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IS THERE EVIDENCE OF HYSTERESIS?

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AN EMPIRICAL ANALYSIS OF UK IMPORTS: IS THERE EVIDENCE OF HYSTERESIS?*

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Abstract

The paper re-examines the validity of the hysteresis hypothesis by applying it to the UK import volume from the world's five largest economies: Germany, France, Italy, Japan and the USA, over the period 1975 to 1994. Disaggregated bilateral data (4-digit ISIC) are used and hysteresis is captured by a dummy variable which is an extension of work by Parsley and Wei (1993). Panel estimation is undertaken and the Seemingly Unrelated Regression (SUR) technique is employed. There is evidence that hysteresis appears important for UK imports and varies across industries and countries.

(JEL C23, F14)

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I. Introduction

In the 1980s the unresponsiveness of trade flows to exchange rate swings inspired models of trade hysteresis. The definition of "hysteresis" was borrowed from physics, and applied to international trade. It however varies greatly from one author to another, and there is some ambiguity in its interpretation.

In a seminal paper Baldwin (1988) refers to hysteresis as the failure of a property changed by an external agent to return to its original value when the cause of the change is removed. He first showed that temporary exchange rate fluctuations can have persistent effects on trade flows.

A partial list of other studies includes among others Baldwin and Krugman (1989), Dixit (1989a,b), Dixit (1994) and Ljungqvist (1994). The abundant rich theoretical work in this area, however, contrasts with the lack of empirical evidence.

A widely used empirical approach initiated by Baldwin (1988) is testing for structural breaks. He found evidence in the US pass-through equation in the 1980s but not for the import volume. Parsley and Wei(1993) introduced another type of empirical test. They looked at whether cumulative changes in the exchange rate determined US bilateral imports from Canada and Japan. They however found little statistical support in the analysed data.

The above two approaches are combined in the current paper, and the importance of the hysteresis hypothesis is re-examined by applying it to the UK imports from the

world's five largest economies: Germany, France, Italy, Japan and the USA over the period 1975 to 1994.

More particularly we consider that cumulative exchange rate changes may lead to structural breaks and cause hysteresis. For this purpose a dummy variable is created. Its construction is based on the work by Parsley and Wei(1993) which is modified and extended by taking into account the maximum and minimum of the exchange rates over a certain period of time.

The empirical analysis is conducted at the 4-digit disaggregated bilateral level which allows us to assess the influence of country and industry characteristics on the relationship between UK imports and hysteresis.

The selected countries are the main UK trading partners. The period of observation is characterised by exchange rates swings – a necessary condition for hysteresis to occur.

The rest of the paper is organised as follows. Section II offers a brief description of the concept of hysteresis and how it is approached in relation to UK imports. The data are described in Section III. The empirical estimation and the results are presented in Section IV. Section V concludes.

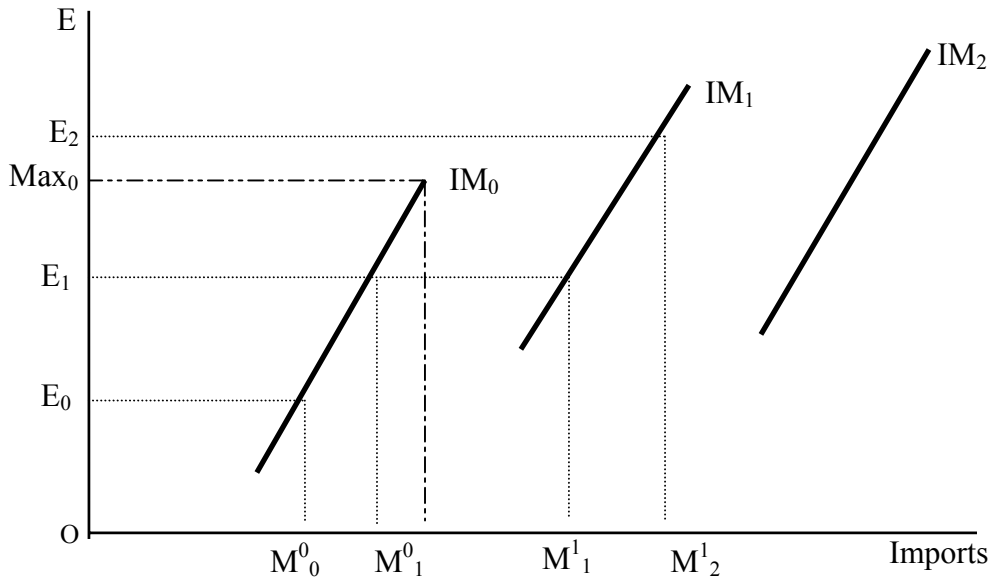
II. The Hysteresis Concept: A Dummy Variable Approach

