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The effects of sunk costs on entry and exit: evidence from 36 countries

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Abstract

Dynamic competitive models of industry evolution suggest that intertemporal variability of the number of firms should be lower in industries with higher sunk costs. We test this proposition using data from 36 countries. The results are consistent with the theory.

Keywords: Sunk costs; Entry and exit

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1. Introduction

Dynamic models of industry evolution suggest that sunk costs are an important determinant of firm behavior and hence of industry evolution over time. Examples include models by Dixit (1989), Sutton (1991), Lambson (1991, 1992) and Cabral (1995). Some predictions of these models have been tested empirically. For example, Bresnahan and Reiss (1994) found that the minimum price that triggers entry by rural dentists is strictly higher than the maximum price that induces exit. Roberts and Tybout (1997) observed that Colombian firms are more likely to remain in the export market (having paid the associated sunk cost previously) than to enter the market. Lambson and Jensen (1995, 1998) found that firm value is more variable in industries exhibiting higher sunk costs. In these and other studies, the theory holds up well when confronted with data.

We test another implication of the sunk cost approach: namely, that the number of firms tends to be less variable over time in high sunk cost industries. The data come from 36 different countries

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exhibiting quite different characteristics, and hence the empirical results are quite general. The results support the theory, adding further to the growing evidence that sunk costs have significant, persistent, and predictable effects on the behavior of firms and the resulting evolution of industries over time.

2. Theory

Suppose a firm must pay a cost ξ to enter an industry. A portion of this entry cost, $\xi - \chi$, is sunk. The scrap value, χ, is recouped upon exit. Theory suggests that, other things equal, the intertemporal range of the number of firms depends negatively on ξ and positively on χ.[1] The intuition is straightforward. On one hand, entering firms must expect to recoup their sunk costs, so expected post-entry output prices must be higher (and hence the level of entry must be lower) if sunk costs are higher. On the other hand, existing firms enjoy more protection from future entry when sunk costs are higher, so they are more willing to endure deteriorating conditions without exiting the industry. These effects combine to reduce the variability of the number of firms over time: fewer firms enter when times are good (so the maximum number of firms is lower) and more of them remain when times are bad (so the minimum number of firms is higher).

Of course, theory suggests other determinants of the variability of the number of firms as well. More volatile market conditions—for example, more volatile demand and factor prices—would naturally induce more entry and exit. Also, if minimum efficient scale in an industry is large, one would expect proportionally fewer firms at all times, and hence less volatility in the number of firms.

The theory thus suggests a regression of the following form:

$$\mathrm{Range}_t(y_t) = \alpha + \beta_\xi \xi + \beta_\chi \chi + \beta_\gamma \gamma + \beta_\theta \theta + \varepsilon, \tag{1}$$

where an observation corresponds to an industry (in a given country), y_t is the number of firms in the industry in period t, γ is a vector of variables describing the volatility of market conditions, θ is a measure of minimum efficient scale, ε is an error term, and α, β_ξ, β_χ, β_γ and β_θ are parameters to be estimated.

3. Data and empirical specifications

The data are from the 'UNIDO Industrial Statistics Database 1999 3-Digit level of ISIC Code,' published by the United Nations Industrial Development Organization. This data set ''contains time series data starting with 1963 to the latest available year for approximately 175 countries. The data are arranged according to the International Standard Classification (ISIC), Revision 2, at the 3-digit level, which provides for the inclusion of 28 industries in the manufacturing sector.''

We selected a subset of the countries represented in the database using two criteria. First, we required a complete time series for the relevant variables for at least 10 years. (Most of the included

[1] See, for example, Lambson (1992, Theorem 4.4).

data come from around 1980–1990.) Second, we required that the ISIC industry definitions be similar. From the original 175 countries represented, there were 36 that satisfied both criteria.

