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## Turbulence in high growth and declining industries

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# JENA ECONOMIC RESEARCH PAPERS



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## **Turbulence in High Growth and Declining Industries**

by

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# **TURBULENCE IN HIGH GROWTH AND DECLINING INDUSTRIES**

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## **Abstract**

We examine turbulence over the product life cycle using the lowest possible level of industry aggregation, allowing for the use of panel data to study the evolution of single product markets. We find that replacement of exiting firms by subsequent entry plays a primary role in generating turbulence in high growth markets, while displacement of incumbents by recent entrants is the main selection force in declining markets. As product life cycles progress, trial-and-error entry subsides, and turbulence decreases.

JEL-classification: L11

Keywords: Entry; Exit; Selection; Product life cycle; Replacement; Displacement

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## 1. Introduction

Entry and exit are at the centre of a continual process of market selection, as products, firms and industries emerge, grow, mature and ultimately disappear. Conventional wisdom suggests that there should be an inverse relationship between entry and exit, since profitable industries should draw more entrants and record lower rates of failing firms. However, empirical studies across industries and countries have found quite the opposite: entry and exit are significantly and positively correlated, as reported in authoritative surveys by Siegfried and Evans (1994), and Caves (1998). While there are significant differences across industries and over time, several key determinants affect entry and exit the same way (a phenomenon termed ‘symmetry’ by Shapiro and Khemani, 1987).

The literature addressing the dynamics of entry and exit is considerable, using a variety of terms to refer to this phenomenon, including ‘turbulence’, as well as ‘churning’, ‘turnover’, and ‘market selection intensity’. To help understand the phenomenon, two explanations have come to be commonly understood. Marshall (1920) suggested that industry evolution was like a forest in that new trees eventually grow up and replace the old trees. Schumpeter (1942) introduced the term ‘creative destruction’ to describe how in capitalist economies the old ways of doing business are driven out, or endogenously destroyed, by new.

Beesley and Hamilton’s (1984) seminal work highlighted the role played by turbulence and new firms as ‘seedbeds’ for new industries, or the renewal of existing ones. Nickell (1996) suggested that competition forces efficiency on firms through market selection.<sup>1</sup>

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<sup>1</sup> “...by letting many flowers bloom and ensuring only the best survive...” (Nickell, 1996, p. 741).

Recent studies found evidence of turbulence's positive effects. For example, Disney, Haskel and Heden (2003a) find evidence that industry restructuring – entry, exit and market share changes – contribute positively to productivity growth, while Aghion et al. (2004) find that more entry leads to faster productivity growth of incumbents.

The present study adds to the literature by examining turbulence and market selection from the viewpoint of the product life cycle. We propose and test hypotheses concerning how the relationships between entry and exit of firms vary over time, and the way these changes influence turbulence.

Some of the most influential studies that have addressed market selection dynamics from a variety of perspectives – such as those by Caves and Porter (1976); Jovanovic (1982); Gort and Klepper (1982); Beesley and Hamilton (1984); Shapiro and Khemani (1987); Dunne, Roberts and Samuelson (1988); Geroski (1991, 1995a); Audretsch (1995); Klepper (1996); and Baldwin (1998) – indicate that, while symmetry is indeed significant,<sup>2</sup> correlation patterns between entry and exit rates also emerge over time. Indeed, entry and exit coexist in a manner such that, while entry compels subsequent exit, exit makes room for more entry (Geroski, 1995b; Fotopoulos and Spence, 1998). Turbulence would then be an instrument of an evolutionary process through which the market selects successful firms by two means:

- i. processes in which new firms enter the market and, by being successful, force the subsequent exit of weak incumbents through 'displacement';
- ii. processes in which new firms seek to fill the 'vacuum' created by the exit of incumbents, or what could be called 'replacement'.

Displacement occurs when new entrants create competitive pressure, forcing the exit of

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<sup>2</sup> For instance, barriers to entry, such as commitment to industry-specific investments, are found to act also as barriers to exit (Caves and Porter, 1976).

the less efficient incumbents. Replacement occurs because the exit of incumbents is perceived as an opportunity by potential entrants. The present paper proposes that, as industries progress through their life cycles, the correlation between turbulence and displacement should become greater, while the correlation between turbulence and replacement should become smaller.

The incidence of displacement and replacement in the market does not tell the whole story about market selection. Beesley and Hamilton (1984) indicate that industry evolution involves large amounts of ‘trial-and-error entry’ (i.e. entry by firms that do not survive in the market for long). Mata and Portugal (1994) found that in industries registering large amounts of entry and exit, most of the exits are of recent entrants. Audretsch (1995) uses a ‘revolving door’ to illustrate this phenomenon. It therefore seems reasonable to suggest that there may be two distinct drivers of replacement:

- i. young, trial-and-error exiters;
- ii. exiting old incumbents whose competences have become obsolete.

We argue that, as industries move from early growth towards decline, the impact of the exit of young firms on turbulence should become smaller.

The present study examines the determinants of turbulence across markets in a context that differentiates industries between high growth, declining and low growth/mature. The analysis is conducted at the lowest possible level of aggregation: the six-digit standard industry classification available before 1994-95. Six-digit sectors virtually correspond to individual product markets.

The rest of the paper is organized as follows. Section 2 develops hypotheses with regard to the role played by displacement and replacement in generating turbulence over the life cycle. Section 3 addresses the construction of the variables required to test those

hypotheses, and discusses control variables concerning industry-level and environmental determinants of turbulence. Section 4 presents the data and addresses methodological issues. Results are presented in section 5, while section 6 concludes.

## **2. Turbulence and Market Selection in High Growth and Declining Industries**

Theoretical analyses of industry dynamics over the product life cycle propose that different stages of the cycle generate different entry and exit rates (Jovanovic and MacDonald, 1994; Klepper, 1996; Jovanovic and Tse, 2006). Noteworthy empirical studies – including, among others: Klepper and Graddy (1990); Baldwin and Gorecki (1991); Klepper and Miller (1995); Agarwal and Gort (1996); Agarwal and Audretsch (2001); and Disney, Haskel and Heden (2003b) – have indicated that entry rates are higher than exit rates in the earlier stages of the product life cycle. As industries age and set standards or dominant designs for their products, the focus of innovative activity switches from product to process, opportunities for scale economies emerge in areas such as production and distribution, price competition becomes more intense and a ‘shakeout’ occurs (Klepper, 1996).