The export of products often involves a substantial initial investment, which could be in market research, in advertising the product in foreign markets, or in the establishments of a shipping and distribution network. These are sunk costs and because of them, once a firm is established in exporting to a foreign market it will not necessarily exit if an unfavourable exchange rate change occurs and makes its current foreign sales unprofitable at existing foreign prices. Rather than withdraw from the market a firm may, therefore, decide to wait for an improvement in market conditions, brought by a reversed exchange rate change, and in this way the firm will not have to pay the fixed costs of re-entry.

The dummy variable used in this paper is constructed to account for exchange rate changes which are likely to create the conditions for the above scenario and for the hysteresis in import volumes to occur.

Figure 1 can easily illustrate the main insights into selecting and constructing the dummy variable. Furthermore, Figure 2 demonstrates how the current approach differes from the one adopted by Parsley and Wei(1993).

Figure 1 : Hysteresis in the Relationship between UK Imports and the Real Exchange Rate



If the real exchange rate (foreign currency per UK currency) is initially E_0, a domestic currency appreciation to E_1 will lead to an increase in imports (from M_0^0 to M_0^1).In the presence of hysteresis, however, there is some critical level of the real exchange rate, such that a further appreciation to E_2 will move the import schedule from IM_0 to IM_1. This shift occurs because it is profitable for new firms to enter the market, and/or for existing foreign firms to expand. Once foreign firms have entered or expanded, due to incurring sunk costs, a depreciation from E_2 back to E_1 will not cause these firms to exit. As a result, imports will be permanently higher, or this is where hysteresis in imports occurs. Only a continuous depreciation which goes below the exchange rate corresponding to the minimum of the imports IM_1 will shift the import schedule back to IM_0.

Following Parlsey and Wei (1993) we construct the following dummy variable:

First, we define the cumulative change (C_t) in real exchange rates over some period (φ), or:

$$C_t = \sum_{i=0}^{\varphi-1} \Delta E_{t-i} = E_t - E_{t-\varphi}$$

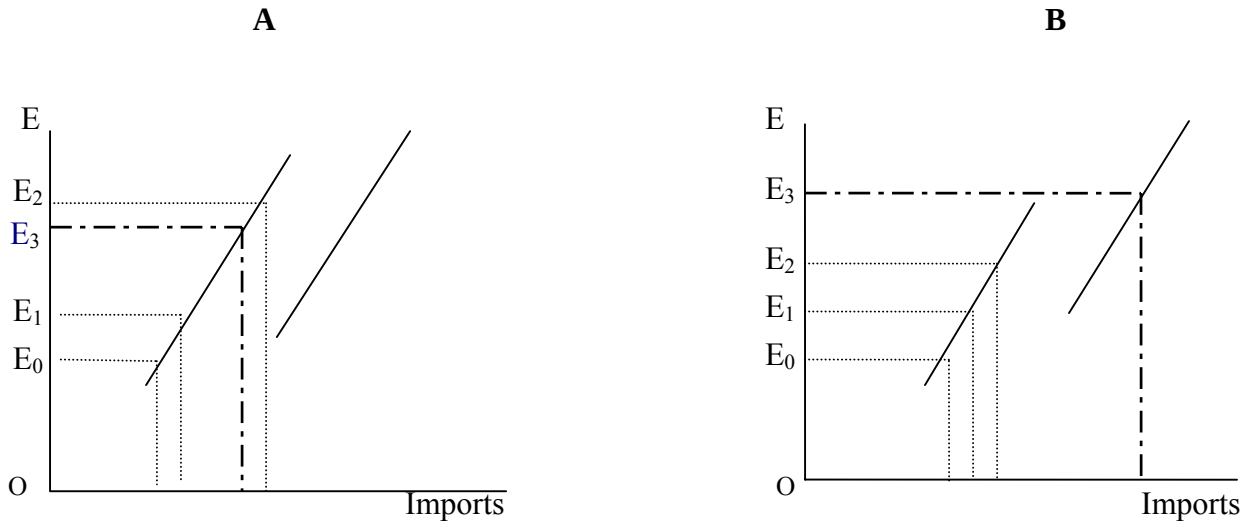
Second, we define the last period change (ΔE_t) and compare its sign with the sign of cumulative exchange rate change. It is important that both signs are the same as this will indicate "a continuous change". Here we introduce the term "continuous" or "long enough" appreciation or depreciation to emphasise the role of direction of the exchange rate change.