We operationalized (1) as follows. For each industry in each country in each year, we defined y_t as the 'number of establishments' reported in the UNIDO database. As defined by UNIDO, ''an establishment is ideally a unit which engages, under a single ownership or control, in one, or predominantly one, kind of activity at a single location; for example, an individual workshop or factory.'' The range of y_t for each industry in each country is the difference between the maximum number of establishments and the minimum number of establishments observed over time. Since this range cannot be negative, we used the logarithm of $\text{range}_t(y_t)$ as the dependent variable.[2]

The variable ξ in (1) is what the theory calls entry costs (per firm). Arguing that capital costs form a large component of entry costs, Lambson and Jensen (1998) used the real gross book value of property, plant, and equipment as a proxy for ξ. This variable is not available in the UNIDO data set. However, the book value is closely related to the sum over time of 'gross fixed capital formation,' a variable that is available. Gross fixed capital formation is ''the value of purchases and own-account construction of fixed assets during the reference year less the value of the corresponding sales. The fixed assets covered are those (whether new or used) with a productive life of one year or more.'' The values are reported in US Dollars for all countries; we calculated real values using the GDP deflator with 1947 as the base year.

Our first proxy for ξ is denoted K_Y. For a given industry in a given country it is the intertemporal mean of the firm mean of the industry's real gross fixed capital formation. Taking the intertemporal mean does two things. First, it smoothes the data by removing the intertemporal variability. Second, it corrects for the differing numbers of periods for which the various industries are observed. Specifically, capital costs are the sum of per-period capital expenditures (ignoring depreciation). However, using the sum over the *observed* periods would tend to estimate higher capital expenditures for industries that are observed for more periods; dividing by the number of observed periods corrects for this.

The variable K_Y is not a perfect measure of ξ, of course. For one thing, it ignores non-capital start-up costs such as the opportunity cost of the entrepreneurial time used to start a company, the initial legal fees, the cost of market research, and so on. Also, the theory assumes that ξ is paid once and for all. In reality, firms pay an initial entry cost to build a plant and then make ongoing capital investments to adjust capacity, compensate for depreciation, and retool with improved technology, among other things. Nevertheless, it is plausible that the level of ongoing capital investment is positively correlated with entry costs, and hence is a reasonable proxy.

We also tried a second proxy for ξ. Since entry costs are probably higher in more capital-intensive industries, we constructed a measure of each industry's capital–labor ratio by calculating the intertemporal mean of gross fixed capital formation per worker. Call this variable K_L. As will be seen, both proxies for ξ yield qualitatively similar results, supportive of the theory.

We have no information on the scrap value, χ, so this variable is omitted from the regressions. There are, however, two reasons to believe this omission is not serious. First, it seems plausible that scrap values are low in all industries because most of a firm's assets are probably industry-specific. Highly specialized machinery, for example, may be no more valuable than scrap metal outside of the

[2] Only one observation exhibited a range of zero. This observation was dropped.

industry. The cost of assembling a managerial staff is not recouped when, at the firm's demise, managers go their separate ways. Similar arguments are valid for other kinds of employees. To the extent that scrap values are uniformly low, the variation in ξ will be large compared to the variation in χ, and the bias in the estimate of β_ξ will be small.

Second, even if there is a lot of variation in χ across industries, finding a negative value of β_ξ is arguably meaningful even though the estimate is biased. Specifically, it seems likely that χ is positively correlated with ξ: firms that are more costly to create probably also have higher scrap values. So since the theory implies $\beta_\chi > 0$, the bias in the estimate of β_ξ is likely to be positive.[3] Thus a negative estimate of β_ξ constitutes strong support for the theoretical prediction that $\beta_\xi < 0$.

Another limitation of our data is the lack of information on the volatility of market conditions. This, however, is probably not serious because there is no reason to believe that the variability of market conditions is correlated with sunk costs. Thus omitting this variable only reduces the precision of the estimates without introducing a bias.

Finally, recall the argument that the minimum efficient scale of production is a determinant of the number of firms and hence of the intertemporal range of that number. To control for this, we used the intertemporal mean of the number of establishments (for a given industry and country), denoted Y, noting that it should be strongly negatively correlated with the minimum efficient scale.

In summary, the empirical specifications considered were

$$\text{Log Range}_t(y_t) = \alpha + \beta_\xi K_Y + \beta_\theta Y + \varepsilon, \tag{2}$$

$$\text{Log Range}_t(y_t) = \alpha + \beta_\xi K_L + \beta_\theta Y + \varepsilon. \tag{3}$$

Theory predicts that, in each regression, $\beta_\xi < 0$ and $\beta_\theta > 0$.

