Entry, Exit and Investment-Specific Technical Change

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Abstract

Using European data, this paper finds that (1) industry entry and exit rates are positively related to industry rates of investment-specific technical change (ISTC); (2) the sensitivity of industry entry and exit rates to cross-country differences in entry costs depends on industry rates of ISTC.

The paper constructs a general equilibrium model in which the rate of ISTC varies across industries and new investment-specific technologies can be introduced by entrants or by incumbents. In the calibrated model, equilibrium behavior is consistent with stylized facts (1) and (2), provided the cost of technology adoption is increasing in the rate of ISTC.

JEL Codes: D92, L26, O33, O41.

Keywords : Entry, exit, turnover, investment-specific technical change, entry costs, vintage capital, embodied technical change, lumpy investment.

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1 Introduction

Entry and exit rates differ significantly across industries. Over the period 1963-1982, Dunne, Roberts and Samuelson (1988) find that five-year entry rates in US manufacturing data range from 21 percent in Tobacco to 60 percent in Scientific Instruments. High-entry industries are high-exit industries, suggesting that entry and exit are largely due to the same industry-specific factors. At the same time, little is known about what these factors might be.

This paper finds a strong, positive link between industry entry and exit rates and the pace of technical progress in the capital goods that the industry uses – the rate of *investment-specific technical change* (ISTC). A significant fraction of entry and exit thus represents the introduction and replacement of capital-embodied technologies.

ISTC is also positively related to the proportion of enterprises in each industry that displays large investment outlays in a given year. That investment often occurs in "spikes" has been known since at least Doms and Dunne (1998), and the results link this pattern to the replacement of new capital-embodied technologies by incumbents. Furthermore, the decision of whether (or when) to exit appears sensitive to policy: in countries in which the cost of entry is high, rates of entry and exit are disproportionately suppressed in industries with high rates of ISTC.

To analyze these findings, the paper develops a general equilibrium model in which changing the vintage of capital used by a particular enterprise is costly. In the model, this vintage is termed a "*technology*", and an enterprise is a technology-manager pair. The manager accumulates expertise with a given technology over time, and at any date may choose to upgrade to a newer technology – at the expense of accumulated expertise, as in Jovanovic and Nyarko (1996). The manager may also choose to close the enterprise at any date – opting instead to open a new enterprise, or to work.

The model generates endogenous entry, exit, and investment spikes. Since adjusting the vintage of the capital at a given establishment is costly, technological improvements in the production of capital goods erode the profitability of incumbents, so that eventually they either close or invest in updated capital. Investment spikes are typically modelled using non-convex capital adjustment costs, as in Khan and Thomas (2008). In the current model, adjusting the quantity of capital is costless: instead, the process of technology adoption itself generates lumpy investment, as in Klenow (1998).

Equilibrium behavior along the balanced growth path of the model economy is consistent with the stylized facts relating turnover to ISTC. The decline in equilibrium profits as an enterprise falls behind the industry frontier is more rapid if the rate

of ISTC is high so that, when only new enterprises may implement new technologies, equilibrium rates of entry and exit are positively related to the industry rate of ISTC. In a calibration of the model in which incumbents too may adopt new technologies, ISTC accounts for a significant proportion of the observed cross-industry variation in entry and exit rates. Rates of ISTC are positively linked to the prevalence of investment spikes, as updating occurs sooner when the rate of ISTC is high. Entry costs in the model also suppress turnover in high-ISTC industries, as in the data. Notably, the ability of the model economy to match the empirical magnitude of these relationships depends on a positive link between technological adoption costs and the rate of ISTC – as in, for example, Greenwood and Yorukoglu (1997).

A theoretical link between turnover and technical change dates back at least to Schumpeter (1934), and an empirical link is studied in Mueller and Tilton (1969), Geroski (1989) and Audretsch (1991). However, these authors do not consider the rate of technical change as a determinant of long term industry differences in turnover and, in particular, none of them raises *ISTC* as an influence on lifecycle dynamics. This paper uses entry and exit data from 18 European countries: most studies of entry and exit are limited to manufacturing data, and an additional contribution of the paper is that service and other industries are covered also.