A big exchange rate change means an increase in volatility which makes it more likely that any change in the level of the exchange rate is temporary and hence it is less worthwhile to incur the costs to enter or exit. The value of the "wait and see" option just rises.

An emphasis should therefore be put on "continuous" appreciation or depreciation of the real exchange rates when hysteresis in import flows is considered.

Furthermore, we extend the approach adopted by Parsley and Wei (1993) and take into account the maximum and minimum of the exchange rate over a certain period of time, which we consider to be important for capturing the structural shift in import volumes. A simple example (Cases A and B, Figure 2) can illustrate this.

Figure 2: The Role of the Maximum Exchange Rate for a Certain Period of Time when the Home Currency Appreciates



Assume that we would like to construct a dummy variable to test for a hysteresis shift in UK imports and we consider a period of four years in which the exchange rate changes in the following way: E_0, E_1, E_2 and E_3. First, we calculate the cumulative exchange rate change for a period of three years (or φ=2, two consecutive changes) and then the change in the last year:

$$C_t = \sum_{i=0}^{1} \Delta E_{t-i} = \Delta E_t + \Delta E_{t-1} = E_t - E_{t-2} \text{ and } \Delta E_t = E_t - E_{t-1}$$

or $C_2 = E_2 - E_0$ and $\Delta E_2 = E_2 - E_1$

In both cases (A and B), the cumulative exchange rate change (C_2) and the change in the last period (E_2) will have the same sign (C_2 and E_2 are both positive). However, in the first case (A) there will be no structural shift. No hysteresis here. But in the second case (B) there will be a shift which will lead to hysteresis. The way we could explain and capture the different scenarios in A and B is by considering year (t+1). More particularly, if the exchange rate in year (t+1) or E_3 is the maximum exchange rate rate over the period (t+1) or not. This is obviously the case in B with hysteresis shift,

and not in case A. This suggests that the construction of the dummy variable should take into account the maximum of the exchange rates, in the case of real appreciation of the domestic currency, and the minimum of the exchange rate when the domestic currency depreciates. The dummy variable is therefore constructed in the following way:

1. *if* $C_t < 0$ *(depreciation) and* $\Delta E_t < 0$ *and* E_{t+1}*=Min for (t+1) period* *EXIT* ($D_{HIS} = 1$)[1]
2. *if* $C_t > 0$ *(appreciation) and* $\Delta E_t > 0$ *and* E_{t+1}*=Max for (t+1) period* *ENTRY* ($D_{HIS} = -1$)
3. *otherwise* *N0- ENTRY, NO- EXIT* ($D_{HIS} = 0$)

We take the logarithm of the real exchange rates and consider their absolute value to calculate the cumulative exchange rate change (C_t) and the change in the last period (ΔE_t). By contrast with Parsley and Wei (1993) work we do not calculate the phase of the exchange rate. The constructed dummy variable (D_{HIS}) is directly used in the estimation of the equation for UK imports. The main argument is that in the current paper we approach the hysteresis concept from a different aspect. By constructing the dummy variable as described above, and more particularly by imposing the further conditions for maximum and minimum value of the exchange rates we capture the case when it is highly likely for the hysteresis shift to occur. Consequently, a correctly signed and a significant dummy coefficient should well capture a structural break in import volumes due to hysteresis.

