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

INTRODUCTION

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, 1989; Chavas, 1994; Dixit and Pindyck, 1994; Pindyck, 1991; Sutton, 1991; Tirole, 1989; Dixit, 1992). Sunk costs occur whenever investment expenditures cannot be fully recovered in the case of later disinvestment. The resulting immobility of capital 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 (1972) raised the issue in their seminal work on 'asset fixity', 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 they can distort economic outcomes and how institutional and policy innovations might improve welfare outcomes when factor mobility is impeded.

Initially, the paper will review the causes of sunk costs, suggesting reasons why they may be more prevalent than is commonly perceived by economists. Discussion of a dynamic model of investment behaviour in the presence of sunk costs, giving different outcomes from those of a standard competitive model, will follow. The next section considers when sunk costs are, and are not, subject to management by private or public agents. The paper concludes with an exploration of the way sunk costs could affect agricultural market performance and trade policy.

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THE MEANING AND ORIGINS OF SUNK COSTS

An investment cost is considered sunk when it cannot be fully recovered through transfer or sale once the investment has been undertaken. 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?

Physical characteristics of investment that make it specific to a given site, time, firm or industry are perhaps the most well known cause of sunk costs. An investment is site-specific when its physical features make it costly to install, remove or relocate, as in the case of structures and infrastructure. It is time-specific when its value deteriorates sharply after a given time period (as with perishables, or inputs with time-sensitive productivity). It is firm or industry-specific when its features make it costly to retrofit or transfer 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.

Secondly, *transaction costs* are an important source of sunk costs, since they can increase original outlays and reduce salvage values. Examples are worker hiring, training and retention, negotiating transfers, transport costs, informational asymmetries among buyers and sellers and accumulated experience or goodwill with suppliers or buyers.

Thirdly, *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.

Finally, *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 is a more common feature than is often recognized in economic analysis and needs to be explored.

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:

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

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, $y_t > 0$ (= 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 behaviour provides all the information needed to understand entry–exit behaviour.

At the 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 function yields $\pi_t = R(y_t, e_t) - C(y_t - (1 - \delta)y_{t-1})$. The agent's budget constraint is:

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

where w_t is the agent's 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 be represented by the expected discounted utility $E\Sigma_{t=1}^{T}\beta^t U_t(z_t)$, where E is the expectation operator, T is the length of the planning horizon, β is the time-preference discount factor ($0 < \beta > 0$) and $U_t(z_t)$ is the agent's von Neumann–Morgenstern utility function at time t. This allows for risk neutrality (when $U_t(z_t)$ is linear) as well as risk aversion (when $U_t(z_t)$ is strictly concave). The agent's economic rationality is then represented by the maximization of $E\Sigma_{t=1}^{T}\beta^t U_t(z_t)$, subject to equations (1) and (2). Assuming learning over time, this can be expressed as the following dynamic programming problem:

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

$t = T, T-1, \ldots, 2, 1$, 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.

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 ($-(1 - \delta)y_{t-1} \le x_t < 0$) when the agent disinvests at time t. The following assumption is made about the cost function $C(x, \cdot)$.

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

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

and

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

(A1) and (A2) 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)). This is illustrated in Figure 1, where

$$\begin{aligned} C(x) &= px \quad \text{if } x \geq 0, \\ &= sx \quad \text{if } x < 0, \end{aligned}$$

p being the unit purchase of price of x, s being the unit selling price (or salvage value) of x and $p > s$. Then $(p - s)$ is the *unit sunk cost of investment*, that is the unit cost of investment that cannot be recovered in the event of a later disinvestment.

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

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

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

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

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

This is the *standard neoclassical 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? Assuming that the random variable e_t becomes observable at time t, its realized value e_t shifts $E_t V_{t+1}$. It follows that the marginal value of capital shifts in some unpredictable fashion over time. Equation (5) then generates four possible investment regimes at time t, 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 behaviour 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 ($x_t^4 = -(1-\delta)y_{t-1}$).

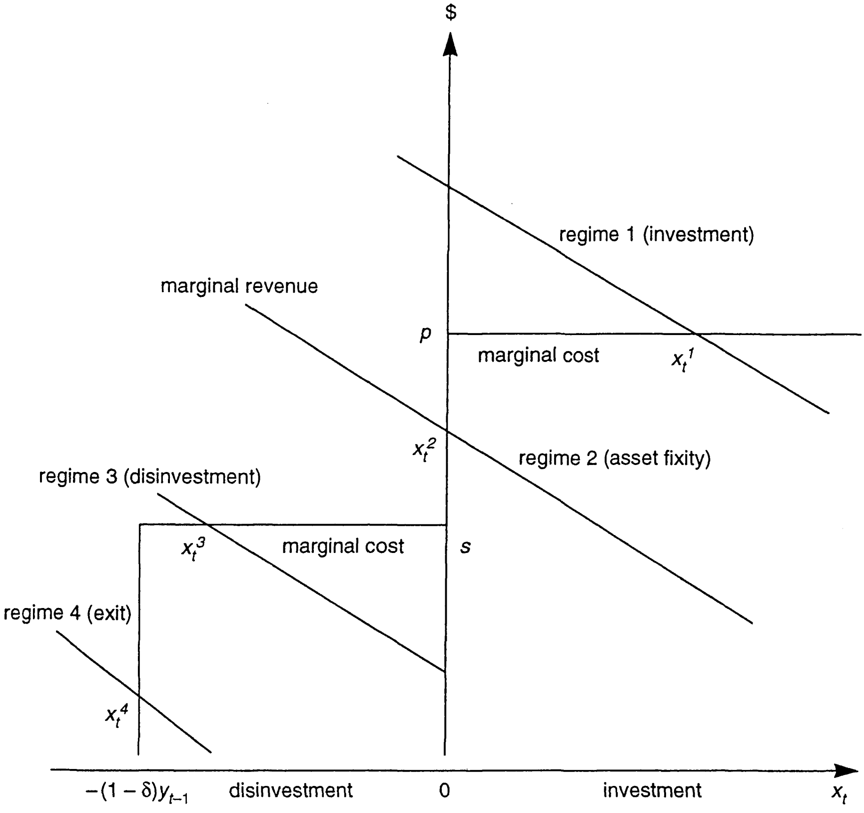

FIGURE 1 *Investment behaviour under sunk costs*

The first implication of this analysis is the existence of a 'zone of *asset fixity*' corresponding to regime 2 (Johnson and Quance, 1972), where it is optimal for the agent not to react to economic signals. Consequently, the agent has no economic incentive to participate in the capital market.

The second concerns the nature of dynamic adjustments. Sunk costs generate *irreversible behaviour* 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 in regime 2 in period t, in regime 1 in period $t + 1$, and back in regime 2 in period $t + 2$. There would be an investment in period $t + 1$, but no disinvestment in period $t + 2$, even though the original signal generating 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, 1994; Chavas, 1994). Consider a situation where an investor has a positive probability of exiting during the planning horizon. In the presence of sunk costs, this means that the investor also faces a positive probability of paying the sunk cost in the case of later disinvestment: the larger the sunk cost and the higher the probability of facing them, the stronger is the disincentive to invest. This implies the existence of key interactions between risk and sunk cost as adversely affecting investment incentives. Such effects can hold irrespective of the agent's risk preferences and across a wide range of economic environments (Chavas, 1994).

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 relates to the incentive to exit. Consider an agent who is disinvesting (exiting) and has a positive probability of reinvesting (re-entering) over the rest of the 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 in that *they reduce the incentive to disinvest and to exit.*

Sunk costs and risk interact to *reduce resource mobility* since 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.

THE MANAGEMENT OF SUNK COSTS

The knowledge that interactions between sunk costs and risk adversely affect efficient resource allocation raises two issues, namely whether sunk costs and risks are subject to management and if so, how and by whom.

Firstly, 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 labour. Another example is provided by the use of private contractual arrangements which 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 with reliance on typical produce markets, primarily because contracts are more effective in controlling quality and managing timing, especially for perishable items.

Secondly, sunk costs may be subject to public management. A simple example is the case of transport costs, which can be reduced by public investment in infrastructure. Another is public investment in education, training, research and market information. The case of sunk investments in research and information collection is especially interesting because efforts to acquire information can involve major sunk costs and uncertainty for private agents, especially those in developing countries. 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, 1986, for discussion of the case of East Asia).

Thirdly, in some cases sunk costs may not be subject to direct public or private management, yet they may be made manageable indirectly by reducing the probability that agents will have to face them. In other words, one way of managing the adverse effects of resource immobility is to reduce the exposure to down-side risk problems faced by agents most affected by sunk costs. Examples include private insurance, social 'safety nets' (including food aid and welfare programmes), price support programmes (such as minimum wage legislation) and limited liability rules. Properly directed, such features reduce exposure to down-side risk and limit the adverse effects of sunk costs on resource allocation.

SUNK COSTS AND AGRICULTURAL ECONOMICS

Agriculture is greatly affected by potentially sunk costs. Investments in land, buildings and equipment, crops, animals or human capital are all affected, to varying degrees, and the implications for farm sector performance may be far-reaching. There are five such implications which can be considered briefly.

First, *new technology adoption* requires investments not only in physical equipment but also in learning, management and handling new relationships. All involve some irreversibility and uncertainty, the extent depending on inherent features of the new technology and the price–cost conditions of the activity to which it is applied. Saha *et al.* (1994) and Purvis *et al.* (1995) explore the discouraging effects on adoption of irreversibility and uncertainty. Arguably, some of the US agriculture's impressive productivity growth since the 1950s stems from investments in technologies which might not have been adopted were it not for the reduction in down-side risk afforded by commodity price floors.

Second, *the entry and exit behaviour of farmers* is likely to be affected since adjustment processes may be slow in agricultural activities where sunk costs and uncertainty are present. Thus, during the price and profitability declines suffered by US agriculture in the 1980s, existing farmers were probably less likely to leave the industry than they would have been in the absence of sunk costs. Alternatively, in more recent years, potential entrants may have been discouraged by the growing down-side risk associated with declining government price supports. Indeed, in the future, there could be periods of high prices and profits before entry and investments become sufficient to expand supply and bring prices down, unless other risk-reducing arrangements emerge as substitutes.

Third, *prices of goods whose production involves 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. The microfoundations of investment behaviour, by incumbent firms and potential entrants, that underly supply inelasticity, and hence the likelihood of larger and longer price swings, have been discussed earlier.

Fourth, *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 down-side risk that in turn encourages outcomes with less underinvestment. Indeed, a price floor that is non-binding 'on average' can offer significant insurance against down-side risk and stimulate additional entry and investment in a sector. As Dixit and Pindyck (1994) argue, government price support programmes could, in this manner, ironically give rise to a 'cheap food' outcome by increasing investment and lowering long-run prices.

Finally, *sunk costs help to explain the persistence of 'family farms'.* If agriculture is prone to high levels of sunk costs and uncertainty, family farms also suffer from them. Investments in land, buildings, equipment and business relations are obvious cases in which costs may be sunk. It is also important to remember, however, that the 'human capital' of the asset owners is very similar. Capital and labour 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.

SUNK COSTS AND INTERNATIONAL TRADE

There are also a set of core issues in international economics where conventional wisdom may be challenged by incorporating imperfect resource mobility associated with sunk costs and uncertainty. Three brief examples can be mentioned.

First, *import protection can provide the basis for export promotion when sunk costs are present* (Brander and Spencer, 1985; Krugman, 1984). 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.

Second, *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, forthcoming).

Third, *trade liberalization may shift returns in favour of capital and against labour because of labour's relative immobility.* If common arguments regarding capital's relative mobility are correct, one reason for recent declines in wage/rental rates in developed countries could be higher levels of sunk costs for labour (related to labour 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 labour, the investment-discouraging effects of labour immobility could be a cause for both growth and distributional concerns.

CONCLUSION

Using a highly general model of individual investment behaviour, three crucial points have been explored. Firstly, 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 in some way. Secondly, 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. Thirdly, conventional wisdom in agricultural economics and trade policy may be shaken once the implications of sunk costs and uncertainty for investment behaviour, market performance and policy options are better understood. A similar statement could probably 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. In common with many other agnostics, 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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