An important conclusion emerges from these studies and is particularly emphasized by both Baldwin and Gorecki (1991) as well as Agarwal and Gort (1996): the levels of turbulence are higher in earlier stages of the industry/product life cycle, decreasing as industries mature and exit rates surpass entry rates. Beesley and Hamilton (1984) observe that emerging sectors are the ones that register greater levels of turbulence.

Klepper and Graddy (1990) report that the change in the mean number of firms goes from positive to negative as industries pass from early to late stages of their life cycles.

If, in addition to symmetry, the evolution of entry, exit and market selection features both replacement and displacement, it is important to examine how these two effects may vary over the life cycle, and how such variation will affect turbulence.

### **2.1. Displacement and replacement over the product life cycle**

Displacement occurs when new entrants create more competitive pressure thus causing overpopulation and forcing the exit of the less efficient incumbents, regardless of age.

In the early stages of the product life cycle, while the market is growing and dominant designs have not yet emerged, competitive pressure should be less intense. New firms are more likely to find customers that are new to the marketplace, while higher levels of product differentiation mean that there is less price competition. As the life cycle progresses and dominant designs emerge, products become homogeneous and new entrants can only achieve success by taking customers away from incumbents. Price competition should become more intense, with the less efficient firms being driven out of the market (Harrigan, 1980, 1982). It seems therefore reasonable to claim that the effect of displacement on turbulence and market selection should become larger as industries age and their growth rates decline.

Replacement occurs because the exit of incumbents creates the perception among potential entrants that there is room in the market to replace the exiting firms. Exit may signal vacant or unmatched customer demand, helping trigger the next wave of entry, exit and turbulence. As industries age and market growth rates decline, potential entrants may no longer perceive incumbent exit as creating a vacuum in the market. As



products become more homogeneous price competition becomes more intense, and successful entry should require a larger scale of production and, thus, greater investment, further increasing the disadvantages of new firms. Fewer new firms will enter the market in response to incumbent exit. It is then reasonable to claim that the effect of replacement on turbulence and market selection should become smaller industries progress towards their decline.

The preceding logic suggests that in early stages of the product life cycle, replacement should be a greater market selection force than displacement; in late stages of that cycle, the importance of displacement as a market selection mechanism should become greater than that of replacement. One can therefore formulate the first hypothesis to be tested in the present study:

*H1: In high growth industries, replacement effects increasing turbulence and should be greater than displacement effects; in declining industries, the inverse should be true.*

## **2.2. Trial-and-error entry and the effect of replacement on turbulence**

As previously noted, both theoretical and empirical work has pointed out that industry evolution involves large amounts of trial-and-error entry by firms that do not survive very long. We argue that it is the replacement of these young exiters with new trial-and-error entrants that generates the sort of ‘revolving door’ process of entry and exit described by Audretsch (1995). While the door revolves faster at the bottom end of the firm size and age distributions than at the top, replacement effects are also associated with exit of older and larger firms (i.e. established incumbents). High levels of turbulence may not pose much of a threat to large industry leaders in the short run but,

even in growing industries, as successful entrants expand and establish themselves in the market, older incumbents may exit the industry, creating vacuum that may be filled by potential entrants. Replacement effects on turbulence and market selection may then be associated with either exit by young firms (trial-and-error), or by older ones.

The share represented by trial-an-error entry on replacement effects is likely to change over the course of the product life cycle. High growth industries are usually populated by many firms with competing product designs and moderate price competition. These industries attract large waves of new entrants, some bringing innovative and competitive products to the market. These waves of entry lead to large waves of exits of those competitors whose abilities are at the fringe. Most of these exiters are likely to be recent entrants (Audretsch, 1995; Geroski, 1995b; Caves, 1998). The opportunities offered by high growth markets may lead potential entrants to feel overconfident about their chances to be successful. High growth signals an abundance of profit opportunities and many small sized entrants with insufficient market knowledge and no visible competitive advantage will enter and exit rapidly (Vivarelli and Audretsch, 1998; Vivarelli, 2004). According to Camerer and Lovallo (1999), under these circumstances entry may be viewed as an expensive lottery ticket with positively skewed returns: although most entrants expect to lose money and fail, entry still maximizes expected profits because the payoffs for success are very large.

Sunk costs may also contribute to greater replacement effects in growing industries. When investment in industry-specific assets is considerable, entry and exit is usually deterred. However, in growing markets the possibility to liquidate equipment and machinery in a spot market is higher than in declining markets. Exiters should be better able to recover at least part of the invested funds, while future entrants may acquire

existing production capacity at a lower cost than they would face by investing in new facilities. In a review of the rise of the tire industry, French (1986) reported that persistent failure rates encouraged new entrants by creating a stock of second hand plants and equipment as the industry continued to grow.

In declining industries, incumbents are usually few and relatively large, with fierce price competition (Harrigan, 1980; 1982; Lieberman, 1990), so the argument can be made that firms entering these markets are more likely to be sure they own a significant cost or differentiation advantage and, therefore, less likely to be trial-and-error entrants. As industries progress over their life cycles, growth rates decline, and trial-and-error entry should fade away. A second hypothesis can then be formulated:

*H2: Replacement effects associated with 'trial-and-error' entrants (i.e. exit by young firms) increasing turbulence and market selection should be greater in high growth industries than in declining industries.*

### **3. Variable Definition and Construction**

Following Beesley and Hamilton (1984), we define the turbulence rate in industry  $i$  at time  $t$  ( $TURBULENCE_{it}$ ) as the sum of the entry and exit rates in that industry at that time ( $ENTRY_{it}$  and  $EXIT_{it}$ ). Entry rates are calculated as the ratio between the number of entrants in industry  $i$  at time  $t$  and the stock of firms in industry  $i$  at time  $t-1$ . Exit rates are calculated as the ratio between the number of exits in industry  $i$  at time  $t$  and the stock of firms in industry  $i$  at time  $t-1$ . We have then:

$$TURBULENCE_{it} = ENTRY_{it} + EXIT_{it} \quad (1)$$

We define that turbulence rates (our dependent variable) are determined by explanatory variables measuring the impact of displacement and replacement effects plus a vector of control variables, which include industry growth and its volatility. The following subsections discuss the rationale behind the choice of control variables, as well as the construction of those variables.