[1] D_{HIS} denotes the dummy variable for capturing hysteresis which is later estimated in the equation for UK imports.

In the empirical analysis below when we model the change in demand for UK imports we expect the estimated coefficient on D_{HIS} to be negative. This is because successive depreciations lead to exit, and thus the import schedule shifts inwards. Similarly, an appreciation after a substantial cumulative appreciation will yield to an outward shift in the import schedule, but now D_{HIS} is equal to -1. Therefore in both cases, when appreciation or depreciation causes hysteresis in import volumes, we expect the estimated coefficient of the dummy variable to be negative and significant.

III. Data

All of the data (with the exception for the exchange rate series) were taken from Anderton et al. (1998) when all the necessary conversions had already been undertaken. The annual disaggregated industry data for the bilateral value and volume of imports from 1975 to 1994 between all country pairs had been supplied by the OECD on an SITC rev2 basis, and then converted to ISIC to obtain data at the 4-digit (ISIC) industry level. The price of imports was calculated as unit values. The demand for the UK (proxied by real final expenditure at 3-digit level) and UK producer prices are based on the UK Standard Industrial Classification (SIC). The bilateral exchange rates used are annual average values from the IMF Database adjusted by the Wholesale Price Index (WPI), IMF Database.

IV. Estimation and Empirical Results

The empirical analysis is undertaken at a disaggregated bilateral level to enable us to capture the influence of hysteresis across various countries and industries. The time period (T) consists of twenty years (T=20).

Given the short sample, we cannot determine with confidence the time-series properties of the variables we estimate. In searching for the appropriate dynamic specification of the model we calculate the mean, the standard deviation, the maximum and minimum value of UK import volumes by industry and destination country[2]. The results reveal high volatility in UK import volumes and quite possibly they are processes integrated of order one. We therefore proceed by taking the first difference and estimate the following dynamic equation for each 4-digit industry and each individual country:

$$\Delta \ln M_t^{i,uk,j} = \alpha_0 + \alpha_1 \ln M_{t-1}^{i,uk,j} + \alpha_2 \Delta \ln RP_t^{i,uk,j} + \alpha_3 \ln RP_{t-1}^{i,uk,j} + \alpha_4 \Delta \ln DEM + \\ + \alpha_5 Dummy_{HIS} + \varepsilon_t \qquad (1)$$

The variables are expressed in logarithms, $\Delta lnM_t^{\ i,uk,j}$ is the annual change of UK import volume of good *i* from country *j* = Germany, France, Italy, USA and Japan; $\Delta ln\, RP_t^{i,uk,j}$ is the change of UK import price of good *i* relative to UK domestic price of good *i*; $\Delta lnDEM_t$ is the change of UK demand for good *i* (proxied by real final expenditure)[3]; $Dummy_{HIS}\ (D_{HIS})$ is described in the previous section.

We run regressions at the 4-digit level and present results at the 2- or 3-digit level[4]. We assume that the long-run parameters for each industry of the model are common and we employ SUR estimation .

[2] All of the results are available from the author upon request.
[3] Initially the lagged demand term was also included in the estimation. As it was insignificant in most cases we dropped it from the equation.
[4] See Tables 1 and 2 in the Appendix for description of the industries at 4-digit and lower level. Note that the industries for which we report the results are determined by the availability of the data.

The expected signs of the coefficients are $\alpha_1 < 0$, $\alpha_2 < 0$, $\alpha_3 < 0$, $\alpha_4 > 0$ and $\alpha_5 < 0$. In most cases the coefficients are correctly signed and significant[5]. Most importantly, the results show that there is evidence of hysteresis which appears to be important in determining UK imports for the estimated industries and countries. The dummy variable capturing hysteresis is in most cases correctly signed (negative) and in 40 per cent of the cases significant (Table 3). It should be noted that industries for which we would not expect to observe hysteresis have a significant hysteresis term. The constructed dummy variable is meant to capture hysteresis in import volume due to entry and exit mainly because of sunk costs, but other factors such as pure uncertainty are not excluded[6].

