = \max_{\{z_t, y_t, x_t, w_t\}} \{E_0 \sum_{t=1}^T \beta^t U_t(z_t) : \text{subject to (1) and (2)}\}.$$

This can be expressed as the following dynamic programming problem:

$$(3) \quad V_t(w_{t-1}, y_{t-1}) = \max_{z_t, y_t} \{E_t U_t(z_t) + \beta E_t V_{t+1}(A(w_{t-1}) + R(y_t, e_t) - C(y_t - (1-\delta)y_{t-1}) - z_t, y_t)\},$$

$t = T, T-1, \dots, 2, 1$, where $V_t(w_{t-1}, y_{t-1})$ is the value function, and E_t is the expectation operator based on the information available to the agent at time t . Equation (3) is Bellman's equation defining $V_t(w_{t-1}, y_{t-1})$ recursively from backward induction.

We consider here the case where the investment decision x_t is unrestricted in sign: it can be positive ($x_t > 0$) when the agent invests, zero ($x_t = 0$) when the agent is inactive in the capital market, or negative ($-(1-\delta)y_{t-1} \leq x_t < 0$) when the agent disinvests at time t . We make the following assumption concerning the cost function $C(x, \cdot)$.

Sunk Cost Assumption: The cost function $C(x, \cdot)$ satisfies:

$$[\partial C / \partial x \text{ given any } x > 0] \text{ is greater than } [\partial C / \partial x \text{ given any } x < 0], \text{ and} \quad (A1)$$

$$C(x, \cdot) > |C(-x, \cdot)| \geq 0 \text{ for any } x > 0. \quad (A2)$$

A(1) and A(2) simply state that the cost of acquiring capital is always larger than the value of its disposal. This difference represents sunk costs, and might stem from a transaction cost associated with the transfer of the capital. Our assumption implies that investment cost is (at least partially) sunk both in terms of marginal cost (as stated in (A1)) and in terms of total cost (as stated in (A2)).

The first-order conditions for an interior solution with respect to (z_t, y_t) in (3) are:

$$\partial E_t U_t / \partial z_t - \beta \partial E_t V_{t+1} / \partial w_t = 0, \text{ and} \quad (4a)$$

$$\partial E_t V_{t+1} / \partial y_t - (\partial E_t V_{t+1} / \partial w_t)(\partial C / \partial x_t) = 0. \quad (4b)$$

Assuming $(\partial E_t U_t / \partial z_t) > 0$, substituting (4a) into (4b) yields the following optimal investment rule

$$\beta (\partial E_t V_{t+1} / \partial y_t) / (\partial E_t U_t / \partial z_t) = \partial C / \partial x_t. \quad (5)$$

This is the standard neo-classical result stating that, at the optimum, the marginal present value product of capital, $\beta (\partial E_t V_{t+1} / \partial y_t) / (\partial E_t U_t / \partial z_t)$, must equal the marginal cost of investment, $\partial C / \partial x_t$.

What are the implications of this decision rule when investment is (at least partially) sunk? Under sunk costs, equation (5) generates four possible investment regimes depending on the level of marginal present value of capital, $\beta (\partial E_t V_{t+1} / \partial y_t) / (\partial E_t U_t / \partial z_t)$ and the gap between original investment cost and its salvage value. These are illustrated in Figure 1, where the investment marginal cost is equal to the unit purchase price p under investment ($x_t > 0$), and to the salvage value s under disinvestment ($x_t < 0$), with $p > s$. In regime 1, the marginal value product of capital is high and cuts the investment marginal cost curve in the positive region, implying that it is optimal for the agent to invest ($x_t^1 > 0$). In regime 2, the marginal value product of capital is at an intermediate level. The agent has no incentive to invest or disinvest ($x_t^2 = 0$). In this zone of "asset fixity", the agent's behavior is unaffected by small changes in the economic environment because of the gap between the original cost and the salvage value of investing. In regime 3, the marginal value product of capital is low, and the agent disinvests ($-(1-\delta)y_{t-1} < x_t^3 < 0$). Finally, regime 4 corresponds to a very low marginal product of capital, where total disinvestment leads to the agent's exit ($x_t^4 = -(1-\delta)y_{t-1}$).

The first important implication of this analysis is the existence of a "zone of asset fixity" (corresponding to regime 2). In this zone, it is optimal for the agent not to react to economic signals. As such, the agent has no economic incentive to participate in the capital market.