The model extends the framework of Hopenhayn and Rogerson (1993) to allow for multiple industries and for technical progress. In a survey of entry and exit, Geroski (1995) reports little success in relating differences in turnover rates to industry characteristics, mostly measures of profitability or entry barriers. In a general equilibrium context, even when there are *no industry differences* in profitability nor entry barriers, the model shows that there can be significant differences in equilibrium turnover rates due to differences in lifecycle dynamics. Following Greenwood, Hercowitz and Krusell (1997) and Cummins and Violante (2002), ISTC is measured using the quality-adjusted relative price of capital used in each industry: however, these papers do not link ISTC to lifecycle dynamics.

Campbell (1998) argues that ISTC may affect the *cyclical* behavior of aggregate entry and exit, and Klenow (1998) studies the cyclicality of investment in a related model. Samaniego (2008) finds that turnover and ISTC are positively related in a calibrated one-sector general equilibrium model. However, none of these papers attempts to account for long term cross-industry differences in turnover – although Jovanovic and Tse (2006) develop a related model in which new industries with a high rate of ISTC experience an earlier wave of capital replacement.

Section 2 surveys the empirical relationship between entry, exit, and the rate of ISTC. Section 3 introduces the model, while Section 4 characterizes the equilibrium and Section 5 studies the relationship between ISTC and turnover in the model.

Section 6 concludes with suggestions for future work. All proofs are in the Appendix.

2 Evidence

We examine the empirical relationship between industry rates of enterprise turnover and industry rates of ISTC. We also relate the prevalence of establishment-level investment "spikes" to ISTC. Finally, we use cross-country data to examine whether the partial correlation between ISTC and turnover is sensitive to policies that make entry costly.

2.1 Data

We measure industry entry and exit rates using the Eurostat database. Eurostat data cover the universe of "enterprises" in the business registers of the member countries of the European Union, and are gathered by their national statistical agencies using a uniform methodology.[1] Previous research on entry and exit mostly focuses on manufacturing data, which produces less than half of GDP in industrialized economies. The Eurostat data provide a more complete view of entry and exit, covering all formal economic activity in the non-public, non-farm sector.

Annual rates of entry, exit and turnover are available for 18 countries over the period $1997 - 2004$. The variable $Entry$ is the proportion of enterprises active in a given year t that entered since year $t-1$, and the variable $Exit$ is the number of enterprises that closed between $t-1$ and t, divided by the number of enterprises active in year t. The variable $Turnover$ is the sum of these two variables. For most of the paper, entry exit and turnover are average annual rates over the sample period for each country-industry pair, to abstract from short term conditions and from possible delays in the reporting of entry and exit.[2]

The measure of ISTC is the annual rate of decline in the quality-adjusted price of capital goods used by each industry, as measured in the United States. Greenwood et al (1997) and Cummins and Violante (2002) show that, in a competitive environment with similar Cobb Douglas production functions for different goods, a decline in the price of one good compared to another reflects an improvement in the productivity with which the first good is produced relative to the second.

[1] The enterprise is equivalent to the concept of the "firm" used by the US Census Bureau. However, in Eurostat mergers and changes of legal form are not counted as entry, nor are temporary shut-downs counted as exit. See the Appendix for further details regarding measurement.

[2] Any delays are likely to be short: for example, in the UK enterprises are removed from the business register three months after the register is notified of their closure.

Cummins and Violante (2002) provide annual quality-adjusted price series for 26 types of equipment. These prices are divided by the official consumption and services deflator for each year, so that all capital goods prices are expressed relative to the price of non-durables. The industry rate of ISTC is the annual rate of decline in the relative price of capital goods used by that industry. This is computed by weighting the declines in the individual good prices using annual capital expenditure shares for each industry, as reported in the Bureau of Economic Analysis (BEA) industry-level capital flow tables.

Country	Turnover	Entry	Exit
Belgium	14.2	7.2	7.0
Czech Republic	18.5	9.8	8.7
Denmark	17.4	9.4	8.0
Spain	15.1	8.9	6.2
Italy	15.1	7.9	7.2
Latvia	25.4	15.0	10.4
Lithuania	20.7	12.1	8.6
Hungary	21.1	11.6	9.5
Netherlands	17.1	8.9	8.2
Portugal	13.4	7.6	5.8
Slovenia	13.6	7.5	6.1
Slovakia	22.8	10.7	12.1
Finland	14.1	7.5	6.6
Sweden	11.1	5.9	5.1
United Kingdom	21.6	11.1	10.5
Romania	25.6	16.8	8.8
Norway	19.4	10.6	8.8
Switzerland	8.0	3.5	4.5
Europe	17.3	9.5	7.8

Table 1 – Summary statistics: Average annual rates of turnover across countries 1997-2004. The value for Europe is the average across countries, weighted by the number of enterprises in each. Source – Eurostat.

The ISTC measure can be constructed with or without structures as an additional capital type. The benchmark results include structures, and results using only equipment goods are reported for robustness. We use the official price series for structures when we include them, following Cummins and Violante (2002).

To control for potential simultaneity or lags in the ISTC-turnover link, the industry ISTC rate is the average over the period $1987-1997$, the decade prior to the measurement of entry and exit rates. For robustness, we also consider average ISTC over the entire post-war period $1947-2000$. The correlation between the two series is 0.91, supporting the interpretation of the rate of ISTC as a long-term industry characteristic.

The BEA capital flow tables use the NAICS industry classification system, whereas Eurostat uses the NACE 1.1 system. The paper reports results for 41 industries, representing the join of the two systems. Rates of ISTC range from about 1.14 percent for Oil and Gas extraction to 8.33 percent for Air Transport. The median industry rate is 4.02 percent.

"Investment lumpiness" is measured using US data from Compustat. Over the period 1997-2004, I identify whether each firm in the database experiences an investment "spike." Doms and Dunne (1998) define a spike as an increase in the capital stock of 30 percent or more within a year. The index *Lumpy* for industry j is the proportion of firms in j that experienced any "spikes" over the period.[3] Compustat covers all publicly traded firms in the US so that, while not being a representative sample of US firms, firms in Compustat are likely to be financially unconstrained, so that their behavior reflects fundamentally technological factors. Values range from about 0.05 in Utilities to 0.95 in Systems Design.

The unit of observation in Compustat is the firm, so that updating at multi-plant firms may not be detected if the updating is not synchronized. Hence, lumpiness is also computed for smaller firms only. The disadvantage of the size-based measures is that there are very few firms in Compustat in some industries below certain size thresholds, so these measures are likely to be noisy.

Some of the regressions require country-level measures of entry costs. I use the cost of starting a business as a proportion of GDP per capita, as reported in Djankov, La Porta, Lopez-de-Silanes and Shleifer (2002), denoted EC. Entry costs are determined by studying the laws and regulations of entry in each country, identifying required procedures and computing the cost of complying with each. For international comparability, and to focus on the costs of entry per se, the procedures considered are those that apply to a "standardized entrant", defined as one that is not subject to any special exemptions, is not in a highly regulated industry (such as tobacco or finance), does not trade internationally, is domestically owned, operates in the most

[3] "Investment" is DATA128 (capital expenditures) and "capital stock" is DATA8 (net property, plant and equipment). The median annual industry value of this variable across manufacturing industries is 6 percent, strikingly similar to the value reported by Doms and Dunne (1998). Data were not available for Educational Services nor for Other Services.

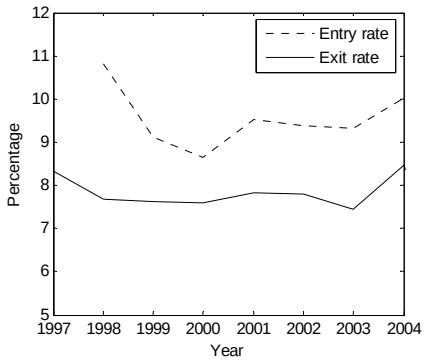

Figure 1: Variation over time in average entry and exit rates in Europe, 1997-2004, based on Eurostat. Countries are weighted by the number of enterprises in each. Eurostat does not report entry rates for 1997. Time variation is small relative to variation across countries and industries, as seen in Table 2.

populous city, does not own real estate and is of medium size. For further details see Djankov et al (2002) and World Bank (2006).

The maintained assumption is that the rate of ISTC (or the ranking) is an industry characteristic that persists across countries. This amounts to assuming similar input-output tables and similar rates of technical progress in any given type of capital good across countries. Since the median rate of ISTC is about 4 percent per year, it is unlikely that significant differences in ISTC for the same industry across countries could be sustained for long in the absence of draconian import restrictions.

2.2 Turnover and ISTC in cross-section

Table 1 reports average entry and exit rates across Europe, and Figure 1 plots their behavior over time. Time does not appear to be an important source of variation in the data. Indeed, analysis of variance indicates that about half of turnover and entry, and about 40 percent of exit, are attributable to variation across industries and countries only – see Table 2.

Variable	Industry	Country	Time	Residual	Obs
Turnover	0.221	0.274	0.011	0.494	2661
Entry	0.249	0.206	0.013	0.531	3197
Exit	0.118	0.204	0.018	0.660	3027

Table 2 – Analysis of variance (ANOVA) for turnover, entry and exit rates. Roughly a quarter of turnover can be attributed to variation across industries, and another quarter to variation across countries.

Define *industry* rates of turnover, entry and exit as the industry fixed effect in a regression of turnover on industry and country dummies.[4] The correlation between entry and exit rates is 0.67, whereas between turnover and entry it is 0.96, and between turnover and exit it is 0.85.[5] Of the 153 possible country pairs in the database, 76 percent of the cross-country correlations in rates of turnover are significant at the 5 percent level. This indicates that entry and exit rates in a given industry in different countries may have common, possibly technological, determinants.

	ISTC coefficient	
	With structures	Without structures
Turnover	1.24***	1.89***
	(0.326)	(0.305)
Entry	0.81***	1.28***
	(0.240)	(0.229)
Exit	0.43***	0.61***
	(0.122)	(0.124)

Table 3 – Coefficients of a regression of turnover on ISTC. Standard errors are in brackets. The link between ISTC and turnover is positive and significant. In all tables, one, two and three asterisks represent significance at the 10, 5 and 1 percent levels respectively.

The data suggest that ISTC may be one of these determinants. Table 3 reports coefficients for bivariate regressions of industry rates of industry rates of entry and

[4] We report this rather than cross-country averages because of a small number of missing observations (for example, 14 out of 738 observations are missing for entry).

[5] The correlation between entry and exit rates reported in Dunne et al (1988) for US manufacturing industries is 0.74. Brandt (2004) finds a similar relationship in OECD data and in an earlier edition of Eurostat which, as here, includes services.

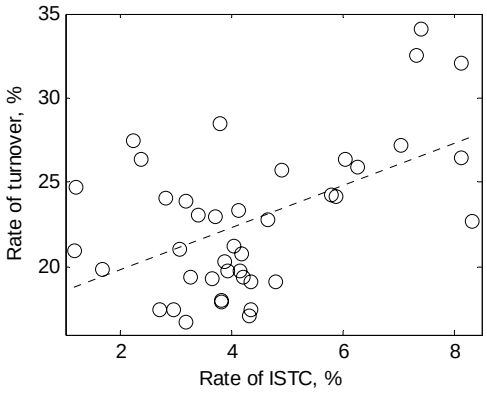

Figure 2: Cross industry comparison of turnover and ISTC. The dotted line represents fitted values using the turnover coefficient in the first column of Table 3.

exit on ISTC. Strikingly, Table 3 and Figure 2 report that these rates are very highly correlated. This is true of manufacturing industries and also of non-manufacturing industries, which report correlations with turnover of 0.45 and 0.56 respectively. Correlations are even stronger for the ISTC measure that excludes structures. The effects are large: a 1 percent increase in ISTC is associated with a 1.24 percent increase in the annual rate of turnover. It is worth noting that, using industry turnover rates at the level of individual countries instead of industry fixed effects, the coefficient on ISTC is significant at the 5 percent level in 14 of 18 cases.

These findings suggest that entry and exit represent, at least in part, the introduction and abandonment of capital-embodied technologies. However, capital may be introduced at *continuing* enterprises as well as new ones. The replacement of a large proportion of the capital stock at a given enterprise is likely to coincide with an investment spike, and we might expect as a result that industries with higher rates of ISTC might display more investment spikes. Indeed, Table 4 shows that the index *Lumpy* is positively and significantly correlated with entry, exit and ISTC. This is regardless of whether *Lumpy* is computed using all firms in Compustat, or only those below a certain size thresholds. A 1 percent increase in the rate of ISTC leads to a 3.8-5.3 percent increase in the prevalence of investment spikes.