Table 3: Estimates of Hysteresis in the Response of Imports to Exchange Rate Changes

Industry and country	**D_{HIS}**	**Industry and country**	**D_{HIS}**
Textiles, leather and footwear (32)		**Petroleum products (35)**	
Germany	-0.0003	Germany	-0.94*
	(0.02)		(0.24)
France	-0.03*	France	-0.17
	(0.01)		(0.16)
Italy	-0.01	Italy	-0.17
	(0.02)		(0.16)
Japan	0.02	Japan	-0.09
	(0.02)		(0.13)
USA	0.03	USA	0.02
	(0.02)		(0.08)
Textiles (321)		**Non-metallic products (36)**	
Germany	-0.13*	Germany	0.09
	(0.04)		(0.08)
France	-0.03	France	-0.05
	(0.04)		(0.05)
Italy	0.01	Italy	-0.16*
	(0.05)		(0.05)
Japan	0.09	Japan	-0.06
	(0.07)		(0.06)
USA	0.007	USA	-0.18*
	(0.03)		(0.08)
Leather products and footwear (323)		**Metal products (381)**	
Germany	-0.02	Germany	-0.18*
	(0.09)		(0.07)
France	-0.02	France	-0.09*
	(0.02)		(0.04)
Italy	-0.10*	Italy	-0.13*
	(0.04)		(0.03)

[5] All results are available from the author upon request.
[6] See Table 4 in the Appendix for industry estimates of sunk costs.

Japan	0.06	Japan	-0.13*
	(0.10)		(0.03)
USA	0.23*	USA	-0.03
	(0.07)		(0.04)
Wood products (33)		**Non-electrical, office and computing machinery (382)**	
Germany	-0.13*	Germany	-0.04
	(0.05)		(0.04)
France	-0.02	France	0.005
	(0.03)		(0.02)
Italy	-0.17*	Italy	-0.06*
	(0.03)		(0.03)
Japan	-0.09	Japan	-0.06*
	(0.15)		(0.03)
USA	-0.07	USA	-0.04
	(0.06)		(0.04)
Paper products (34)		**Electrical apparatus (383)**	
Germany	-0.03	Germany	-0.05*
	(0.07)		(0.02)
France	-0.08	France	-0.02
	(0.06)		(0.05)
Italy	-0.16*	Italy	-0.09*
	(0.05)		(0.04)
Japan	-0.02	Japan	-0.14*
	(0.10)		(0.06)
USA	-0.05	USA	-0.07*
	(0.04)		(0.03)
Professional goods (385)		**Other manufacturing (39)**	
Germany	-0.07*	Germany	-0.13*
	(0.03)		(0.04)
France	0.003	France	0.01
	(0.05)		(0.07)
Italy	-0.03	Italy	-0.13*
	(0.02)		(0.03)
Japan	-0.12*	Japan	-0.03
	(0.04)		(0.10)
USA	0.01	USA	-0.0009
	(0.03)		(0.02)

Notes: Standard errors are in parentheses; *Significant at 5% level.

We use the estimates of sunk costs by industry from Anderton (1996), assuming that the importance of these is the same across countries. Anderton proxies sunk costs by the percentage of total inputs accounted for by wholesale and retail distribution, transport services and advertising. There is a great variation in total sunk costs across industries (2.5-7.5%).

Table 5 provides a summary of the importing countries and industries for which we receive the hysteresis term to be significant.