4. Empirical results

The results for (2) and (3) when the data are pooled (and country binary variables are included) are given in Table 1. (The reported standard errors have been corrected for heteroskedasticity using the White correction.) In each case the coefficients are of the predicted sign and are statistically

Table 1
Dependent variable: logarithm of the range of the number of firms

	S.E.	Y	S.E.	Adj. R^2	Obs.
K_Y					
−0.56	0.141	0.000286	0.000088	0.53	946
K_L					
−1.48	0.329	0.000300	0.000093	0.48	946

K_Y is measured in millions of real dollars (base year 1947) per firm. K_L is measured in thousands of real dollars (base year 1947) per worker.

[3] See Greene (1990, p. 259).

significant. The results for (2) and (3) when separate regressions are run for each country are in Tables 2 and 3, respectively. One star in the column labeled 'Sig.' denotes significance at the 10% level or better, two stars denote significance at the 5% level or better, and three stars denote significance at the 1% level or better. The smaller sample size associated with each country yields less precise estimates, but the results are still rather striking. In both tables the estimated coefficient of the ξ proxy has the predicted negative sign in every country with the exceptions of Tanzania and Zambia,

Table 2
Independent variables: per firm capital costs (K_Y), and mean firm number (Y). Dependent variable: logarithm of the range of the number of firms

Country	K_Y	S.E.	Sig.	Y	S.E.	Sig.	Adj. R^2	Obs.
Australia	−1.83	0.808	**	0.000921	0.000173	***	0.63	28
Bulgaria	−0.70	0.087	***	0.003100	0.000459	***	0.80	25
Canada	−0.56	0.196	***	0.000704	0.000104	***	0.69	28
Colombia	−1.64	0.102	***	0.002189	0.000341	***	0.73	28
Croatia	−8.94	1.270	***	0.003128	0.000471	***	0.74	28
Hungary	−0.91	0.152	***	0.004796	0.001176	***	0.73	27
India	−0.57	0.146	***	0.000188	0.000051	***	0.45	28
Indonesia	−5.86	1.920	***	0.001013	0.000241	***	0.61	26
Israel	−4.06	0.701	***	0.002229	0.000488	***	0.54	25
Italy	−0.16	0.064	***	0.000828	0.000159	***	0.63	27
Kuwait	−3.01	0.943	***	0.001484	0.000388	***	0.25	25
Malaysia	−1.32	0.145	***	0.002932	0.000814	***	0.73	28
Malta	−23.80	16.600		0.008473	0.002701	***	0.44	24
Netherlands	−0.14	0.014	***	0.002735	0.000301	***	0.74	26
New Zealand	−0.86	0.144	***	0.001485	0.000181	***	0.78	27
Denmark	−10.10	3.360	***	0.002770	0.000385	***	0.72	27
Ecuador	−0.75	0.159	***	0.007123	0.001760	***	0.31	28
Finland	−0.22	0.084	**	0.003624	0.000752	***	0.43	28
Greece	−0.59	0.210	***	0.002551	0.000563	***	0.57	28
Panama	−15.10	6.040	**	0.011078	0.002694	***	0.50	25
Peru	−11.40	6.000	*	0.001974	0.000496	***	0.65	28
Poland	−0.95	0.178	***	0.005056	0.000808	***	0.78	28
Portugal	−0.77	0.048	***	0.000873	0.000134	***	0.70	28
Singapore	−0.28	0.146	*	0.006246	0.000788	***	0.68	26
Slovenia	−15.10	9.800		0.001803	0.000850	*	0.45	14
Spain	−10.50	2.120	***	0.000094	0.000021	***	0.69	27
Sri Lanka	−22.20	4.750	***	0.005132	0.000857	***	0.67	28
Sweden	−0.58	0.136	***	0.002021	0.000385	***	0.57	26
Tanzania	0.20	1.140		0.020504	0.007158	***	0.28	23
Thailand	−0.25	0.031	***	0.001192	0.000397	***	0.49	27
Tunisia	−3.66	1.230	***	0.001910	0.003721	***	0.68	21
Turkey	−1.34	0.074	***	0.003333	0.000596	***	0.82	28
Venezuela	−0.36	0.038	***	0.001554	0.000309	***	0.64	28
Yugoslavia ≤89	−1.32	0.682	*	0.002621	0.000326	***	0.70	28
Yugoslavia >89	−47.50	6.030	***	0.001557	0.000284	***	0.76	28
Zambia	0.51	0.428		0.032345	0.004898	***	0.59	23

K_Y is measured in millions of real dollars (base year 1947) per firm.