### **3.1. Displacement**

Displacement occurs when new entrants' competitive pressure drives firms out of the market. The effect of the intensity of entry on subsequent turbulence is expected to be positive and significant for all industries. The lagged entry rate ( $ENTRY_{it-1}$ ) is used to capture this effect. We assume a one period (i.e. one year) lag as reference for the construction of variables associated with displacement and replacement. While decisions to enter or exit markets motivated by previous incumbent exit or entry may take longer to happen, we expect that turbulence rates corresponding to the number of entries and exits recorded during a twelve month period should pick up most of the displacement and replacement caused by entries and exits which occurred in the previous twelve month period.<sup>3</sup> Furthermore, assuming lags greater than one year would reduce the number of observations significantly.

### **3.2. Replacement and exit by young firms and established incumbents**

Entry due to replacement is assumed to occur as a response to last period's exits. The lagged exit rate ( $EXIT_{it-1}$ ) is used to capture the overall replacement effect. The number of exits (and, therefore, the exit rate) can be grouped according to the age ( $k$ ) of the

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<sup>3</sup> Data are recorded annually, with steady twelve month periods in-between observations.

exiting firms. Considering  $K$  years as the threshold separating young firms from established incumbents, the exit rate can be written as:

$$\text{EXIT}_{it} = (\text{EXIT}_{it})^{k \leq K} + (\text{EXIT}_{it})^{k > K} \quad (2)$$

$$\text{where: } (\text{EXIT}_{it})^{k \leq K} = \sum (\text{EXIT}_{it})^k \quad (k=1, 2, \dots, K) \quad (3)$$

$$\text{and: } (\text{EXIT}_{it})^{k > K} = 1 - (\text{EXIT}_{it-1})^{k \leq K} \quad (4)$$

where  $(\text{EXIT})^k$  is the ratio between the number of exits of firms aged  $k$  years and the stock of firms in the industry in the previous period.

The entrepreneurship literature often regards the first three years after start-up as critical for the survival and success of new firms (Littunen et al., 1998). The Global Entrepreneurship Monitor (GEM) survey of entrepreneurial activity defines young businesses as firms that have been active for three and a half years or less.<sup>4</sup> Mata and Portugal (1994) find that more than 40% of new entrants in the Portuguese industry have exited by the fourth year, which seems to indicate that firms remaining in the market four years after entry may be deemed ‘established’ incumbents. We therefore adopt the three year threshold ( $K = 3$ ) to differentiate exits of trial-and-error entrants (i.e. exits by young firms) from exits by established incumbents. Hence, we define two distinct components accounting for the replacement effect on subsequent turbulence:

- i. exit by young firms (i.e. trial-and-error entrants), measured by the exit rate of firms that were three years or younger, lagged one period:  $\text{EXIT3} = (\text{EXIT}_{it-1})^3$
- ii. exit by established incumbents, measured by the exit rate of firms that were four years or older, lagged one period:  $\text{EXIT4} = 1 - (\text{EXIT}_{it-1})^3$

While acknowledging that this is a rough and somewhat arbitrary classification, we feel it fulfils the present study’s objective of clarifying the mechanics of industry dynamics

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<sup>4</sup> According to the GEM definition, an enterprise is classified as a young business if it has paid salaries and wages for more than three months but for less than 42 months, and as an established business if it has paid salaries and wages for more than 42 months (Acs et al., 2005).

by allowing us to identify which type of exit plays a bigger role in generating turbulence through replacement at different stages of the product life cycle.

### **3.3. Control Variables: industry growth and its volatility**

High market growth rates are taken as a signal of significant profit opportunities by potential entrants (Geroski, 1995b; Caves, 1998; Camerer and Lovo, 1999). However, growth rates in expanding markets usually fluctuate significantly. Studies of markets conducted by a variety of disciplines, including industrial organization and organizational ecology, have shown that demand growth volatility is a significant source of uncertainty (Hannan and Freeman, 1989; Geroski, 1991).

Gort (1963) argued that rapid growth generates instability in two ways. First, given imperfect foresight, some firms adjust their scale of production faster than others and this leads to shifts in market share. Second, assuming there are recurrent lags in the adjustment of supply to rapid changes in demand, earnings will rise above a normal rate of return. This last effect will attract more entrants into the industry, thus generating turbulence.

Like incumbents, potential entrants in industries with high, volatile growth rates will face uncertainty with their scale of entry. On one hand, uncertainty with regard to market growth may cause overconfidence, leading potential entrants to invest too much, thus affecting their chances to be profitable (Camerer and Lovo, 1999). On the other hand, uncertainty could also conceivably cause potential entrants to delay their investment decisions, resulting in less entry and, therefore, lower levels of turbulence (Dixit, 1989; 1992).

The present study uses annual industry employment growth rates (GROWTH)<sup>5</sup> to account for industry growth and its effect on turbulence rates.<sup>6</sup> Growth rates are usually positively correlated with volatility. It is then necessary to distinguish the effects of industry growth on industrial turbulence from those caused by its volatility.

Volatility in growth rates has been measured in a variety of ways (see Camerun *et al.*, 1987 for a brief review). The present study adopts a procedure similar to that proposed by Schwartz and Altman (1973), regressing industrial employment growth rates against time and taking the absolute value of the residuals. In order to mitigate the relatively high level of correlation between the volatility measure and the employment growth variable, we use the natural logarithm of volatility (VOLATILITY) in our estimations; this reduces the problem of correlation between growth and its volatility considerably, so both variables can be used simultaneously in estimation.