Table 5: Sectors for which Hysteresis Term is Correctly Signed and Significant at 5% level

Germany	France	Italy	Japan	USA
Textiles (32)	Textiles (32)	Textiles (32)	Rubber products (35)	Petrolium and coal products(35)
Wood products (33)	Metal products (381)	Wood products (33)	Pottery, china, glass and non-metallic products (36)	Non-metallic products (36)
Chemical products (35)		Paper products (34)	Metal products (381)	Electrical machinery (383)
Metal products (381)		Non-metallic products (36)	Non-electrical machinery (382)	
Professional goods (383)		Metal products (381)	Electrical machinery (383)	
Other manufacturing (39)		Non-electrical machinery (382)	Professional goods (385)	
		Electrical machinery (383)		

Almost all of the industries with significant hysteresis terms can be justified by the ranking of the sunk costs. The hysteresis term, for example, for the top position in Table 4 (383-electrical machinery) is correctly signed and significant for four out of the five countries, namely, Germany, Italy, Japan and the USA (Table 5). The unexpected industries for which we receive significant results are "Wood products" (33) for Germany and Italy, "Paper products" (34) for Italy, and "Textiles" (32) for Germany, France and Italy. According to the ranking these industries are in the bottom positions. Anderton (1996), however, also finds fairly strong evidence of hysteresis for both import and export volumes of textiles. This would suggest that in some cases hysteresis may just be due to economic uncertainty.

V. Summary

This paper casts some doubt on the validity of the empirical tests which failed to provide convincing support to the trade hysteresis hypothesis.

The importance of the hysteresis concept is re-examined by applying it to the UK imports from the world's five largest economies: Germany, France, Italy, Japan and the USA over the period 1975 to 1994. This is a bilateral, disaggregated analysis at the 4-digit level which reflects the specific characteristics of the different industries and countries.

By creating a dummy variable based on cumulative exchange rate changes, two aspects of the hysteresis concept are interrelated, and a test for a structural shift in the UK import volume termed hysteresis is undertaken.

As a whole, the results show significant evidence of trade hysteresis. These are mainly industries with relatively high sunk costs, such as electrical machinery, professional and scientific goods, metal and chemical products. Support has also been received for some industries with relatively low sunk costs, such as: textiles, wood and paper products.

Appendix

Table 1: Description of the Industries at 4-digit level

Code	Activity/Description
3111	Slaughtering, preparing and preserving meat
3112	Manufacture of dairy products
3113	Canning and preserving of fruits and vegetables
3114	Canning, preserving and processing of fish, crustacea and similar foods
3115	Manufacture of vegetable and animal oils and fats
3116	Grain mill products
3117	Manufacture of bakery products
3118	Sugar factories and refineries
3119	Manufacture of cocoa, chocolate and sugar confectionery
3121	Manufacture of food products n.e.c.
3122	Manufacture of prepared animal feeds
3131	Distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials
3132	Manufacture of wines
3133	Manufacture of malt liquors and malt
3134	Manufacture of soft drinks; production of mineral waters
3140	Manufacture of tobacco products
3211	Spinning, weaving and finishing textiles
3212	Manufacture of made-up textile goods except wearing apparel
3213	Manufacture of knitted and crocheted fabrics and articles
3214	Manufacture of carpets and rugs
3219	Manufacture of textiles n.e.c.
3220	Manufacture of wearing apparel, except footwear
3231	Tanning and dressing of leather
3232	Fur dressing and dyeing industries
3233	Manufacture of products of leather and leather substitutes, except footwear and wearing apparel
3240	Manufacture of footwear, except vulcanised or moulded rubber or plastic footwear
3311	Manufacture of veneers, sheets, plywood, laminated wood, particle board
3312	Manufacture of wooden and cane containers and small cane ware
3319	Manufacture of wood and cork products n.e.c.
3320	Manufacture of furniture and fixtures, except primarily of metal
3411	Manufacture of pulp, paper and paperboard
3412	Manufacture of containers and boxes of paper and paperboard
3419	Manufacture of pulp, paper and paperboard articles n.e.c.
3420	Printing, publishing and allied industries
3511	Manufacture of basic industrial chemicals except fertilisers
3512	Manufacture of fertilisers and pesticides
3513	Manufacture of synthetic resins, plastics materials and man-made fibres except glass
3521	Manufacture of paints, vanishes and lacquers
3522	Manufacture of drugs and medicines
3523	Manufacture of soap and cleaning preparations, perfumes, cosmetics and other toilet preparations
3529	Manufacture of chemical products n.e.c
3530	Petroleum refineries
3540	Manufacture of miscellaneous products of petroleum and coal
3551	Manufacture of rubber tyres and tube industries
3559	Manufacture of rubber products n.e.c.
3560	Manufacture of plastic products n.e.c.
3610	Manufacture of non-structural and non-refractory ceramic ware (pottery, china, and earthenware)
3620	Manufacture of glass and glass products
3691	Manufacture of structural clay products
3692	Manufacture of cement, lime and plaster
3699	Manufacture of non-metallic mineral products n.e.c.
3710	Iron and steels basic industries
3720	Non-ferrous metal basic industries
3811	Manufacture of cutlery, hand tools and general hardware
3812	Manufacture of furniture and fixtures primarily of metal