The second implication concerns the nature of dynamic adjustments. Sunk costs generate irreversible behavior and hysteresis. Hysteresis is characterized by irreversible effects

where particular changes are not reversed after their original cause is removed. To illustrate, consider an agent that is in regime 2 in period t , in regime 1 in period $t+1$, and back in regime 2 in period $t+2$. This agent would make an investment in period $t+1$, but would not disinvest in period $t+2$, even though the original signal that had generated the incentive to invest in $t+1$ was reversed in $t+2$.

The third implication relates to the adverse effects of risk on investment under sunk costs (see Dixit and Pindyck; Chavas). The arguments go as follows. Consider a situation where an investor has a positive probability of exiting during her planning horizon. In the presence of sunk costs, this means that the investor faces a positive probability of paying the sunk cost in the case of later disinvestment: the larger the sunk cost, the higher the probability of facing them, the stronger the disincentive to invest. This implies the existence of key interactions between risk and sunk cost, as they adversely affect investment incentives. Such effects can hold irrespective of the agent's risk preferences and across a wide range of economic environments (Chavas).

The fourth implication is a corollary to the third. To the extent that entry requires investment, it follows that sunk cost and risk interact with each other to provide negative incentives to enter. In other words, sunk cost and risk constitute entry barriers under very general conditions.

The fifth implication concerns the incentive to exit. Consider an agent who is disinvesting (exiting) and has a positive probability of reinvesting (re-entering) over the rest of her planning horizon. In the presence of sunk costs, the agent will have a positive probability of facing the sunk cost in the case of later reinvestment (re-entry): thus, the larger the sunk cost, the higher the probability of facing them, the less the incentive to disinvest (exit). This reveals another vital interaction between risk and sunk costs, which is they reduce the incentive to disinvest and to exit.

Sunk costs and risk interact to reduce resource mobility, as they adversely affect both the incentive to invest and/or enter and the incentive to disinvest and/or exit. In this sense, sunk cost and risk are sufficient conditions to invalidate the standard competitive market equilibrium. Since such conditions appear prevalent in the real world, this suggests a need to examine in more detail their implications for resource allocation, contract and institutional design, and policy prescription.

IV. The Management of Sunk Costs

Knowing that interactions between sunk costs and risk adversely affect resource allocation raises two issues, namely: are sunk costs and risks subject to management? If so, how and by whom?

First, sunk costs may be subject to private management. For example, private investment in education and training can reduce the specificity of human capital and thus improve the mobility of labor. Another example is the use of private contractual arrangements that reduce the uncertainty associated with sunk assets. Examples in agriculture include production and marketing contracts or vertical integration schemes commonly found in the fruit and vegetable industry. In these cases, contracts appear to be a superior means of allocating resources compared to markets, primarily because contracts are more effective in controlling quality and managing timeliness, especially for perishable products whose value is totally sunk outside a narrow time window.

Second, sunk costs may be subject to public management. A simple example is the case of transportation costs, which can be reduced by public investment in infrastructure. Another is public investments in education, training, research and/or market information. The case of sunk investments in research and information collection is especially interesting, because information acquisition efforts can involve major sunk costs and uncertainty for private agents (e.g. developing country efforts to reverse engineer new technologies). Government support for such

investments, via coordination and assistance with inter-firm information sharing, can reduce the sunk costs and uncertainty involved, stimulating investment in learning and increasing resource mobility and productivity improvements (see Pack and Westphal for the case of East Asia).

Third, in some cases sunk costs may not be subject to direct public or private management, yet they may be manageable indirectly by reducing the probability that agents will face them. In other words, one way of managing the adverse effects of resource immobility is to reduce the downside risk exposure of agents most affected by sunk costs. Examples include private insurance, social "safety nets" (including food aid and welfare programs), price support programs (e.g. minimum wage legislation), and limited liability rules. Properly targeted, such programs reduce exposure to downside risk and limit the adverse effects of sunk costs on resource allocation.

V. Sunk Costs and Agricultural Economics

Agriculture has considerable potential for sunk costs. Investments in land, building and equipment, crops, animals, and human capital are all, to varying degrees, sunk. The implications for farm sector performance may be far reaching. We briefly consider five such implications:

1. **New technology adoption** requires investments in learning, management, equipment, and new relationships, all of which involve some irreversibility and uncertainty. The extent depends on inherent features of the new technology and the price-cost conditions of the activity to which the technology is applied. Saha *et al.* and Purvis *et al.* explore the adoption-discouraging effects of irreversibility and uncertainty. Arguably, some of U.S. agriculture's impressive productivity growth since the 1950's stem from investments in technologies enabled by the downside-risk reducing effects of commodity price floors.