### **3.4. Control variables: determinants of turbulence across industries**

Since the influential work of Orr (1974), a broad range of empirical studies have found that entry and exit respond to a variety of incentives and barriers (recent examples include: Carree and Dejardin, 2006; and Arauzo et al., 2007). These factors impact both entry and exit (symmetry) and influence the intensity of competition.

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<sup>5</sup> We drop industry and time indices for the rest of our discussion of explanatory variables. Values for the variables change both across industries and over time, except for the variable accounting for the business cycle, which is the same for all industries.

<sup>6</sup> An important drawback of our growth and volatility measure is that we use employment data instead of sales, due to the unreliability of sales data at our disposal. However, estimations using growth rates and volatility indexes based on corrected sales data, which are not reported here but are available from the authors upon request, yielded very similar results to the ones reported in the present paper.

*Scale economies*

Studies such as those by Caves and Porter (1976), Harrigan (1981), and Shapiro and Khemani (1987), established that technological and structural factors affect entry and exit. Such factors include sunk costs and scale economies in production, R&D, marketing and distribution. Also, strategic barriers to entry may arise if large firms in a highly concentrated market act collusively (Schmalensee, 1988; Bunch and Smiley, 1992). The larger the industry's minimum efficient scale (MES), the costlier it will be for new firms to enter the market and achieve efficiency in operations, so the size of the MES should have an impact on turbulence. Following Pashigan (1969), and Fotopoulos and Spence (1998), we define the MES for industry  $i$  in year  $t$  as:

$$\text{MES} = \sum_{j=1}^N (A_j / n_j)(A_j / A) \quad (5)$$

where  $A$  represents total employment in the industry;  $A_j$  denotes total employment in the  $j^{\text{th}}$  firm size class,  $n_j$  denotes the number of firms in the  $j^{\text{th}}$  firm size class, and  $N$  is the total number of size classes in the industry. Hence, the MES is computed as the average firm size in the  $j^{\text{th}}$  firm size class, weighted by the share of industry employment accounted for by firms in that class.

The extent to which the MES represents an effective barrier to entry is dependent on the cost disadvantage faced by firms entering at scales lower than the MES (Caves et al., 1975). This disadvantage has been measured using the cost disadvantage ratio (CDR) – see, for instance, Caves et al. (1975); and Schmalensee (1988). We approach the CDR by taking the ratio between average firm size and the MES. The lower the CDR, the less effective a barrier to entry the MES is likely to be, and so the greater should be turbulence.



### *Concentration*

In theory, an inverse relationship between industry concentration and both entry and exit should be expected. High levels of concentration allow incumbents to collude in order to control entry and exit, while stabilizing market shares (Schmalensee, 1988). However, even in markets where the MES is relatively large and concentration levels are high, small firms can coexist with much larger ones. This may happen either because these firms are small enough not to be perceived as a threat by the larger ones, or because the degree of product differentiation is significant (Gelman and Salop, 1983; Lieberman, 1990; Bunch and Smiley, 1992). We examine the relationship between concentration and turbulence using both the four firm concentration ratio (CONCENTRATION) and the share of micro-firms (5 employees or less) in the industry (MICROSHARE),<sup>7</sup> both measured in terms of employment figures.

Industry concentration is expected to have varying impacts on turbulence depending on industry growth and the extent of barriers to entry. High concentration might be a temporary phenomenon, especially in emerging and growing industries where barriers to entry are low. Concentration levels change over the product life cycle, so there is in fact a degree of feedback and endogeneity between turbulence and concentration over time (Jovanovic and MacDonald, 1994; Klepper, 1996; Jovanovic and Tse, 2006). While concentration may be high in the very early stages of an industry's evolution, high levels of turbulence (mostly due to entry) will follow, leading to less concentration. As the industry matures with its resulting shakeout, turbulence (now mostly due to exit) remains significant and concentration increases. In the later stages of the life cycle,

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<sup>7</sup> In this way we are able to appraise the influence on turbulence of the evolution of the share represented by both the largest and the smallest firms in the market. The greater the combined market share of the largest firms, the lower should be the turbulence rate; the greater the combined market share of very small firms, the higher should be the turbulence rate.

concentration should be high with low turbulence. Levy (1985) suggests that the rate of change in concentration influences entry. For example, sharp increases in market concentration indicate increasing levels of industry barriers causes less turbulence. Therefore, we also test whether turbulence levels respond negatively to changes in concentration using the annual variation in the Herfindahl index (VARHERF) as an explanatory variable.

### ***The extent of multi-plant operations***

In a study of the determinants of entry, Duetsch (1984) found that the extent of multi-plant operations significantly limits entry. Multi-plant operations may signal that incumbents have expanded across geographic markets to save in transport costs, and/or have segmented their product lines and are taking advantage of scale economies in plant specialization. While the extent of multi-plant operations may act as a barrier to entry in growing markets, it also acts as a barrier to firm exit in declining markets, since having a large number of plants allows a firm to discontinue operations gradually (Ghemawat and Nalebuff, 1985, 1990; Lieberman, 1990). The extent of multi-plant operations is then expected to be negatively correlated with industry turbulence. The logarithm of the average number of establishments per firm (PLANTS) is used to capture the effect of multi-plant operations on turbulence.

### ***Industry size and the business cycle***

Studies of entry and exit suggest that larger industries have more entry and exit activities (Orr, 1974; Khemani and Shapiro, 1986), hence we include the share of industry employment in total employment in the economy (INDUSTRY SIZE) as an

explanatory variable. In order to capture effects associated with macroeconomic cycles, a dichotomous business cycle dummy (YEARDM) variable has been added to capture the effects of business cycles (expansion=1 vs. recession=0) on turbulence levels.