3813	Manufacture of structural metal products
3819	Manufacture of fabricated metal products except machinery and equipment n.e.c.
3821	Manufacture of engines and turbines
3823	Manufacture of metal and woodworking machinery
3824	Manufacture of special industrial machinery and equipment except metal and woodworking machinery
3825	Manufacture of office, computing and accounting machinery
3829	Machinery and equipment except electrical n.e.c.
3831	Manufacture of electrical industrial machinery and apparatus
3832	Manufacture of radio, television and communication equipment and apparatus
3839	Manufacture of electrical apparatus and supplies n.e.c.
3841	Ship building and repairing
3842	Manufacture of railway and tramway locomotives and rolling stock
3843	Manufacture of motor vehicles
3844	Manufacture of motorcycles and bicycles
3845	Manufacture of aircraft
3849	Manufacture of transport equipment n.e.c.
3851	Manufacture of professional and scientific, and measuring and controlling equipment n.e.c.
3852	Manufacture of photographic and optical goods
3853	Manufacture of watches and clocks
3901	Manufacture of jewellery and related articles
3902	
3903	Manufacture of sporting and athletic goods
3909	Manufacture of carbon paper, small metal articles n.e.c.

Table 2: Description of the industries for which regressions are run

Industries (groups)	Industries at 4-digit level
32 – Textiles, leather and footwear	3211, 3212,3213,3214,3215,3219,3220, 3231, 3232, 3233, 3240
321 - Textiles	3211, 3212,3213,3214,3215,3219
323- Leather products	3231, 3232, 3233
33-Wood products	3311, 3312, 3319, 3320
34- Paper products	3411, 3412, 3419, 3420
354-Petroleum products	3530, 3540
369-Non-metallic products	3691, 3692, 3699
381-Metal products	3811, 3812, 3813, 3819
382-Non-electrical, office and computing machinery	3821, 3822, 3823, 3824,3825, 3829
383-Electrical apparatus	3833, 3839
385-Professional goods	3851,3852,3853
39-Other manufacturing	3901, 3902, 3903, 3909

Table 4: Estimates of Sunk Costs

ISIC Classific.	Sunk Cost	Ranking
MEL (383) Manufacture of electrical machinery apparatus, appliances and supplies.	7.5	1
MIO (385+3825) Professional, scientific, measuring and controlling equipment; photographic and optical goods (385) and office and data processing machines (3825).	7.3	2
MNM (36) Manufacture of non-metallic mineral products, except products of petroleum and coal.	5.7	3
BMA (381) Manufacture of fabricated metal products, except machinery and transport equipment.	5.5	4
CHE (35) Manufacture of chemicals and chemical, petroleum, coal rubber and plastic products.	5.3	5
MAI (382) Manufacture of agriculture and industrial machinery except electrical.	4.6	6
MTR (384) Manufacture of transport equipment.	4.5	7
FOD (31) Manufacture of food, beverages and tobacco.	4.3	8
TEX (32) Textiles, wearing apparel and leather industries.	3.9	9
WOD (33) Manufacture of wood and wood products, including furniture.	3.7	10
PAP (34) Manufacture of paper and paper products, printing and publishing.	2.4	11

Source: Anderton (1996)

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