Table 3
Independent variables: capital–labor ratio (K_L), and mean firm number (Y). Dependent variable: logarithm of the range of the number of firms

Country	K_L	S.E.	Sig.	Y	S.E.	Sig.	Adj. R^2	Obs.
Australia	−0.189	0.119		0.001032	0.000222	***	0.53	28
Bulgaria	−2.130	0.501	***	0.003159	0.000486	***	0.74	25
Canada	−0.012	0.023		0.000734	0.000114	***	0.66	28
Colombia	−1.245	0.570	**	0.002154	0.000381	***	0.63	28
Croatia	−4.833	2.044	**	0.003152	0.000509	***	0.68	28
Hungary	−1.407	0.242	***	0.004870	0.001162	***	0.71	27
India	−0.189	0.250		0.000191	0.000053	***	0.43	28
Indonesia	−1.323	0.773	*	0.001088	0.000265	***	0.54	26
Israel	−0.433	0.184	**	0.002277	0.000520	***	0.50	25
Italy	−0.094	0.057	*	0.000807	0.000173	***	0.63	27
Kuwait	−0.566	0.296	*	0.001416	0.000457	***	0.17	25
Malaysia	−0.294	0.050	***	0.002902	0.000810	***	0.72	28
Malta	−0.445	0.797		0.009646	0.002558	***	0.39	24
Netherlands	−0.142	0.018	***	0.002709	0.000306	***	0.75	26
New Zealand	−0.009	0.0001	***	0.001485	0.000181	***	0.78	27
Denmark	−0.718	0.199	***	0.002924	0.000452	***	0.68	27
Ecuador	−0.450	0.082	***	0.006043	0.001521	***	0.46	28
Finland	−0.166	0.108		0.003594	0.000734	***	0.43	28
Greece	−0.158	0.067	**	0.002525	0.000561	***	0.57	28
Panama	−0.894	0.635		0.011389	0.002769	***	0.44	25
Peru	−0.703	0.551		0.002102	0.000496	***	0.62	28
Poland	−2.704	0.400	***	0.005019	0.000696	***	0.77	28
Portugal	−1.920	0.764	**	0.000677	0.000117	***	0.69	28
Singapore	−0.076	0.039	*	0.006156	0.000773	***	0.68	26
Slovenia	−0.727	1.881		0.002370	0.000672	***	0.34	14
Spain	−0.941	0.294	***	0.000105	0.000024	***	0.54	27
Sri Lanka	0.815	2.629		0.005833	0.000952	***	0.51	28
Sweden	−0.173	0.052	***	0.002014	0.000393	***	0.57	26
Tanzania	0.269	0.506		0.021242	0.007350	***	0.29	23
Thailand	−0.220	0.041	***	0.001186	0.000393	***	0.49	27
Tunisia	−0.469	0.661		0.002089	0.000515	***	0.49	21
Turkey	−1.283	0.428	***	0.003271	0.000691	***	0.73	28
Venezuela	−0.208	0.028	***	0.001489	0.000289	***	0.66	28
Yugoslavia ≤89	−0.371	0.359		0.002705	0.000322	***	0.67	28
Yugoslavia >89	−5.129	2.153	**	0.001857	0.000373	***	0.59	28
Zambia	0.055	0.151		0.031941	0.005309	***	0.58	23

K_L is measured in thousands of real dollars (base year 1947) per worker.

whose positive coefficients are statistically insignificant. The coefficients of the ξ proxy are statistically significant at the 10% level or better in 32 countries (89%) in Table 2 and in 23 countries (64%) in Table 3. As expected, the coefficient on the intertemporal mean number of firms is overwhelmingly positive and highly significant.

We conclude that the data are consistent with the theory.

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