#### **4. Data and Methodology**

##### **4.1. The data**

In order to test the hypotheses in our study we explore the *Quadros de Pessoal* database, a longitudinal matched employer-employee data set built from mandatory information submitted annually by all firms with at least one employee to the Portuguese Ministry of Employment and Social Security. Each year there is at least 145,000 firms with 170,000 establishments, and 2,000,000 employees and owners which are fully traceable with unique identification numbers, thus allowing for the identification of both new entrants and exiting firms, as well as the opening and closing of subsidiaries.

While the Portuguese economy is characterized by a small average firm size (which is consistent with Portugal being a small open economy), we believe this does not impede the validity of our results in comparison with other developed economies, as much of the Portuguese data is consistent with data from other countries. In particular, Cabral and Mata (2003) provide compelling evidence that the Portuguese economy displays similar patterns to those of larger and more developed countries with regard to the firm size distribution across industries.

Our panel covers a time span of eight years, from 1986 to 1993. Each firm is classified by the six-digit sector of industry aggregation. This provides unprecedented detail,

allowing for the recognition of turbulence patterns and identification of emerging and declining product markets within more widely defined industries. However, the use of such detailed, market-level data has a cost: firms competing in more than one industry are allocated to the sector where it does the majority of its business. While this means that some information is lost, a large percentage of firms – indeed most new entrants – is small and in fact competes in only one market, or six-digit sector. We believe that the insight gained from examining turbulence at the product market level outweighs the loss of information due to the process of allocating firms to product markets. Our study then focuses on 319 six-digit industrial sectors which covered about 95% of total industry employment in 1993. Each sector had at least 100 employees in 1993. Table 1 presents definitions and summary statistics for all the variables used in the present study, based on the observations for the 319 sectors over eight years.

These sectors were ranked by average employment growth rates over the 1986-1993 period. The highest growth sectors comprising up to 10 percent of total employment in 1993 were classified as ‘high growth’ industries (yielding a total of 64 sectors). The lowest growth sectors comprising up to 10 percent of total employment were classified as ‘declining’ industries (yielding a total of 50 sectors).<sup>8</sup>

We have therefore divided our sample of 319 six-digit industrial sectors into three groups: high growth (64 sectors); declining (50 sectors); and the remaining (205) sectors, which we term ‘low growth’ or ‘mature’ industries in order to facilitate further discussion.<sup>9</sup>

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<sup>8</sup> This procedure is similar to the one used by Birch (1987).

<sup>9</sup> We realize that the 205 sectors included in this group are too different in terms of structure and growth stage to be classified under only one heading. The purpose of this ‘midway’ is solely to act as a control for the high growth and declining industry groups.

Table 2 presents a comparative overview of the mean values of entry, exit, turbulence, growth and volatility in growth rates over the 1986-1993 period for all six-digit industrial sectors, as well as for high growth, declining and low growth/mature sectors indicated individually. Mean values for exit of younger (trial-and-error) and established incumbents are also presented.

In order to determine whether the high growth and declining industry groups are significantly different from the whole sample, Levene's (1960)  $F$  test of equality of variances and Welch's (1947)  $t$  test of equality of means were used. Levene's test rejected the variance equality hypothesis for all the variables. Welch's test confirmed that mean values for all variables in high growth and declining industries differ significantly from the those for the whole sample, except for the exit rate of established incumbents in high growth industries.<sup>10</sup>

Evidence in Table 2 shows that both turbulence and net entry rates are considerably higher than the mean in high growth industries, which registers higher rates of entry and exit than declining industries, while, as expected, the values for the low growth/mature group are between the high-growth and declining groups. These statistics suggest that, as an industry progresses through its life cycle, entry rates decline further than exit rates, thus average net entry rates become negative. These results are consistent with Agarwal and Gort (1996) for the US; Baldwin and Gorecki (1991) for Canada; and Disney et al. (2003b) for the UK.

Exit rates of young firms are significantly higher than average in high growth sectors, and significantly lower than average for declining ones, while the low growth/mature

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<sup>10</sup> The same tests were conducted for all remaining explanatory variables used in the present study. Results are available from the authors upon request. Equality of means and variances between the high growth and declining industry groups, and the whole sample was rejected at the 5% significance level or lower for all variables, except for the mean value of the four firm concentration ratio in high growth sectors.

group registers values between the other two. However, differences between mean exit rates for established incumbents across groups are weakly significant, suggesting that replacement effects associated with the exit of established incumbents likely play an important role in market selection regardless of the point in the product life cycle.

#### **4.2. Empirical methodology**

Table 3 displays the correlation coefficients between the variables used in this study. The minimum efficient scale (MES) variable displays a high correlation coefficient with the logarithm of the average number of establishments per firm (PLANTS), which is probably a result of our measure for the MES having been calculated using firms and not individual plants as a reference.<sup>11</sup> Since this correlation would result in collinearity problems, we excluded the MES variable from our analysis, as we believe that our proxy for the cost disadvantage ratio (CDR) – the ratio between the average number of firms in the industry and the MES – provides a strong enough indicator of the significance of scale economies (increases in the CDR would strengthen barriers to entry and exit, and thus lower turbulence).

Using TURBULENCE as the dependent variable, we run models for the whole sample of 319 six-digit industrial sectors and for each industry group – high growth, declining and low growth/mature – separately. For each industry group, we run a reduced model including the full lagged exit ( $EXIT = EXIT3 + EXIT4$ ) and a complete model, in which the lagged exit rate is divided into exit by young businesses (EXIT3) and exit by older incumbents (EXIT4). The complete model equation is then:

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<sup>11</sup> In defining the MES with reference to firms and not plants we attempted to capture scale economies that are not restricted to production technologies, but include company-level cost components such as advertising, distribution, sales, and R&D.