2. **The entry and exit behavior of farmers** are likely to be subject to implications 4 and 5 from section III; i.e., adjustment processes may be slow in agricultural activities where sunk costs and uncertainty are present. Thus, during the price and profitability decline suffered by U.S. agriculture in the 1980s, incumbent farmers were probably less likely to exit farming as they would have been in the absence of sunk costs. Alternatively, in recent years, potential entrants may have been discouraged by the growing downside risk associated with declining government price supports. Indeed, unless other risk-reducing institutions emerge as substitutes, in the future there could be a period of high prices and profits before entry and investments are sufficient to expand supply and bring prices down.

3. Prices of activities with high sunk costs are likely to be more volatile than those with low sunk costs. Structuralists have long argued that primary product prices are more volatile than other sectors because of their inelastic demand and supply. Section 3 reveals the microfoundations of investment behavior by incumbent firms and potential entrants that underly supply inelasticity and hence the likelihood of larger and longer price swings.

4. Free markets may not be optimal in agriculture under uncertainty. For the reasons given above, price floors or better futures markets can provide pareto-improving insurance against downside risk that in turn encourages outcomes with less underinvestment. Indeed, a price floor that is non-binding "on average" can offer significant insurance against downside risk, and stimulate additional entry and investment in a sector. As Dixit and Pindyck argue, government price support programs could, in this manner, ironically give rise to a "cheap food" outcome by increasing investment and lowering long-run prices.

5. Sunk costs help to explain the persistence of "family farms." If agriculture is prone to high levels of sunk costs and uncertainty, family farms are wrought with them. Not only are investments in land, buildings, equipment, and business relations often sunk, but the human capital of the asset owners may also be sunk. Returns to capital and labor are thus all tied up in the family farm, making easy adjustments to price signals unlikely. This feature may help to explain the persistence and resilience of family farms worldwide under varying economic conditions, both within a generation and across generations.

VI. Sunk Costs and International Trade

There are also a set of core issues in international economics where conventional wisdoms may be challenged by incorporating imperfect resource mobility associated with sunk costs and uncertainty. We present three brief examples.

1. Import protection can provide the basis for export promotion when sunk costs are present (Brander and Spencer, Krugman). Preemptive commitments to a sector by one country can in turn lower the returns to sunk investments in that sector for other countries. This first-mover advantage can be especially valuable as a basis for export promotion if the sector has increasing returns to scale, either internal or external, to firms.

2. Export promotion can induce overinvestment and adjustment problems when sunk costs are present. Overinvestment can result from direct subsidy of sunk costs or the "overinsuring" of investments in export-oriented activities. The prevailing enthusiasm in international development and trade circles for export-led growth strategies could lead countries to (over)encourage investments in sectors with high levels of sunk costs and uncertainty. This problem could be especially acute for small

countries with a strong reliance on one or two sectors with high sunk costs (Barham and Coomes).

3. Trade liberalization may shift returns in favor of capital and against labor because of labor's relative immobility. If common arguments regarding capital's relative mobility are correct, then one reason for recent declines in wage/rental rates in developed countries could be higher levels of sunk costs for labor (related to labor market skills and location commitments. If the origin of external economies (a core mechanism in endogenous growth models) is in the skills and training of labor, then the investment-discouraging effects of labor's immobility could be a cause for both growth and distributional concerns.

VII. Conclusion

Using a highly general model of individual investment behavior, we demonstrate three crucial points. First, sunk costs and uncertainty generate investment outcomes that are distinct from those predicted by standard competitive models and thus call into question the efficiency of markets where the ill effects of the imperfectly mobile resources are not managed. Second, depending on the circumstances of a given investment decision, the problem of sunk costs may be subject to direct or indirect management by private or public agents. Third, conventional wisdoms in agricultural economics and trade policy may be shaken once the implications of sunk costs and uncertainty for investment behavior, market performance, and policy options are better understood. We believe that a similar statement could be made for almost any field in economics.

This paper only illustrates some of the many possibilities for further research. The issue of whether sunk costs can be managed and by whom is fundamental, and similar to the agnosticism expressed by many others we view public efforts to solve market problems as prone to information problems and institutional imperatives of their own. However, the degree to which sunk costs can, and do, shape economic performance in ways not predicted by standard competitive models should be the initial research priority; for it is only after we understand more

about potential and observed outcomes that the fundamental issues of institutional and policy design can be carefully examined.

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Figure 1 - Investment Behavior under Sunk Cost:

