Sunk Costs, “News” and Economic Methodology

by

Robert F. Owen*

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N.B. All ideas are contestable, so that comments are most welcome. Not for citation without the permission of the author.

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*Professor of Economics, University of Nantes. His professional address is: LEN-C3E Research Center, Faculty of Economics and Business Administration, University of Nantes, Chemin de la Censive du Tertre, B. P. 52231, 44322 Nantes Cedex 3, Telephone Numbers: 33-2-40141761 (direct) and 33-2-40141717. Home Office Telephone/Fax Number: 33-1-39219096. E-mail address: RobertOwen@compuserve.com
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Abstract

An enlarged conceptual framework for understanding sunk costs and their implications is proposed. A crucial distinction is made between ex ante sunk costs and ex post or de facto sunk costs. The latter capture the interrelation between economic irreversibilities and their ex post evaluation in general equilibrium, in light of unforeseen contingencies, the revelation of new information and associated revisions in agents’ optimal decisions. Initial investments and commitments, can be regarded as open options, which have associated uncovered values that are “called” by “news”. Alternatively, such ex post sunk costs can be considered to result from “lock-in” effects, which are a manifestation of a latent hold-up problem. As such, they are argued to be essential for analyzing scenarios of decommitment and recommitment. Such ex post sunk costs thereby capture a key channel by which history defines economic analysis. More specifically, the ex post revaluation of initial investments can trigger the entry and exit decisions of agents to/from markets, as well as other dynamic aspects of their economic performance. The distinction between ex ante and ex post sunk costs points to a central identification problem for economic modeling, along with distinctive hysteresis effects. Paradoxically, there can be quite divergent implications of sunk costs for the decisions of individual agents, relative to their overall impact on the evolution of economic systems, as a whole.

Certain propositions are based on a more extensive analysis and additional simulations of the two-country oligopolistic model, proposed by Owen and Ulph (2002), in which an unanticipated integration shock corresponds, in terms of expectations, to a “big bang” event or “pure news”. This framework suggests that expected utility analysis, along with standard specifications for consumer and producer optimization, can obfuscate the inter-temporal evaluation of irreversibilities embodied in past investments and sunk costs. Generic implications for a range of economic problems are suggested. These include consequences for understanding the efficacy of government policy interventions and the microfoundations of related debates about the adaptive versus rational expectations.

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Professor of Economics, University of Nantes. His professional address is: LEN-C3E Research Center, Faculty of Economics and Business Administration, University of Nantes, Chemin de la Censive du Tertre, B. P. 52231, 44322 Nantes Cedex 3, Telephone Numbers: 33-2-40141761 (direct) and 33-2-40141717. Home Office Telephone/Fax Number: 33-1-39219096. E-mail address: RobertOwen@compuserve.com
Can One Expect the Unexpected?

Thinking about the Unthinkable.

Or, without a Fundamentally Different Conceptualization of Sunk Costs, Is Existing Economic Methodology Completely Complete?

I. Introduction

Most major graduate microeconomic and macroeconomic textbooks make only fleeting reference to the issue of sunk costs. Such an omission appears to discount the significance of any vital role for sunk costs in general equilibrium analysis, macroeconomics and a wide range of other, modeling frameworks. Furthermore, only cursory, and often divergent, treatments of this concept are typically proposed in many introductory and intermediate microeconomic and/or macroeconomic textbooks. On the one hand, one approach to the treatment of sunk costs is represented by the idea: “Let bygones be bygones.” Often it is explicitly stated, or implied, that such existing sunk costs should be treated as exogenous variables, which enter only ostensibly, or not at all, in agents’ objective functions. As such, they are taken to not influence decision-making processes, which are understood to be separable from such sunk costs. From such an ex post perspective, the basic argument appears to be that, since sunk costs reflect past commitments, their values and characteristics are irrelevant for subsequent optimization processes. Such an approach suggests a rather ahistorical role for sunk costs, whereby the irreversibilities, stemming from past investments and commitments, have already been fully internalized and are irrelevant for optimal choices. Hence, it is understood that they do not influence future economic decisions and the associated trajectories of economic systems.

Admittedly, the role of sunk costs in defining market entry, contestability and industrial structures is clearly recognized in the industrial organization literature, which includes, notably, the seminal work of Baumol, Panzer and Willig (1982) and Sutton (1991). Their research, along with other contributions relating to sunk costs, is synthesized in intermediate and advanced textbook expositions, such as those by Cabral (2000), Martin (1993), Shy (1995) and Tirole (1988). However, the prevailing approaches focus on ex ante interpretations of sunk costs, which highlight the potential impact of anticipated irreversibilities on individual agents’ current optimal choices. For example, firms’ market entry, advertising, and R&D decisions are examined, under the underlying premise that agents either face known market conditions determining the evaluation of sunk costs, or given probability distributions representing their values. The

1 In this regard, see Kreps (1990), Mas-Colell, Whinston and Green (1995), along with Varian (1992).
3 This terminology is explicitly used, for example, by Mankiw (2001; p. 298), who goes on to suggest that: “Because nothing can be done about sunk costs, you can ignore them when making decisions about various aspects of life, including business strategy” (p. 299).
subsequent reformulation of agents’ decisions in light of the *ex post* revelation of information and unforeseen contingencies, or, alternatively, “news”, is not, typically, central to that analysis.

Dixit and Pindyck (1994) have introduced implications of uncertainty, more explicitly, in their analysis of the timing of sunk costs as optimal investment options. However, an implicit feature of their real option approach is that the interrelation between uncertainty and sunk costs is fully internalized by agents in their *ex ante* optimal decisions and strategic interactions. The latter are based on correctly surmised distributions of expected probabilities and future discounted values of eventual sunk cost investments. Hence, in such a forward-looking paradigm agents, in effect, can optimally formulate their decisions in order to incorporate the “call” option value of future sunk cost commitment. Furthermore, much of their analysis concentrates on the interrelation between uncertainty and sunk costs from the standpoint of a single representative agent, facing known *ex ante* probabilities and sunk cost evaluations. As such, their analysis does not allow for eventual ramifications of “news” for the *ex post* reoptimization of individual agents’ decisions, and the resulting endogenous revaluation of the irreversibilities, represented by investments and associated sunk costs, in general equilibrium.

Stated differently, the existing analysis of investments under uncertainty does not consider the consequences of unforeseen contingencies for the open option value of irreversible commitments in general equilibrium. Thus, there is a need to examine how existing sets of investment values are impacted by different forms of “news”, at the time information is revealed, and how such changed spot revaluations are interrelated with economic agents’ optimal behavior and strategic interactions. In the expanded framework proposed here, sunk costs can be understood to embody dimensions of both *ex ante* commitments and the endogenous *ex post* evaluation of those commitments, along with their interrelation with eventual decommitment and recommitment. Notably, these issues are of particular portent and complexity in the presence of heterogeneous characteristics and information sets across economic agents, as well as different historical investment patterns. Thus, the reconfiguration of agents’ information sets, following the revelation of partially, or fully, unforeseen contingencies, may result in the reoptimization of their decisions. Indeed, what might be coined the “economics of mistakes”, corresponding to *ex post* reevaluations of existing irreversibilities, is reflected in the endogenous determination of sunk costs. These can be critical for understanding entry, exit, and other performance decisions of economic agents, along with the associated evolution of economic systems in general equilibrium.

The purpose of this paper then is to propose an enlarged conceptual framework for understanding sunk costs and their consequences, thereby identifying generic implications for economic modeling. Notions of irreversibility, and hence of commitment, are intrinsic to sunk costs. More specifically, a sunk cost is understood

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4 While it is often convenient to consider the proposed analysis of sunk costs in terms of investment theory, it is apparent that the analysis applies with equal validity to a more general analysis of commitment, so that these terminologies will be used interchangeably.

5 From the standpoint of specific agents, unforeseen events can arise from a variety of economic shocks, including, for example, technological breakthroughs, changes in macroeconomic environments or natural phenomena, and are also linked to the newly revealed strategies of other agents. One subset of such cases arises under asymmetric information, when previously uninformed agents gain access to new information.
here to entail an irrecuperable change in market value of an earlier investment or commitment, at a given point of time. The sunk cost corresponds to the discrepancy between the historic value of the investment, which embodies an irreversibility, and its subsequent spot evaluation or, alternatively, scrap value. Furthermore, the extent of sunkedness depends on how the revaluation of the existing irreversibility is defined by the liquidity of markets for that asset or commitment, along with eventual discrepancies between such market evaluations and the returns to the committed agents. The evaluation of sunk costs are of particular relevance to economic analysis, when existing commitments “bite”, in the sense that there are associated consequences for the reoptimization of agents’ decisions. A consideration of the reactualized value of existing commitments, relative to the consequences of decommitment, serves to capture the role of history in accounting for the dynamic evolution of economic systems.

A crucial distinction is made here between, on the one hand, ex ante sunk costs and, on the other hand, ex post or de facto sunk costs. Ex ante sunk costs are based on either foreseen states of nature, or anticipated probability distributions, along with known scenarios regarding strategic interactions with other agents. Unlike fixed costs, the irreversibilities embodied in ex ante sunk costs generate exit costs, if agents leave markets. As such, they capture effects of irreversibilities, which are, at least to some degree, already internalized in individual agents’ optimal decisions and are exogenously specified within a given time and economic framework. It is this forward-looking specification for sunk costs, which currently prevails in most economic analysis.

In contrast, economic values linked to the irreversibilities embodied in ex post or de facto sunk costs can be crucially defined, in general equilibrium, by the impact of partially, or wholly, unforeseen contingencies. This distinctive category of sunk costs could alternatively be termed “sunk costs with endogenous effects”. A critical insight is that, when there are partially, or completely, unforeseen contingencies, economic agents will potentially reoptimize their earlier decisions, thereby internalizing such “news”. This leads to an associated endogenous determination, in general equilibrium, of the economic values linked to sunk costs. In this process, different initial irreversibilities across agents can generate pecuniary externalities which can define the impact if sunk costs and associated investment returns. Furthermore, the present discounted evaluations, by individual agents, of the residual value of initial investments can diverge from market values due to various factors, including, notably, transaction costs. Thus, the initial investment or commitment can be regarded as an open option value, which has associated revaluation that is “called” by “news”. Analogously, whenever agents make commitments, there is the associated possibility of revaluations of not only those commitments, but also the opportunity costs of decommitment and recommitment. These effects need to be simultaneously considered in a complete theory of economic systems.

Although the terminology, “sunk costs”, implies losses, changes in value, linked to irreversible decisions, can clearly be positive as well. It is decisions in time and historical values of investments at specific times in the past, rather than their subsequent values, that are fundamentally irreversible. Furthermore, relative to initial evaluations, the residual values of investments, or other commitments, clearly have variably evaluations at different points in time. In this sense, “sunkedness” is inherently a question of degree. In effect, sunk costs can constitute a form of double irreversibility, since neither the original historical commitment to the investment, nor its initial asset value, can be ignored.

Learning and search processes inherently, also, engender sunk investment costs with both ex ante and ex post characteristics.
wherein the *ex ante* and *ex post* evaluation of sunk costs embodies the duality between such commitment and decommitment. Finally, it is argued that the impact of unforeseen contingencies on the evaluation of sunk costs can be crucial for correctly identifying alternative structural economic models, and in accounting for the nature of distinctive hysteresis effects in the dynamic evolution of economic equilibria. Thus, the distinction between *ex ante* and *ex post* sunk costs points to a central identification problem in economic analysis.

An expanded taxonomy for understanding sunk costs is proposed here, which recognizes the state and time contingency of sunk cost evaluations. The present research initially offers an extension of analysis proposed in Owen and Ulph (2002), by examining a further model simulation and extended interpretation of associated findings. The framework for that analysis is a two-country oligopolistic model, which links configurations of fixed and sunk costs to distinctive sets of *ex post* equilibria, following an unanticipated integration shock. Since firms initially assign a zero probability to an event, which is then actually realized, the unanticipated reduction of variable trade costs corresponds, in terms of expectations, to a “big bang” event. As such, the integration shock constitutes a form of “pure news”. Endogenous industrial structures arise due to firms’ entry and exit from the two markets. More specifically, it is shown that there is an unique mapping from constellations of fixed and sunk costs to three different trade regimes. These correspond to traditional trade theory, “new” trade theory, and a distinctive market access regime. The latter scenario, which had not previously been identified, highlights a scenario where there is an *ex post* evaluation of irreversibilities entailing market exit costs. A specific set of such sunk costs, linked to establishing market access, plays a dominant role in accounting for these equilibria, relative to other *ex ante* fixed and sunk cost commitments. In comparison, the “new” trade theory is a regime where fixed costs, again linked to obtaining market access, have a preponderant influence. These fixed costs capture lumpy irreversible expenditures within a given time period, which are internalized in the firms’ beginning-of-period decisions. Finally, the equilibria corresponding to traditional theory are those where neither fixed, nor sunk, costs of market access are relatively important, when compared to other *ex ante* cost commitments.

It is contended here that the distinctive trade regimes actually suggest a central identification problem in economics; wherein distinctive categories of sunk costs can critically define alternative structural economic models, associated reduced form solutions and welfare changes, following economic shocks. Indeed, it is crucial to recognize both the potential impact of partially, or completely, unforeseen contingencies, along with the associated revelation of information, on agents’ decisions and strategic interactions, in light of the extent of existing *ex ante* irreversibilities over given time periods. An application of the analysis is to understanding how the efficacy of economic policies can critically depend on not only the extent that they are foreseen, and already internalized in agents’ intertemporal decisions, but also degrees of commitment, as reflected by evaluations of *ex post* sunk costs. This latter observation suggests microfoundations of debates regarding adaptive and rational expectations.

The organization of the rest of this paper is as follows. The next section offers a brief overview and critique of representative textbook, and other, treatments of sunk costs. It is contended that existing specifications for sunk costs have not adequately
considered the interrelation between, on the one hand, irreversible investments, and, on the other hand, their ex post evaluation in general equilibrium in light of unforeseen contingencies and information revelation. This suggests a potential paradox regarding the divergent roles of sunk costs in partial and general equilibrium is discussed. Section III proposes an analysis, which extends the research of Owen and Ulph (2002). A central identification problem in economics is suggested, which is linked to the nexus between sunk costs and “news”. Once the impact of unforeseen contingencies is recognized, a category of sunk costs can be identified, which have distinctive hysteresis effects and other implications, relative to those of ex ante sunk costs. These ex post or de facto sunk costs capture the impact, in general equilibrium, of past irreversiblities on market and non-market evaluations. It is shown how the evaluation of the effects of such sunk costs can be endogenously determined, when agents reformulate their optimal decisions in light of the specific nature of unforeseen contingencies and the related ex post evaluation of ex ante investments/commitments. Based on this analysis, Section IV then proposes a new taxonomy for understanding sunk costs and their interrelation with market adjustment processes, along with a range of applications of the analysis. The principal insights of the paper and directions for further research are then considered in a concluding section.

II. An Overview of Existing Interpretations of Sunk Costs

A striking feature of existing textbook, and other, discussions of sunk costs is an apparent lack of consensus regarding an appropriate definition for this concept. One representative, pedagogical treatment of sunk costs is provided in the intermediate microeconomic theory textbook by Nicholson (1998). There the notion is principally developed in the context of firms’ ex ante “commitments” to investment and market entry. Specifically, Nicholson defines sunk costs in the following terms:

“One-time investments that must be made in order to enter a market. Such investments allow the firm to produce in the market but have no residual value if the firm exits the market”. p. 615

This discussion is rather restrictive, since it ignores the issue of possible implications of a potential loss in value for such investments, over specific time periods, even when the firm remains in the market. A related issue concerns the need to consider determinants of the residual value of such investments, as well as how unanticipated changes in a firm’s economic environment they impact its strategic decisions and performance. Indeed, many treatments of sunk costs appear to be singularly atemporal. Moreover, the somewhat exclusive emphasis on a firm’s market entry decisions seems to suggest that the concept is not of relevance to other economic scenarios.

The anticipatory specification for the role of sunk costs is also reflected in the definition proposed by Walsh and Stiglitz (2002), who consider sunk costs to arise if “...an expenditure has already been made and cannot be recovered no matter what choice

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9 Collectively, the divergent characterizations of sunk cost generate a rather impressionistic formulation of this concept.
is made, a rational person would ignore it.” p. 37 This characterization seems to equate the non-recuperable nature of sunk costs with the suggestion that the sunk costs do not influence an agent’s subsequent decisions, regardless of the evolution in their value over time. An implicit implication of their analysis is a strong rationality assumption that agents can anticipate all relevant states of nature, and thereby preclude any state where the irreversibilities reflected in sunk costs might influence their subsequent decisions.

Alternatively, there is the definition proposed by Pindyck and Rubinfeld (2001), as reflected by the following two excerpts:

“Although an opportunity cost is often hidden, it should be taken into account when making economic decisions. Just the opposite is true of a **sunk cost**: an expenditure that has been made and cannot be recovered. A sunk cost is usually visible, but after it has been incurred, it should always be ignored when making future economic decisions.

Because a sunk cost cannot be recovered, it should not influence the firm’s decisions. For example, consider the purchase of….The expenditure on this equipment is a sunk cost. *Because it has no alternative use, its opportunity cost is zero*. Thus it should not be included as part of the firm’s costs. The decision to buy equipment may have been good or bad. It doesn’t matter. It’s water under the bridge and shouldn’t affect current decisions.” p. 205

“Now consider a **prospective** sunk cost. Suppose, for example, that the firm has not yet bought the specialized equipment but is merely considering whether to do so. A prospective sunk cost is an **investment**. Here the firm must decide whether that investment in specialized equipment is **economical** – i.e., whether it will lead to a flow of revenues large enough to justify its cost.” p. 205

Note that this last paragraph highlights the idea that it is possible to envisage future investment decisions in an essentially atemporal context, where lags from immediate, or earlier, economic shocks are ignored. In much of the associated discussion, there is an implicit, if not explicit, understanding that sunk costs are fully known *ex ante* by agents, who are able to integrate such sunk costs in their optimization behavior. This constitutes a strong rationality assumption in terms of agents’ ability to understand future economic processes and precludes a role for unanticipated events, arising from a wide class of exogenous shocks. Indeed, it will be contended that the artificial partitioning of sunk costs in *ex ante* and *ex post* terms, as set out in basic textbooks, obfuscates what may be one of the most neglected issues in economics. Thus, it will be maintained that sunk costs can be associated with important invisibilities across agents, due to the asymmetric partitioning of information spaces, or, alternatively, informational failures.

In the industrial organization literature, Baumol, Panzer, and Willig (1982) and Sutton (1991) have examined the role of sunk costs as investments, which can explain market contestability and industrial structures. Further advanced treatments of investment and capacity issues related to sunk costs have been explored by Dixit and Pindyck (1994). More specifically, the latter authors examine irreversible investment

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10 See, alternatively, Varian (2003) for an alternative treatment, as well as, Frank (2003) and Mankiw (2001), among others, for comparable discussions at more introductory levels.
under uncertainty and analyze the interrelation between such decisions and option pricing. Nonetheless, the explicit treatment of sunk costs, defined in one way or another, is conspicuously absent from many other areas of economics, including, notably, most general equilibrium and macroeconomic modeling exercises. Furthermore, there appears to be a starkly ambiguous treatment of sunk costs as alternatively ex post and ex ante notions, in different contexts, without adequate attention to the underlying dynamic processes, which might generate sunk costs. Notably, the expectational dimension of the determination of sunk costs, when there are unforeseen contingencies, is conspicuously absent from most existing analysis.

Contrary to prevailing approaches to the treatment of sunk costs, which are reflected by the foregoing representative treatments, it is maintained here that sunk costs can be associated with important invisibilities across agents, due to the asymmetric partitioning of information spaces. As such, the evaluation of sunk costs often entail informational market failures. Furthermore, it will be contended that the determination of past sunk costs can be critical for the understanding “future economic decisions” in a general equilibrium framework, where the strategic decisions of agents are impacted by “news”. In this regard, a critical distinction needs to be made between, on the one hand, the extent of irreversibilities in the value of initial investments and, on the other hand, the stream of returns generated by such sunk cost investments. More specifically, this paper will distinguish between, on the one hand, ex ante sunk costs and, on the other hand, ex post or de facto sunk costs, which are impacted by, at least partially, unforeseen contingencies or “news”. The latter can also be termed as sunk costs with endogenous effects.

III. Sunk Costs and “News”: Hold-up versus Lock-in

The potential dependency of the evaluation of sunk costs on “news” is illustrated by the analysis of Fukuda and Owen (2004). The general concern there is with the interrelation between unique features of Japanese labor markets and the pronounced macroeconomic slowdown in Japan during the 1990s. More specifically, it is shown how firm-specific human capital, which is financed by firms, can, in conjunction with “life-long” labor contracts and a seniority wage system, be crucial for determining recent macroeconomic adjustment processes in Japan. A central insight is that ex post evaluations of sunk costs, linked to ex ante investments in firm-specific human capital, are critically defined by the extent of unanticipated demand shocks. This idea hinges critically on a distinction between the characterization of such human capital investment in terms of an ex ante hold-up problem and the ex post analysis of the associated lock-in effect, resulting from unforeseen contingencies. More specifically, the “lock-in” problem, in this instance, is crucially linked to combined ex ante conditions, which relate to the firm-specific nature of the human capital formation and to these investment costs being borne by the firms. As a consequence, the firms are potentially vulnerable to an unanticipated macroeconomic slowdown, which unexpectedly reduces product demand. This leads firms to retain skilled workers even though the ex post marginal product of their continued employment falls short of the ex ante financing cost for their training.11

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11 Fukuda and Owen (1994) demonstrate that unskilled workers bear a disproportionately large brunt of an initial unforeseen macroeconomic shock.
The combined role of the hold-up problem and lock-in effect can define both the endogeneity of sunk costs to news and their *ex post* evaluation. This argument can be further developed on the basis of Graphs 1 and 2. The *ex ante* determination of a representative firm’s optimal decisions for hiring and investing in human capital formation are illustrated in Graph 1. In this initial scenario the firm is assumed to know with certainty the demand for its products and, hence, the downward sloping gross marginal value product (MVPs) of the skilled workers. The shaded rectangle, reflecting the training costs, is defined by the number of skilled workers hired, $N^S_t$, and the training costs per worker, $g$, which correspond to the vertical distance of the rectangle. In the Japanese system of life-long employment, the standard investment hold-up problem, is resolved by the life-time seniority labor contracts.\(^\text{12}\) Thus, firms have traditionally been prepared to absorb all of the training cost, since they are assured of receiving the full returns to that human capital investment. The corresponding salary paid out to the skilled workers amounts to $w^S_t$.


13 Fukuda and Owen (2004) analyze how alternative evaluations of such sunk costs correspond to distinctive hysteresis effects. These are shown to magnify the effects of an initial macroeconomic shock and permanently lower firms’ overall skill formation.

14 While the case of a macroeconomic slowdown is highlighted in this example, it is apparent that a variety of other unexpected changes could generate a range of sunk costs. For example, an unexpected technological change could, by impacting the returns to earlier human capital investments, define the incentive that a firm has to hold on to older workers, rather than train new ones.
However, when the size of the unanticipated shock is sufficiently large to generate a shift in the gross MVPs below the intersection between $L^S$ and the net MVPs schedule, the firms suffer a sunk cost losses, which are at least as large as the original training costs. In this second sub-regime, firms will seek to fire, at least some, of their skilled workers. However, to the extent that that the workers are willing to renegotiate their salaries, a corresponding bargaining solution can be depicted in terms of the lower upward-sloping portion of the $L^S$ curve. With such a wage-bargaining outcome, the workers also incur sunk cost losses, since the new equilibrium outcome entails a wage below $w^S_t$ for those workers who maintain their jobs, while others lose their jobs. The former of these sunk cost losses, borne by the workers, is illustrated by the smaller rectangle in Graph 2.

Insert Graph 2:
The Ex Post Analysis of Labor Market Equilibrium

IV. Sunk Costs and “News”: A Central Identification Problem and Reformulation of Related Concepts

The analysis of this section highlights further how economic consequences of the irreversibilities embodied in sunk costs can be crucially defined by “news” and the associated strategic interactions between agents. More specifically, the present research initially offers an extension of the analysis proposed in Owen and Ulph (2002), based on a further model simulation and extended interpretation of associated findings. The analysis thereby suggests a need to redefine sunk costs by distinguishing between ex ante and ex post evaluations of sunk costs, in light of the impact of unforeseen contingencies on irreversible dimensions of investments. As a consequence, there exists a sub-category of sunk costs, which are state and time contingent. The analysis thereby suggests a central identification problem in economic modeling, which results when agents, having internalizing new information, potentially reformulate their optimal decisions in light of strategic interactions with other agents. As a consequence, existing economic models, based on assumptions of known irreversibilities, may not adequately capture subsequent structures arising from unanticipated economic shocks.

The two-country oligopolistic model proposed by Owen and Ulph (2002) offers a framework for considering a nexus of issues concerning the interrelation between market contestability, expectations, strategic interactions between agents and their interrelation to the impact of an unanticipated integration shock. The analysis highlights how different configurations of fixed and sunk costs determine distinctive sets of ex post equilibria, following an unanticipated integration shock. A crucial distinction is made between fixed costs and sunk costs. While the latter generate exit costs, the former do not. More specifically, fixed costs are understood to involve the creation of an asset that has a proprietary value to an agent within a given time period, but continue to be equally valued by other agents at the end of the period. As such, while fixed costs entail identical
repeated flow expenditures in successive time periods, at the end of any given period, the associated assets can be fully liquidated in outside markets without any loss in value relative to the initial investments. In contrast, sunk costs arise when an asset only has value to the agent creating it, so that there is no resale value on outside markets, thereby generating exit costs, when a firm ceases operation.

An initial autarchic steady-state equilibrium is defined by the endogenous entry of the oligopolistic firms, producing a single homogeneous good, in each of two countries. These markets are, however, for simplicity, assumed to be identical. Under the initial scenario of infinite trade costs, assuming Cournot-Nash behavior, and under the free-entry condition that the present discounted value of profits is zero, $n_0$ identical firms set up production in each country’s market. The firms make their sunk-cost commitments, which are essential for market entry, under the assumption that a state of autarchy will prevail indefinitely.

A second steady-state equilibrium is then examined, following “news” of an unanticipated integration shock between the two economies, in the sense that the variable costs of serving markets fall to zero. Since firms initially assign a zero probability to this event, which is then actually realized, the unanticipated reduction of variable trade costs corresponds, in terms of expectations and the agents’ information sets, to a “big bang” event. As such, the integration shock constitutes a form of “pure news”.

The analysis then characterizes the firms’ entry and exit decisions in the two markets, following the integration shock. It thereby highlights how different endogenous industrial structures emerge, which correspond to three distinct trade regimes. Thus, relative to the initial number of $n_0$ firms in each country, a critical consideration is how many of these firms, $N$, will survive in each country, and, of those, how many firms, $E$, will export. These numbers are shown to depend on the configuration of prevailing sunk and fixed cost. More specifically, it is shown that there is a unique mapping from constellations of fixed and sunk costs to the three different trade regimes. These correspond to traditional trade theory, “new” trade theory, and a distinctive market access regime. The latter set of equilibria had not previously been identified. It is a scenario where the ex post evaluation of an specific set of sunk costs – those linked to establishing market access - plays a dominant role, relative to other ex ante fixed and sunk cost commitments. In comparison, the “new” trade theory is a regime where fixed costs, again linked to obtaining market access, have a preponderant influence. These fixed costs capture lumpy irreversible expenditures within a given time period, which are internalized in the firms’ beginning-of-period decisions. Finally, the equilibria corresponding to traditional theory are those where neither fixed, nor sunk, costs of market access are relatively important, when compared to other ex ante cost commitments.

More specifically, the fixed and sunk costs are both broken down into two categories each, relating to technology and market access costs. The sunk costs of initially acquiring a technology are denoted by $S_T$, while $F_T$ represents the fixed costs.

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15 This initial number of the entrants depends inversely on the overall ex ante levels of fixed and sunk costs that the firms face in acquiring a given technology and obtaining market access.

16 A distinctive feature of our modeling analysis of the economic integration process is that, unlike in the papers by Smith and Venables (1988, 1991) and Venables (1990a,b), we allow for the effects of hysteresis, as captured by the role of sunk costs.
technology costs of subsequently using a given technology in each period. Thus, in the proposed model these respective technology costs are essential for initial establishing, and then maintaining a given technological base, corresponding to a fixed marginal cost of production. Analogously, the costs of accessing a new market, are divided into both sunk and fixed cost components, while $S_A$ and $F_A$ constitute, respectively, sunk and fixed market access costs.\footnote{Following a market integration shock, firms, which are incumbents in a given market, have to decide whether or not to incur the market access costs (sunk and fixed) of entering the other country’s market.} These market access costs entail, respectively, the expenses needed to establish market entry and then subsequently service a market(s) during a given period. Although the mechanisms determining such realized sunk costs are not made explicit, a complete set of feasible fixed and sunk cost values are considered.

It is shown that the nature of the post-integration equilibrium, and associated welfare changes, are crucially dependent on the relative significance of market access costs and fixed costs, in relation to the total costs, which are initially incurred by the firms in a state of autarchy. Thus, the following two crucial variables can be used to capture the principal findings of the analysis:

$\alpha$ - the ratio of market access costs (both sunk and fixed) to total fixed and sunk costs;

$\phi$ - the ratio of fixed costs (both production and market access) to total fixed and sunk costs.

Formally, these are given by:

\[
\alpha = \frac{(S_A + F_A)}{(S_T + F_T + S_A + F_A)}; \quad \phi = \frac{(F_T + F_A)}{(S_T + F_T + S_A + F_A)}.
\]

The following two additional variables turn out to be useful for determining certain properties of the model:

\[
\gamma = \frac{F_A}{(S_T + F_T + S_A + F_A)}; \quad \nu = \left[\frac{(n_0 + 1)}{(2n_0 + 1)}\right]^2.
\]

More specifically, the first of these latter two variables denotes the ratio of fixed market access costs to total costs, while $\nu$ is the ratio of operating profits, when there are $2n_0$ firms serving each market, as compared with the firms’ operating profits when there are just $n_0$ firms serving each market. As such the variable $\nu$ gives a measure of the maximum increase in competitiveness that can arise post-integration, when all firms survive and serve both markets.

The analysis in Owen and Ulph (2002) shows that there are three distinct trade regimes, labeled as a classical trade paradigm (R1), “new trade” theory (R2) and a market access regime (R3). Each regime is characterized by a set of unique functional forms for its structural equations and the associated, \textit{ex post} welfare changes. It is demonstrated that the emergence of the distinctive set of structural equations characterizing these alternative trade scenarios, depends critically on specific underlying configurations of fixed and sunk costs. Following the unanticipated integration shock, the structure of these costs determine the number of firms initially present in each autarchic country,
which will survive and, eventually, serve the other country’s market through exports. Each of the three trade regimes is also shown to entail distinctive sets of changes in economic welfare, following the integration shock. These welfare changes, measured in terms of consumer and producer surplus, are shown to critically depend in a continuous way on alternative combinations of the fixed costs, which are known \textit{ex ante} and on specific sunk costs – those relating to market access. These can assume different \textit{ex post} values, relative to the total of the fixed and sunk costs, which initially determined market entry under autarchy.

These sets of different equilibria, corresponding to the three distinct trade regimes, are represented in Figures 1a and 1b by contiguous regions, which depend crucially on the two variables, $\alpha$ and $\phi$. Figure 1a shows, how the ratio of market access costs to total costs, $\alpha$, and the ratio of fixed costs to total costs, $\phi$, define three distinct sets of equilibria. Figure 1b offers a further simulation, not reported in Owen and Ulph (2002), of the model for specific parameter values. It depicts the associated changes in welfare, defined as the sum of consumer surplus and producer surplus (firms’ profits), following the integration shock. The associated structural equations, which specify sufficient conditions for each of the three regimes to arise, along with certain other regime characteristics, are now elaborated below.

\footnote{Alternative formulas, specifying the specific set of structural models for each of the three post-integration regimes, are presented in Owen and Ulph (2002). The initial number of firms in each country, $n_0$, in the autarchic equilibrium plays a critical role relative in these formulas and the associated welfare calculations.}
Figure 1b

Technical Note: The parameters used in this simulation are $n_0 = 2$ and $\gamma = 0$.

Figure 1c
Technical Note: The parameters used in this simulation are $n_0 = 100$ and $\gamma = 0$.

Regime 1 (R1) The Traditional Trade Theory Regime

\[ \alpha \leq \nu \quad \text{and} \quad \alpha + \phi \leq 2\nu. \]

In this traditional trade theory regime, where all firms survive and all firms export, so that $E = N = n_0$, both fixed costs and market access costs are relatively small.

Regime 2 (R2) The New Trade Theory Regime

\[ \alpha \leq \phi \quad \text{and} \quad \alpha + \phi > 2\nu. \]

In this new trade theory regime, where economies of scale are paramount, some firms are driven out of the market, but all the surviving firms export, so $n_0 > N = E > 0$. Here market access costs are relatively small in relation to fixed costs. As in the previous regime, economic integration generates welfare gains when market access costs are sufficiently small, but welfare losses when market access costs are large.
Regime 3 The Market Access Regime

\( \alpha > \nu \) and \( \alpha \geq \phi \).

In this regime all firms survive, but only some of them export, so \( n_0 = N > E > 0 \).

This is a new scenario where market access costs are the dominant consideration, we refer to it as the market access regime. In this regime, while the net change in welfare is always negative, it is strictly increasing in market access costs, as represented by \( \alpha \).

As shown in Figure 1b, there is an unique mapping relating the welfare changes for each of the foregoing three trade regimes to the configuration of sunk and fixed costs. Accordingly, without a knowledge of these underlying costs, each of these regimes can not be identified. Hence, a central finding is that to the extent that sunk costs are ignored in the analysis of economic integration there are associated modeling misspecifications and miscalculations of welfare changes. Furthermore, when there are economic shocks and/or news, sunk costs are the source of distinctive hysteresis effects in economic adjustment processes. However, it should be emphasized that the second-best environment of imperfect competition, in combination with strategic interactions between agents, is crucial for these identification issues to arise. More specifically, as illustrated in Figure 2c, the distinctive welfare effects characterizing each of the regimes tend to disappear as the number of firms approaches a competitive equilibrium.

The critical features of our analysis, which generate the foregoing findings are the highlighting of how fixed and sunk costs account for the initial equilibrium, with strategic interactions between firms, followed by new equilibrium states, which arise because of an unanticipated integration shock. A critical insight is that it is not possible to determine which trade regimes hold, without an understanding of the underlying sunk cost structures. This finding points to a more general central identification problem in economics, which can be stated in the following terms:

**Proposition 1: A Central Identification/Selection Problem in Economic Modeling**

In the presence of game-theoretic interactions between heterogeneous economic agents and/or at least one market imperfection, a characterization of different categories of sunk costs may be essential for distinguishing between different structural economic relations, when there is “news”, reflecting unanticipated economic shocks.

Thus, unanticipated irreversibilities, corresponding then to \textit{ex post or de facto} sunk costs, have the inherent potential of generating distinctive identification/selection problems for structural models of economic systems relative to anticipated irreversibilities, as represented by \textit{ex ante} sunk costs and fixed costs.\(^{19}\)

\(^{19}\) Such \textit{ex post} sunk costs could also be designated as \textit{endogenous sunk costs}. This alternative terminology was suggested to me by François-Charles Wolff.
The foregoing proposition is based a distinctive formulation of the notion of sunk costs, relative to existing literature. That definition is as follows:

**Proposed Definition of Sunk Costs**

Irreversibilities associated with investment decisions are at the origin of sunk costs, which are defined here as irrecoverable differences between the initial cost of *ex ante* investment expenditures and their subsequent residual (or scrap) value at a particular subsequent period of time.  

There are two categories of sunk costs. On the one hand, *ex ante* sunk costs, and, similarly, *ex ante* fixed costs, can be considered (often by way of simplification), as fully anticipated. As such they are already fully internalized in agents’ optimal decision-making processes. On the other hand, *ex post* or de facto sunk costs are those, which actually arise following a partially, or completely, unforeseen contingency. Accordingly, an economic shock and an associated revelation of “news” can generate a difference between *ex ante* and *ex post* evaluations of sunk cost.

In the context of the foregoing central proposition regarding the potential role of *ex post* sunk costs in identifying the structure of economic systems, “news” is understood to constitute new information not in agents’ existing information sets. Although this proposition was demonstrated by Owen and Ulph (2002) in a specific economic context for the case of “pure news”, it undoubtedly also applies when economic agents partially, but not fully, anticipate future shocks. A key insight is that when economic agents’ information sets, regarding future states of nature, are incomplete, *ex ante* and *ex post* decisions can potentially differ, and depend critically on the value of sunk costs, at the specific moment in time when information is revealed. In contrast, to the extent that agents have a full understanding of all future events, they will already have internalized the effects of sunk costs in their decisions. Alternatively, consider an initial steady state for an economy in general equilibrium where all agents have optimized their objective functions. Then, let us envisage an economic shock, which was not anticipated by at least a subset of agents, then those agents will be compelled to reoptimize, and thereby internalize new information in their decisions and strategic interactions in a new general equilibrium outcome. In such a scenario, past commitments, represented by prevailing sunk costs will potentially impact the agents’ decisions, but the implicit *ex post* value (or

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20 While a consideration of sunk costs, in the spirit of existing treatments of this subject, might focus on scenarios where there are losses, relative to initial investment expenditures, it should be recognized that changes in the value of investments may be either positive or negative. As emphasized later, it is decisions in time, which are fundamentally irreversible, and not economic values.

21 To the extent that agents can be viewed as assigning *ex ante* probabilities to such partially anticipated shocks, the *ex post* realization of such an event confirms an incompleteness in the agents’ *ex ante* information sets concerning the likelihood of its occurrence. Expressed differently, there is an inherent contradiction between *ex ante* expected utility analysis and the *ex post* realization of events. This is reflected in what could be termed “partial news”, whereby agents’ prior probabilities must be revised once conceivable events, contained in the agents’ information sets, actually occur.
returns) from those sunk cost investments/commitments will be defined endogenously by the new general equilibrium steady state. In other words, “news” redefines the value streams associated with past commitments, as a result of revised general equilibrium interactions between agents, who are internalizing such new information in their potentially revised decisions.

The proposed redefinition of sunk costs in ex ante and ex post terms can beneficially be related to that for fixed costs, which, however, do not entail exit costs. Fixed costs are understood to entail expenditures, over a given period of time and, eventually, the associated creation of an asset, which has a known value on external markets. Hence, the value of a fixed cost incurred by a specific agent is hypothetically the same as that for other agents, in a comparable economic situation, and is constant within a given time framework. Furthermore, it does not give rise to specific opportunity costs for that agent, if the agent were to envisage exiting markets at the end of a period of reference. In contrast, as defined here, a sunk cost is characterized as an investment for which there is an irreversibility such that a discrepancy exists between the ex ante and ex post market evaluation of that asset over a given time horizon, and as such there is an irrecoverable lose of value. Such a form of irreversibility for the value of an asset, which can be either created or purchased, may arise for different reasons. The investment may only have a residual value to the agent itself, which differs from that in outside markets, because of transactions costs associated with, for example, the process of market entry and sales, or asymmetric information between agents. This is illustrated by the example of a recently purchased car, for which there may be an important discrepancy between its sales value, in light of the prevailing market rate for its capital depreciation, and the use value for its owner. Such a discrepancy can determine, then, whether the agent will enter or exit the car market, as well as an evaluation of the associated sunk cost.

The distinction between ex ante and ex post sunk costs can be represented more formally by considering the evaluation over time of an initial investment by a representative agent. Let $I_t^0$ denote the initial value of an investment of type 1, at time 0. Then the ex ante sunk cost at a future time, $t$, evaluated at the time of that investment, can

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22 Since the value of the fixed cost is known, it is inherently characterized by “lumpiness”.
23 Over different sub-periods of time, there may be known irrecoverable changes in the values of such fixed costs due to market forces, as in the case of a specific rate of capital depreciation, which applies for all agents. Although this constitutes a irreversibility in value over time, critical factors which demarcate sunk from fixed costs are whether there are “exit” costs associated with the initial investment and whether such losses have already been fully internalized in agents’ ex ante optimization decisions. A further related issue is whether such a change in value constitutes an overall systemic market risk, with uniform effects across agents, or, what is typically a more likely scenario, engenders distributional implications, across different agents, stemming from ex post changes in the value of their initial asset commitments. Thus, if an unforeseen event occurs, then what was initially viewed as a fixed cost, may entail a degree of sunkedness ex post, and force the agent to leave the market. As pointed out latter, such sunk costs can entail divergences between ex ante and ex post returns to, and/or the resale value of, the investment or commitment.
24 Although the terminology, “sunk costs”, implies losses, changes in value, linked to irreversible decisions, can clearly be positive as well. It is decisions in time, rather than values, that are fundamentally irreversible.
25 It should be stressed that there may be important invisibilities, which hamper the evaluation of such sunk costs at a more systemic level, due to segmented information sets across economic agents.
be expressed in terms of the difference between the expected value of the investment at
that time, 0, and its anticipated residual, or scrap, value at that time, t,

\[ E_0(S^{0,t}_1) = I^0_1 - E_0(I^{0,t}_1) \]

Analogously, over time the evaluation of the ex ante sunk cost can vary and be expressed, as of a subsequent period \( k \), as:

\[ E_k(S^{k,t}_1) = I^0_1 - E_k(I^{0,t}_1) \]

These expressions can then be compared with an evaluation of the ex post sunk cost in
periods \( k \) and \( t \), when the sunk cost value is either relevant for evaluating an agent’s
decisions, or is finally “called”, in the sense that the sunk cost is actually realized:

\[ S^{k,t}_1 = I^0_1 - I^{k,t}_1 \]

\[ S^{t,t}_1 = I^0_1 - I^{0,t}_1 \]

V. A Revised Formulation and Taxonomy of Sunk Costs

A. Sunk Costs and Uncertainty

Existing economic research appears to have obfuscated this critical distinction
between ex ante and ex post sunk costs, which is essential for understanding a wide
range of economic phenomena. Moreover, the potentially critical role of ex post sunk
costs in defining structural economic models has not been recognized. A key insight is
that “news” which means that previously optimal ex ante decisions may generate
economic scenarios where ex post sunk costs “bite” in the sense that they impact the
revised decisions of economic agents. In effect, such de facto sunk costs introduce an
additional constraint, which can redefine agents’ optimal choices.

When an agent undertakes an initial investment in a tangible or intangible asset at
period \( t_0 \), it must be the case that the present discounted value of the return from that
investment is at least as great as the costs being incurred, so that:

\[ \text{PDV}_0 \geq c_0 \]

Alternatively, if \( V_i \) and \( r_t \) represent, respectively, the value of the return from an
investment and the interest rate at time \( t \), the foregoing relation can be expressed more
explicitly, over a time horizon of \( n \) period, as:

\[ V_0 + V_1 / (1 + r_0) + \ldots + V_k / (1 + r_0)^k + \ldots + V_n / (1 + r_0)^n \geq c_0 \]
Now, let us consider certain implications of an economic shock at a subsequent period designated as $k$. At the moment of such a shock there are two facets to the *ex post* evaluation of the residual value of the initial investment/commitment. First, to the extent that the initial asset continues to yield returns, over an ongoing time horizon, to the economic agent, who currently owns the property rights for that asset, those can be expressed as a residual present discounted valued:

$\text{(11) } \text{PDV}_k^* = \frac{V_k^*}{(1 + r_k)^k} + \ldots + \frac{V_N^*}{(1 + r_k)^N}$

Note that the economic shock, or alternatively “news”, can potentially impact the agent’s evaluation of the return, $V_k^*$ in period $k$, as well as in the subsequent periods over the remaining timing horizon until period $N$. Furthermore, both the interest rate, $r_k$, and relevant time horizon may be modified by the news. These potentially modified values will be determined as a result of a general equilibrium process in which agents will be strategically internalizing the implications, if any, of the economic shock for their optimal decisions.

Similarly, the economic shock will “call” the residual market value of the asset at the time $k$, which can be designated as $c_k^*$. Consequently, as a result of changed economic environment, the economic agent then faces a choice of whether to keep the asset or sell it, depending, respectively, on whether:

- $(12a) \text{PDV}_k^* \geq c_k^*$
- $(12b) \text{PDV}_k^* < c_k^*$

### B. Towards a Reformulation of Sunk Costs

Let $I_0$ be the value of an investment at an initial period of time, designated as $t_0$. Then, the expected present discounted value of the returns, or alternatively, associated benefits, to such an investment, as of this initial point in time, can be designated by $B_0$. For a rational agent to undertake such an investment, it must be the case that

$\text{(13) } B_0 \ni I_0 + Z_0 + M_0$

Here, $Z_0$ represents the non-recuperable, and hence sunk, transaction costs of entering the market in order to realize that investment, while $M_0$ is the discounted present value of the maintenance costs at $t_0$. Note that the variable $Z_0$ reflects the efficiency, or alternatively, the liquidity of the market for that investment.

Let us also define a parameter $\theta$, such that $\theta \in [0, 1]$. This parameter captures the share of the initial value of the investment, $I_0$, which is considered to be non-

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26 An asterisk has been used to distinguish these flow values of returns to the asset, since they may differ from the initial *ex ante* values.
recuperable at the time the investment is undertaken. Hence, the *ex ante* value of this anticipated sunk cost is defined by:

\[ SC_0 = 8_0 I_0 \]

Certain critical insights regarding implications of *ex ante* and *ex post* sunk costs for demarcating market and non-market activity, can be obtained by analyzing implications of “news” for spot evaluations at a future time, \( t_1 \). Such news can entail revealed information previously outside either the representative, or other, agents’, initial information sets. Such redefined sets can potentially impact the present discounted value of benefits from an investment, and/or the residual spot market value, if any, of that investment, \( I_1 \).

More specifically, let us consider three hypothetical cases, reflecting the representative economic agent’s initial assessment of the extent of irreversibility at the time of the investment, as reflected by the value of \( 8_0 \).

First, let us consider an *ex ante* scenario of full irreversibility, where \( 8_0 = 1 \), so that it is expected that there will be no future residual market value for the initial investment.\(^{27}\) This scenario can alternatively be interpreted as one of full commitment. This means that an economic agent will hold on to that asset provided the revalued present discounted value of the stream of benefits is greater than the anticipated maintenance costs, minus eventual non-recuperable disposal costs, \( Z_1 \), of reentering the market and selling off the asset:

\[ B_1 \geq M_1 - Z_1 \]

It is apparent that the foregoing inequality critically defines the division between non-market and market activities, as well as the extent that history matters, in the sense that an understanding of existing commitments is crucially for defining the subsequent evolution of economic systems. Notably, this distinction can be applied to understanding the borders and interactions between institutions and markets. The former can be though of as imbedding a wide range of sunk costs.

Alternative scenarios for the extent of *ex ante* and *ex post* irreversibilities can be represented by different combinations of values for \( 8_0 \) and \( 8_1 \). Thus, while initially there may be no anticipated irreversibility, such that \( 8_0 = 0 \), it is quite conceivable that \( 8_1 > 0 \). Such a scenario is illustrated by the discussion in Section II relating to the interrelation between the hold-up problems and lock-in effects. The extent of such *ex post* irreversibilities can critically define not only a given agent’s market exit, reentry and performance decisions, but also those of other agents undertaking economic activities, which are interdependent with those of the specified agent. Once heterogeneous agents and initial economic conditions are envisaged for different representative agents, \( i \) and \( j \), it is essential to analyze the role of both *ex ante* values of \( 8_0^i, I_0^i, 8_0^j, \) and \( I_0^j \) and *ex post* spot value of the asset, \( I_1 \). Such an outcome is implicitly treated in the subsequent discussion of the other cases.

\(^{27}\) Nonetheless, it need be recognized that there may, unexpectedly, be a positive *ex post* spot value of the asset, \( I_1 \). Such an outcome is implicitly treated in the subsequent discussion of the other cases.
values for $8_i^1$ and $8_i^j$. These values define alternative scenarios which capture the extent to which different asymmetries across agents are critical for defining their distinctive reactions to the economic givens of history and the agents reoptimization decisions. Thus, for example, agents with \textit{ex post} sunk costs have reoptimization decisions, which do not incorporate such sunk costs, whereas the optimization for other agents may be critically impacted by their obligation to incur \textit{ex ante} sunk costs. It is precisely this mechanism, which explains the asymmetric positions of incumbent firms and new entrants in the analysis of Owen and Ulph (2002). This in turn generates three distinctive trade regimes and associated identification/model selection problem, as previously discussed.

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To be further elaborated:

\textbf{Proposition 2: Pecuniary Externalities, Sunk Costs and the Identification of Structural Models}

In the presence of one, or more, market imperfections, the investment irreversibilities, at the origin of \textit{ex post} or \textit{de facto} sunk costs, can be associated with pecuniary externalities, when “news” causes economic agents to reoptimize their decisions. The extent to which the internalization of unforeseen contingencies will cause economic agents to revise economic decisions can depend on the historical time profile and values of their \textit{ex ante} investment decisions, relative to those of other agents, as well as the magnitude of informational and other economic shocks. The pecuniary externalities can arise because of general equilibrium effects on the returns to initial investments and/or due to changes in the residual or scrap value of those investments. These then can generate distinct structural models, depending on the extent of both past and future economic irreversibilities.

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C. Sunk Costs Matter

The foregoing analysis suggests what might be called the “sunk cost trilogy”. More specifically, the state contingent irreversibilities, embodied in sunk costs, can matter for market entry, market performance and market exit decisions. While it is well recognized in the industrial organization literature that \textit{ex ante} sunk costs can determine market contestability. For an individual agent, market entry occurs when anticipated returns are greater than anticipated sunk costs. What is perhaps less appreciated is that there is a potential discrepancy between the partial equilibrium calculations of individual firms, for example, and the associated general equilibrium outcomes. More specifically, sunk costs can be associated with both costs which are not fully determined at the time of an initial investment and streams of returns to investment over time. These can have quite different \textit{ex post} evaluations, relative to an individual agent’s \textit{ex ante} assessment of
their future value, once a general equilibrium outcome is determined. Clearly, with more heterogeneous agents, more incomplete information spaces, and higher degrees of uncertainty, the greater are the potential discrepancies between exogenous specifications for the partial equilibrium evaluations of individual agents, and the endogenous evaluations in general equilibrium evaluations. Thus, there is an inherent contradiction in specifications of the role of sunk costs in partial and general equilibrium.

A second part of the “trilogy” is that endogenous sunk cost evaluations can very much matter for an agent’s decisions even if these are not related to entry and exit decisions in the specific market where those sunk costs arose. An issue here is that there can be varying degrees of complementarity and substitutability between sunk costs in different markets. This is illustrated by the complementarity that arises between the training of workers in the use of information technologies and investments in computer hardware. A firm, for example, that faces high labor turnover might not be willing to invest in computers with new technological capabilities if it anticipated high additional irreversible losses from the retraining of its existing stock of workers.

A third critical way in which sunk costs can matter is with regard to agent’s exit decisions from markets. At a given point in time, an irreversible loss of value in an initial investment implies a spot cost commitment, which is effectively a “bygone” in terms of the agent’s decision to exit the market if it does so because the perceived present discounted value of the returns to that investment are less than the residual value of the asset. It can be noted that this evaluation may be contingent on changes in other markets, as arises when goods with superior characteristics become available at affordable prices. Yet, when the agent decides not to liquidate the asset and thereby stays in the given market, the irreversibility remains as a potential state contingent put option. In this sense, the sunk cost continues to matter. Again, the interrelation between the partial and general equilibrium analysis is crucial for understanding the idea that the \textit{ex post} evaluation of sunk costs may, or may not, matter depending on state contingent outcomes, which depend on the distribution and evolution of information over time.

There are apparent implications of the foregoing analysis for the specification of the conventional utility and profit optimization behavior of consumers and firms. Indeed, much of standard economic analysis is profoundly ahistorical. For example, the standard representative consumer problem,

\begin{equation}
\text{(13) Max } U(X_1, X_2, \ldots, X_n) \text{ subject to } \sum_{i=1}^{n} P_i X_i = Y
\end{equation}

essentially freezes the stream of history, since it ignores the determinants of market entry and exit in general equilibrium. These can critically depend on the evaluations of existing stock holdings of goods which are related as substitutes or complements with the set of goods, \(X_1, X_2, \ldots, X_n\), which are being considered for purchase. If a hypothetical set of such stocks are represented by, \(Z_1, Z_2, \ldots, Z_n\), then a “history augmented” utility function could be conceived as being represented by \(U(X_1, X_2, \ldots, X_n; Z_1, Z_2, \ldots, Z_n)\). The critical insight here is that consumers calculation of marginal utilities with prices depends on such stocks, which imbed endogenous sunk cost evaluations, as reflected, for example, by a vector of quality variables \(q_1, q_2, \ldots, q_n\), which capture the evolution of the goods characteristics over time. Thus, a historical augmented utility function could be represented in the standard Cobb-Douglas case by:
$$U(X_1, X_2) = (X_1 + [Z_1/q_1])^\forall (X_2 + [Z_2/q_2])^\exists$$

It is a trivial exercise to show that the historical values of such stocks and quality indices impact the agents purchases of $X_1$ and $X_2$. Alternatively, these historical stock values could be specified in terms of a series of potential inequality conditions, which need to be verified to ascertain whether the agent will enter or exit the market. Critically, these stock and quality index values embed irreversibilities, which can change endogenously over time as a result of market entry and exit decisions, as in the example, of goods with certain technological characteristics. Furthermore, an agent’s preferences, as represented by the coefficients $\forall$ and $\exists$ in the Cobb-Douglas, can be understood to evolve over time, as a function of sunk learning costs. Analogous reasoning could be applied to a reformulation of the standard theory of the firm, wherein there are historical values of labor and capital stocks, which have endogenous evaluations in general equilibrium.

Thus a frontier for ongoing research in a wide range of areas in economics entails seeking to identify *ex post* sunk costs and understand their potential implications for existing structural models of economic phenomena, as well as econometric estimations aimed at identifying associated structural changes.28

The analysis of ex ante, and ex post, sunk costs is closely interrelated with the analysis of commitment in economics. Indeed, irreversible investment decisions constitute just one form of commitment. The notion of commitment applies to a wide range of other economic phenomena, including notably different contractual relations, such as labor contracts and those imbedded in the internal functioning of institutions, as well as their external relations. Existing commitments can give rise to *ex post, sunk opportunity costs*. These result from at least temporary restrictions on agents’ optimal decision spaces and the attainment of higher welfare states. As in the case of ex post sunk costs, the evaluation of sunk opportunity costs is critically defined by different forms of “news”, which are *ex post* to the commitment. When an economic agent maintains its commitment, even though there are potentially preferable outcomes, at least in the short run, to decommitting, the agent experiences such *ex post*, sunk opportunity costs. However, at the moment the agent abandons such a commitment, it will be subject to incurring associated sunk costs. This point is illustrated by the case of a central bank, which is seeking to defend the value of its exchange rate during a financial crisis. There can be an opportunity cost to the central bank’s using its reserves to defend its currency, but were its intervention to be swamped by speculative forces, it will suffer a sunk cost from the loss of its commitment. That sunk cost will correspond to the value of reserve losses, evaluated at the new *ex post*, devalued exchange rate.

An unanticipated economic shock can generate an irrecoverable change in value because of *ex post* irreversibilities in decisions, relating to *ex ante* investments or commitments. Such irreversibilities may arise on the expenditure/cost side, or because of

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28 A recent paper by Mailath, Postlewaite and Samuelson (2004) proposes a model of investments in housing with sunk costs and uncertainty. In particular, they consider the interrelation between the agents’ investments and optimal savings to demonstrate that, even in competitive markets, unpredictable future housing markets prices can generate inefficient investment and trade. Viewed at a more general level, their findings are consistent with the international trade findings in Owen and Ulph (2002) that when sunk costs are dominant, unanticipated shocks can lead to welfare losses with trade.
either the reevaluation of an asset value or change in the opportunity cost associated with a decision. A essential insight is that sunk costs often arise, ex post, because following an unanticipated shock, ex ante decisions are not longer optimal and there is an associated opportunity cost to those previous decisions. Thus, sunk costs can, alternatively, be conceived of in terms of either the actually realized changes in values, or in terms of restrictions in sets of previously attainable economic spaces/outcomes. In the latter sense, certain sunk costs can also be viewed as a missed opportunity, and, hence, the opportunity cost of a prior irreversible decision.

A form of duality in economics which may not have been adequately recognized is that whenever there is a commitment there can be associated sunk costs and/or sunk opportunity costs which depend on prevailing states of nature. These can trigger, alternatively, the “calling” of sunk cost values or the unraveling of existing commitments. In order to fully understand such processes it is essential to evaluate both the sunk costs and sunk opportunity costs associated with not only the commitment, but also the conclusion of that commitment. For example, a theory of marriage is incomplete without also a theory of divorce. Analogously, examining the credibility of a central bank’s announced commitment to defending a given fixed exchange rate, necessitates an appraisal of the sunk opportunity costs of maintaining or abandoning such a commitment in different states of nature. Similarly the analysis of investment precommitments, reflecting in the well-known “hold-up problem”, has a dual in the form of the “lock-in effect”, which are both critically related to sunk costs and sunk opportunity costs.

It should be further noted that the very process of decision making, and expectations formation, inherently entails sunk costs, since economic agents invest time and resources to gather information and formulate their decisions. Put differently, sunk costs are an intrinsic feature of economic systems and adjustment processes.

D. Sources of Sunk Costs

Although the role of sunk costs in investment and finance decisions is now well recognized, as investigated by, notably, Dixit and Pindyck (1994), the foregoing definition suggests a much wider array of optimization decisions that can arise beyond those of holding assets or physical and technological investments. Such an expanded array of intertemporal commitments include explicit and implicit contracts, the structures and internal functioning of firms and institutions, and, indeed, many aspects of human behavior, including, notably, learn processes.

Viewed in such a larger context, it is readily apparent that a vast research agenda lies ahead. Indeed, the role of sunk costs, in impacting economic performance and welfare, in labor economics, international economics, the economics of transition, technological competition, behavioral and experimental economics, is but the “tip of the iceberg”.

E. On the Measurement of Sunk Costs

29 Fukuda and Owen (2003) offer an analysis, which illustrates the role of hold-up and lock-in effects in the case of a macroeconomic slowdown and long-term labor market contracts in Japan.
A crucial insight is that sunk costs are a form of market failure. Indeed, they are doubly so. First, there is the most obvious loss of value, which a sunk cost can entail. This is apparent in the case of bankruptcy where, for example, there is a likely loss of intangible assets, such as those linked to unfinished technology projects. Such technological investment may have little, or no, residual market value outside a specific firm that initiated those R&D activities. But, there is also a second form of market failure in terms of a potential informational loss, hence a failure, for the efficiency of economic systems as a whole. From the standpoint of the overall economic system, this is a form of incompleteness and defines bounds to the “rationality” of economic agents participating in that system, in the sense that their decisions will not incorporate all potential information. A essential point to stress here is that the informational sets that agents may have regarding a specific sunk cost, may be quite disjoint. \( A \textit{ priori} \), the information sets will be most complete for those economic agents, which are closely associated with the intertemporal commitments linked to a given sunk cost.

In many respects, the informational content of sunk costs can be viewed as a private good, which is only partially observable by outside agents. Consequently, those external agents may make decisions, having formulated conjectures regarding their own evaluation of sunk costs, which can entail varying degrees of misperceptions. Thus, a key issue here is that the information sets of agents can vary substantially across an economic population. In order to understand the impact of an economic system engendered by the constraints and other consequences of a specific sunk cost, it is essential to consider the distribution across agents of shares of a hypothetical information set, which would contain all of the hypothetically relevant information relating to the sunk cost. In this respect, it should be noted that the information sets of agents most closely concerned with a given sunk cost may themselves be incomplete, to the extent that they lack information regarding the true opportunity cost of an economic shock. This leads to an inherent identification problem in economics, since it is inherently complex interactions between agents, based on often unobservable factors, which will define structural models. Such an identification problem is further complicated by the possibility of successive unanticipated shocks, which will greatly complicate characterizations of the interfaces between different agents’ information sets. From an econometric viewpoint, there is an apparent methodological limitation to forecasting the consequences of given unanticipated external shocks.

Certain of the arguments presented here are in a number of respects analogous to those of the Lucas critique. Yet, there is the further insight that an understanding of whether processes of forming expectations are more akin with that of a frictionless world, or one in which adaptive specifications based on existing equilibria, may be critically explained by the interrelation between expectations formations at the micro level of individual agents’ information sets and opportunity costs of processing information, which entail sunk cost issues. Yet again, unanticipated sunk costs can entail an inherent source of information loss in economic systems, which are essential for understanding the strategic interactions between agents and economic adjustment processes.

F. Effects of Sunk Costs and Related Conceptual Issues
Viewed at a somewhat abstract level, the class of problems identified in this research can be viewed as related to issues in mathematics relating to the analysis of limits and discontinuities. More specifically, the basic expectational framework is one where the initial probability assigned to an event (in this instance the integration shock,) is zero \( (p = 0) \), whereas the realization of this unanticipated event with certainty, leads to an \textit{ex post} probability of one \( (p=1) \).

At the time of a “big bang” associated with an unanticipated shock, there is a critical question of how much existing economic structures and relations matter.

Crucial differences exist in the relation between sunk costs and aggregate market performance, on the one hand, and between sunk costs and individual institutions, firms and individuals, on the other hand. By endogenizing exogenous shocks market forces may produce price and quantity changes, which generate sunk costs. As previously noted, this can constitute a form of market failure. Indeed, price, and other, market changes may also be the source of “news”, which can, by themselves, be a form of exogenous shock. This idea is illustrated by the effect that stock market movements may have on agents’ expectations formations. In contrast, institutions, firms and individuals can often be viewed as imbedding sunk costs that are either generate by market forces, or by their own strategic decisions, or those of others. One mechanism by which such sunk costs arise is through either explicit or implicit contractual relations. Nonetheless, the foregoing distinction may not always be so clear-cut, since explicit and implicit contractual relations between economic agents constitute different facets of market mechanisms.

Note, furthermore, that sunk costs could in certain instances change the preferences of agents. One can imagine, for example, that investors in the stock market might be more risk averse once they experience a loss due to a forced sell off during an economic downturn. For example, less liquid investors could become more risk averse, as a result of an irrecoverable loss of value associated with their having to sell off their holdings during a macroeconomic slowdown. This, in turn, could lead to a dampening of their willingness to reenter the market, thereby accounting for more protracted periods of recession. The very fact that such investors would be leaving markets, would, in turn, lead to the previously discussed identification problem. Thus, for relatively liquidity-constrained investors, knowledge of the timing and prices associated with their initial stock market purchases (market entry) and subsequent sales (market exit) decisions would be, for the most part, private information. Of course, more liquid and diversified investors, which are typically larger ones, would not be as likely to experience such sunk cost losses and would consequently be able to “ride out the storm”. A clear implication of the foregoing remark is that modeling efforts to try and capture swings in the shock market should try to obtain proxies for the number of small, relative to large, investors, as well as associated measures of their degree of liquidity.

\textit{History Matters}
Hysteresis effects arise when there is a path dependency of equilibria, such that past equilibria impact the trajectory of future equilibria. There are two senses in which the hysteresis effects, arising from sunk costs, could be thought of as impacting the historical evolution of an economy’s performance. The first of these relates to the speed of convergence from an initial equilibrium to the final one that would prevail in a frictionless scenario. The second results from a path dependency, which depends on the configuration and levels of sunk costs, such that a frictionless equilibrium is never attained. The latter scenario would arise if there are persistent sunk cost effects which never dissipate. One reason for such sustained hysteresis effects is the informational loss, associated with the market failure nature of sunk costs, is distributed asymmetrically across agents. Furthermore, to the extent that there are divergent information sets across agents, there is the potential for associated changes in agents’ strategic decisions, which may be the source of complex interactions. A crucial insight to emerge from the analysis of this paper is that economic irreversibilities influence history not only when they are fully surmised by economic agents, but also when there full implications are not initially understood, because of unforeseen contingencies.

VI. Applications to Different Fields of Economics

These include the realization that:

1. that the economics of institutions, pioneered notably by Williamson (1986, 1990, 1996), involves governance structures and contracts which imbed fixed and sunk costs explaining institutional hysteresis. Indeed, by definition the contractual and non-market exchanges which such institutions engender entail intertemporal commitments, which are regularly subject to external macroeconomic, technology and other shocks from the external market environment. The flexibility of internal management responses to such shocks, in turn, can be defined endogenously the extent of \textit{ex post} sunk costs borne by the firm.

2. individual behavior and preferences can both be characterized as being contingent on sunk informational costs, associated with the acquisition of information linked to “learning” and the formation of expectations. Furthermore, strategic, and other, decisions can be viewed as both contingent \textit{ex ante} on such sunk costs, as well as entailing \textit{ex post} sunk costs, which impact on agents’ subsequent decisions, strategic interactions and welfare. Indeed, past informational investments may impact agents’ future decisions by influencing their willingness to acquire new information. Thus, an appropriate way to consider “trees” of

\footnotesize{\textsuperscript{30} See, for example, the related discussion by Arrow (2004), which he formulates in a competitive paradigm.\textsuperscript{31} Of course, an additional shock during such an adjustment period would likely mean that such a final frictionless equilibrium would not be reached.\textsuperscript{32} For example, in the case of reputational hysteresis, agents’ judgments of other agents’ characteristics may be largely based on the past acquisition of information, which can be perceived as having a residual value.}
intertemporal gaming behavior is to envisage sunk costs as characterized the nodes of such “trees”.

A clear implication of our analysis is that the extent to which expectations formation can be viewed as “adaptive”, rather than “rational”, could critically dependent on whether there are significant sunk costs in economic adjustment processes. In a frictionless world, adjustment is instantaneous and conventional comparative static analysis may be appropriate, without significant concern for alternative dynamic adjustment paths. In contrast, in a world characterized by important sunk costs, hysteresis effects dominate such that past equilibria may play a particularly important role in accounting for new equilibria states. Hence, there are apparent issues relating to the microeconomic foundations of the “Lucas critique”, which are imbedded in questions relating to the specification of sunk costs, as state variables that determine unique path-dependent adjustment processes. A critical insight is that, even if the ex post, economic influence of sunk costs diminishes (depreciates) the final steady-state equilibrium will be uniquely interrelated to the specific time-profile of their values.

Clearly, to the extent that experimental economic approaches do not explicitly take into consideration such sunk costs of individual decision-making they can entail critical misspecifications. Another issue, which can arise in the case of individual behavior involving strategic interactions between agents, is the idea of reputational hysteresis, which offers additional insights concerning the well-known “lemons” problem set forth by Akerlof (1970).

VII. Conclusion

A central tenant of the foregoing analysis is that sunk costs appear to be one of the most neglected and poorly understood topics in economics. Indeed, the current treatment of sunk costs entails a fundamental analytical flaw, since the postulated past and future roles of sunk costs are characterized in an essentially atemporal fashion, based on an artificial partition of the past and future at a hypothetical moment in time. Such an approach obfuscates the role of sunk costs as state variables, which fundamentally impact agents’ choice sets through wealth effects and restrictions on agents’ choice sets.

The analysis presented here rests on a central theorem established in the paper by Owen and Ulph (2002). More specifically, it is demonstrated in the context of a two-country model of oligopolistic behavior, that the final equilibria states and associated welfare changes resulting from an unanticipated integration shock depend critically on the combined role of fixed and sunk costs. It is apparent that the modeled market imperfections and strategic interactions between agents play a critical role in accounting for these findings. In a frictionless world, without any historical “memory” a competitive equilibrium would prevail instantaneously, leading to a different final outcome from the equilibrium from those which are identified in our paper, and shown to be uniquely dependent on underlying cost structures and market imperfections. A clear corollary of the foregoing results is that many existing international trade paradigms have inherent
weaknesses, to the extent that they view the world as a frictionless one, in which new trade equilibria are either explicitly or implicitly understood to arise from exogenous shocks. It is clearly essential to model the diffusion mechanisms by which such shocks filter through the economy. In particular, such tatonnement, or other adjustment processes, need to consider the effects that sunk costs have as state variables defining the trajectory of equilibria. They can reflect, for example, liquidity and other constraints, as well as wealth effects.

Expressed in other terms, a key contention of this paper is that at the time of a “big bang”, associated with an unanticipated economic shock, economic agents’ existing commitments play a critical role in defining subsequent economic equilibria and welfare. These ex ante commitments correspond, in a very real sense, to the weight of history in influencing economic outcomes. In a frictionless world, with complete markets, history does not matter. However, “for better or for worse, until death does us part”, most, if not all of the world in which we live in is characterized, in my view, by the impact of varying degrees of pre-commitments and market imperfections, along with associated hysteresis effects. In this “real world”, sunk costs can be understood to inherently capture certain of these effects. Nonetheless, we as economists, may face grievous difficulties in measuring and identifying such effects of sunk costs, due to the inherent information losses to economic systems, which constitute a form of market failure, associated with such unanticipated economic shocks. In light of this market failure, there is a major limitation to eventual econometric approaches, which naively tend to extrapolate from existing models, since these may not reflect underlying adjustment mechanisms associated with unanticipated shocks.

In light of the analysis of this paper, it can be noted that even the simple multiplier calculations that are part of comparative static analysis in introductory economics course can be viewed as misleading if one admits the possibility of frictions in adjustment processes due to underlying sunk costs. The latter can redefine the fundamental structure of economic mechanisms and relations such that naïve derivative calculations based on an ex ante model can turn out ex post to be quite misleading since such methodology obfuscates the very processes that it is seeking to explain.

The analysis presented here gives a center stage role for sunk costs in understanding a wide range of economic phenomenon, while emphasizing that existing understandings of the role of such sunk cost effects are often fundamentally flawed. Undoubtedly, one reason for the existing fallacies regarding sunk costs is that little if any attention has been given to the point of discontinuity between ex ante and ex post roles for sunk costs. Such approaches fail to realize how the frontiers of economic analysis have been severely handicapped by a reliance on analytical tools which actually have imbedded assumptions regarding the role of such sunk cost effects. In the big bang of transition from p=0 to p=1, there is most certainly a role for the associated effects on agents’ expectations and optimizing behavior, in scenarios where the world does not instantaneously adjust and there are effects of hysteresis, which correspond to historical givens that can critically matter. To paraphrase a quote from Robert Frost: “Two paths diverged in a wood and I thought about “taking the one least traveled by”, but there was an external shock, so that I ended up on yet another path and “that has made all the difference.” From an economic standpoint it is not just “character that is fate”, the past matters in complex ways, which depend on sunk costs, which are a form of economic
mutation. In sum, like the emperor, when it comes to the proper specification and
consideration of sunk costs, much of existing economic analysis “has no clothes”.

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