$$\begin{aligned}
TURBULENCE_{it} = & \beta_0 + \beta_1.ENTRY_{it} + \beta_2.EXIT3_{it} + \beta_3.EXIT4_{it} + \beta_4.GROWTH_{it} + \\
& + \beta_5.VOLATILITY_{it} + \beta_6.CDR_{it} + \beta_7.PLANTS_{it} + \\
& + \beta_8.CONCENTRATION_{it} + \beta_9.MICROSHARE_{it} + \\
& + \beta_{10}.VARHERF_{it} + \beta_{11}.INDUSTRYSIZE_{it} + \beta_{12}.YEARDM_t
\end{aligned} \tag{6}$$

Panel data estimators are used to examine the effect of changes in the explanatory variables over time on turbulence levels across industries. Considering the variety of explanatory variables being used and the reduced level of sector aggregation in the data, the presence of heteroskedasticity is a potentially serious problem.<sup>12</sup> The Cook-Weisberg test for heteroskedasticity found that this problem is significant at the 1% level when performing estimations using all 319 sectors ( $\chi^2=1348.5$ ), and persists when estimations are conducted for high growth and declining industry groups separately ( $\chi^2=270.2$ ; and  $\chi^2=133.9$ , respectively).

It is also reasonable to assume that errors are correlated over time and across industrial sectors. We test for serial correlation using the Breusch-Pagan Lagrange multiplier (LM) test for first-order (AR1) serial correlation (Baltagi and Li, 1995). Results found serial correlation at the 1% significance level ( $\chi^2=15.2$ ) for all 319 sectors. While the declining industries group does not display significant signs of serial correlation ( $\chi^2=0.28$ ), this problem is significant at the 1% level for high growth industries ( $\chi^2=8.4$ ). Since errors are correlated over time, ordinary least squares (OLS) will not produce unbiased estimates. We therefore use the feasible generalised least squares (FGLS) estimator (Parks, 1967; Beck and Katz, 1995), which corrects for AR(1) serial correlation specific to each panel and is also appropriate to deal with heteroskedasticity, as it handles cross-sectional correlation as well.

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<sup>12</sup> The number of firms in each of the 319 six-digit industrial sectors being examined varies from one to 13014, with a mean of 409.5 and a standard deviation of 1017.7, so we expect significant variance in the values of explanatory variables.

The models are also estimated using the Prais-Winsten OLS estimator with panel-corrected standard errors, which also allows for estimation of panel models with heteroskedastic and unbalanced panels and with AR(1) serial correlation. While the FGLS work better with larger samples (Beck and Katz, 1995), the Prais-Winsten OLS estimator provides a benchmark for checking the robustness of the results.

One final empirical issue concerns the endogeneity of the dependent variable (TURBULENCE) and the explanatory variables measuring lagged entry and exit rates. The sum of three of the explanatory variables – lagged entry (ENTRY), lagged exit of young firms (EXIT3), and lagged exit of established incumbents (EXIT4) – corresponds to the lagged value of the dependent variable. The possibility of endogeneity may require a different approach to model estimation, such as the use of generalised methods of moments (GMM) estimators, which entails the use of instrumental variables correlated with the explanatory variable but not with the dependent variable.<sup>13</sup> It should be pointed out, however, that correlation coefficients between the dependent variable and these three lagged explanatory variables are not especially high.<sup>14</sup> We therefore do not believe that endogeneity is significant enough to seriously affect results and do not pursue the GMM approach.

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<sup>13</sup> Uncovering an observable variable that is correlated with, for instance, lagged entry, but not with turbulence is not an easy task.

<sup>14</sup> According to Table 3, correlation coefficients with the explanatory variable (TURBULENCE) are: 0.18 for EXIT4; 0.29 for EXITT3; and 0.41 for ENTRY.



## 5. Results

Estimation results of the complete model with all 319 six-digit industrial sectors are presented in Table 4. Tables 5-7 present the results of the complete and reduced models for high growth, declining and low growth/mature industries. The results do not display significant incongruities between estimations for the full sample and for each industry group. Coefficients of the FGLS estimations are consistent with those of the Prais-Winsten estimations (in particular, the signs and significance levels are typically the same), indicating that results are sufficiently robust, so FGLS results are used as the reference for our discussion.

### 5.1. Displacement and replacement effects on turbulence

In order to test the Hypothesis *H1* we use the reduced model (including full entry and exit rates, lagged one period) for each group of industrial sectors. Both lagged entry (ENTRY) and lagged exit (EXIT) have positive and significant effects on turbulence in estimations for all industry groups. Results therefore indicate that both displacement and replacement have significant effects on turbulence regardless of the stage of the product life cycle.

Figure 1 plots the estimated (FGLS) coefficients of the displacement and replacement variables for individual industry groups, in order to display their evolution throughout the product life cycle. Displacement effects increase in magnitude as an industry evolves from high to low growth/maturity, and then levels off: an increase of one percentage point in entry rates increases the turbulence rate in the following period by roughly 0.38 for both declining and low growth industries, but only by about 0.31 for

high growth industries. Replacement effects decrease later in the product life cycle, as predicted: an increase of one percent in the exit rate increases turbulence rates in the subsequent period by about 0.465 in high growth markets. The effect's magnitude is still relatively high (0.43) for the midway group, but decreases to only 0.28 in declining industries.

These results provide support for *H1*: the magnitude of the replacement effect is indeed greater than that of the displacement effect in high growth industries, while the opposite holds true for declining industries. Replacement effects remain greater than displacement effects in the midway group but, given its size, it is hard to pinpoint at which stage the magnitude of displacement effects on turbulence rates overtakes that of replacement in the product life cycle.

## **5.2. Replacement effects and the exit of young firms and established incumbents**

In order to test Hypothesis *H2*, we examine the replacement effects associated with exit by young firms (trial-and-error entrants) and established incumbents separately using the complete models, including the exit rates of young firms and established incumbents (EXIT3 and EXIT4) instead of the full lagged exit rate (EXIT). The replacement effect associated with exit of young firms is positive and significant for high growth industries, as well as for the low growth/mature industry group. However it is not significant for declining industries, suggesting that once industries reach decline, trial-and-error entry is no longer important – an assessment which we can show in Table 2, where the average exit rate of young firms in declining industries over the 1986-1993 period is only 2.4%, less than half the same rates for low growth/mature and high growth sectors.

Figure 2 plots the evolution of the magnitude of displacement and replacement (of young firms and established incumbents) effects on turbulence, taking into account the non-significance of the coefficient of EXIT3 for declining industries. The displacement effect displays a similar pattern to that exhibited in the reduced model, increasing as industries evolve from high growth to maturity and stabilizing afterwards. Even though its magnitude decreases substantially, levelling off as industries approach decline, replacement of exiting established incumbents remains the main market selection force underlying turbulence over the whole product life cycle. Replacement of young exiters declines steadily as industries progress from high growth towards maturity, later becoming insignificant for declining industries, as pointed out above.

We consider that Hypothesis *H2* is confirmed, because the replacement of young firms (trial-and-error entrants) plays a less important role in generating turbulence as markets evolve eventually becoming insignificant for declining markets. This fact is likely to be the reason why the magnitude of displacement effects surpasses that of replacement effects for declining industries in the reduced model estimations.

### **5.3. Control variables**

In the model estimated for all sectors together, an increase of one percentage point in the industry growth rate (GROWTH) increases the turbulence rate by about 0.065. The coefficient for the industry growth rate is, however, quite different when models for high growth, declining and other industries are estimated separately. Firstly, the magnitude of the positive coefficient of industry growth rates on turbulence is greater for low growth/mature industries than for high growth ones: an increase of one percentage point in the industry growth rate yields an increase of about 0.05 in the

turbulence rate for high growth industries, but the same change yields almost double that value (about 0.09) for low growth industries. Secondly, the coefficient for the growth rate in declining industries is negative. The fact that growth rate volatility is included amongst the explanatory variables may play a part in generating these results. Volatility is higher when growth rates are higher, so if volatility generates turbulence through uncertainty, it may be suggested that a significant part of the effect of industry growth on turbulence is associated with uncertainty generated by fluctuations in growth rates.

Most of the other control variables are significant and have the expected effects. Turbulence increases with a large share of employment held by microfirms in the industry (MICROSHARE), and decreases the significance of scale economies (CDR) increases. The extent of entry barriers has the expected effects on turbulence rates. Larger industries are more turbulent and turbulence is significantly higher when the business cycle is positive.<sup>15</sup> The number of establishments per firm (PLANTS) has the expected negative effect on turbulence, but this is only significant in the FGLS estimation.

The results obtained from separate estimation of the models for high growth, declining and low growth/mature industries are similar to the model including all sectors together, both in terms of direction and size of the effects, suggesting that these control variables affect turbulence the same way regardless of the stage in the product life cycle. The main exception is the variable measuring the industry's share in total employment (INDUSTRY SIZE). The relative size of the industry in the economy has insignificant effects on turbulence for both high growth and declining industries, but it affects

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<sup>15</sup> The fact that the Portuguese economy went through significant deregulation changes in the period 1986-1989 (immediately after entering the EU) very likely also plays a role in the significantly positive coefficient for YEARDM.

turbulence positively in midway industries. The explanation for these results is straightforward. On the one hand, industries in the early stages of their life cycle register higher levels of turbulence due to higher levels of uncertainty, as well as both replacement and displacement, even though their overall size and share of the economy might still be small. On the other hand, declining industries decrease in size and significance in the economy as firms exit; turbulence levels reflect such exit and therefore are less likely to be affected by the corresponding decrease in share of the industry in the economy.

The effects of concentration on turbulence are more ambiguous, thus reinforcing the suggestion that concentration and turbulence are endogenous to a certain degree. The coefficient for the four firm concentration ratio (CONCENTRATION) only has a significant (negative) effect on turbulence in the FGLS estimation and, even then, the magnitude of the coefficient is relatively small – an increase of one percentage point in the combined market share of the four largest firms would result in a decrease of only 0.017 in the turbulence rate. The dynamic role played by decreases in concentration in generating turbulence (as proposed by Levy, 1985), measured by the effect of the change in the Herfindhal index, although significant, is also relatively small.

While the share of microfirms firms keeps its positive and significant effect on turbulence regardless of the level of industry growth, the same is not true for the other market structure variables. CONCENTRATION has significant negative effects on turbulence for high growth and declining industries, but is insignificant for the large midway group. An annual increase in concentration (as measured by VARHERF) has a positive effect on turbulence in declining industries, but a negative impact for all other industries. The positive relationship between concentration and turbulence observed in

declining sectors may result from the exit of incumbents, which would increase turbulence while also increasing concentration of market shares in the remaining firms.

## **6. Concluding Remarks**

This study uses the concept of turbulence (entry and exit) in seeking to uncover the underlying dynamics of industry selection and evolution over the product life cycle. The data set allowed for an unusual observation of the evolution over time of six-digit industrial sectors, which virtually correspond to product markets. While previous studies showed the significance of symmetry in the effects of the determinants of both entry and exit across several industries, the evolution of the dynamic relationship between entry and exit over the product life cycle has received less attention from multi-industry empirical studies. Indeed, while having been the focus of noteworthy theoretical and industry-level empirical studies (such as those by Jovanovic, 1982; Gort and Klepper, 1982; Klepper and Graddy, 1990; Jovanovic and MacDonald, 1994; and Klepper, 1996), the evolution of market dynamics over the product life cycle has not, as far as we know, been previously examined for a large sample of industries at such a low level of aggregation.

This study departed from the idea that there are two mechanisms simultaneously at work influencing the intertemporal relationships between entry and exit and, therefore, affecting market selection and industry evolution:

- i. displacement, in which new firms enter the market and, by being successful, force the exit of less efficient incumbents; and

- ii. replacement, in which new firms are attracted into the market by the existence (or the perception of existence) of a vacuum left by exiting incumbents.

The present study contributes to the literature by investigating how the dynamics of displacement and replacement evolve over the course of the product life cycle, uncovering which mechanisms play a major role in generating turbulence and market selection as industries grow and decline, a question that goes back to metaphors of industry evolution introduced by Marshall (1920) and Schumpeter (1942).

Our results indicate that displacement and replacement both play a role as market selection mechanisms, having significant impacts on turbulence at all stages of the product life cycle. As predicted during development of the hypotheses tested in this study, displacement effects increase in magnitude as industries evolve from high growth to mature stages (even though levelling off as they approach decline), while replacement effects decrease in magnitude during the course of industry evolution. In high growth industries, as well as in industries closer to maturity, selection occurs primarily through the replacement of exiting firms by subsequent entry; while in declining industries, selection occurs primarily via the displacement of incumbents by recent entrants.

Overall, replacement appears to play the biggest role in market selection throughout most of the product life cycle, as the vacuum created by exiting firms is filled with new entrants. It is only when industry growth rates become persistently negative that the displacement effect surpasses replacement effects as a market selection force. By highlighting the dual nature of replacement effects, and separating them into those generated by the exit of trial-and-error entrants (i.e. those firms that exit markets soon after entry) and by established incumbents, the dynamic relationship between

replacement and displacement changes over the product life cycle is exposed. While the exit of established incumbents plays a significant role in generating turbulence throughout the life cycle, the effect of the exit of young businesses on turbulence declines steadily, eventually becoming insignificant as industries reach decline.

Exit of young, trial-and-error entrants (who are quickly replaced by new firms) is higher than that of established incumbents for about 85% of the six-digit sectors examined (high growth and mature product markets). However, the revolving door slows down as markets progress from high growth towards maturity and decline, as the vacuum created by the exit of young firms becomes smaller or, at least, less attractive to potential entrants. We suggest that the decrease in the size of the replacement effect of young exiters plays a significant role in changing the dynamics between replacement and displacement as industries reach decline.

Furthermore, although the magnitude of replacement effects associated with the exit of established incumbents decreases as industries progress from high growth to maturity, it remains greater than the replacement effects associated with young firm exits, suggesting that the exit of an established incumbent creates a stronger impression of vacuum in the market than that of a trial-and-error entrant.

Our results confirm that for most industries the observation advanced by previous work (such as, for instance, Beesley and Hamilton, 1984; and Agarwal and Gort, 1996) that turbulence decreases as the product life cycle progresses and market growth rates decline. However, by examining the effect of growth rates at different stages of the product life cycle, the present study provides new insights into this relationship. Firstly, we find that the positive effect of market growth on turbulence is actually higher in low growth/mature industries than in high growth ones. This may be due to two sorts of



reasons: on the one hand, since growth rates fluctuate more in high growth industries, potential entrants may decide to “wait and see” if the increase in growth is sustained; on the other hand, growth increases in mature industries may be interpreted as changes in the current trend towards decline, thus attracting new entrants to take advantage of this perceived revival. Perhaps more remarkably, the effect of growth rates on turbulence is actually negative in declining markets. In these markets, an increase in the growth rate may be interpreted as a sign that decline is slowing down, inducing incumbents to delay exit.

It is possible that our findings with respect to the effect of market growth on turbulence are linked to the inclusion in our models of the variable measuring volatility in growth rates. Volatility is greater when growth rates are higher, so if volatility generates turbulence through uncertainty, it may be possible that part of the turbulence usually associated with high market growth rates is in fact a result of uncertainty in the decisions of recent entrants and older incumbents, in the course of learning and strategic interaction processes occurring in markets. Theories of learning and selection in markets spawned by the seminal work of Jovanovic (1982) highlight the role played by the uncertainty of young entrants with regard to their efficiency and to demand conditions. We find that turbulence is positively influenced by volatility in growth rates for all but declining industries.

In general, our study finds that the mechanisms propelling industry evolution are different for different stages of the product life cycle. These differences are not simply the result of changes in market growth rates, but are frequently associated with changes in competitive dynamics and in uncertainty with regard to market growth. Future avenues for research into the role played by displacement and replacement mechanisms

in selection and industry evolution should include the examination of industry-level and environmental determinants of these processes and their components, in order to shed more light on variations in replacement and displacement across industries.

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**Table 1: Variable definitions and descriptive statistics<sup>16</sup>**

Variable	Description	Mean	Std. Dev.
TURBULENCE	Turbulence rate = entry rate + exit rate (measured in percentage points)	19.47	16.35
ENTRY	Lagged values of entry rates (in percentage points, i.e. 0-100)	11.06	13.73
EXIT3	Lagged values of exit rates by firms aged 3 years or less (in percentage points)	5.16	5.89
EXIT4	Lagged values of exit rates by firms aged 4 years or more (in percentage points)	3.96	4.64
VOLATILITY	Log of volatility in growth rates	2.02	1.06
MES	Minimum efficient scale	471	1919
CDR	Proxy for cost disadvantage ratio	0.20	0.13
GROWTH	Industry employment growth rate (in percentage points)	6.38	44.23
CONCENTRATION	Four firm concentration ratio (in percentage points)	43.44	31.31
MICROSHARE	Share of firms with 5 employees or less in the industry (in percentage points)	36.24	22.83
VARHERF	Yearly change in the industry's Herfindahl index (in percentage points)	0.71	41.80
PLANTS	Log of average number of establishments per firm in the industry	0.30	0.62
INDUSTRY SIZE	Share of industry in total employment in the economy	0.29	0.61
YEARDM	Dummy variable: 1986 to 1989 = 1; else = 0	0.50	0.50

<sup>16</sup> Variables observed for 319 industry sectors over eight years (2560 observations). One year lagged variables observed over 7 years (2240 observations).

**Table 2: Mean values of key variables**

<b>Variable</b>	<b>High Growth Industries</b>	<b>Declining Industries</b>	<b>Other (Low Growth / Mature) Industries</b>	<b>All Industries</b>
<b>ENTRY</b>	15.8 <sup>(*)</sup> (§)	5.5 <sup>(*)</sup> (§)	10.48 <sup>(*)</sup>	10.77
<b>EXIT</b>	10.1 <sup>(*)</sup> (§)	7.1 <sup>(*)</sup> (§)	8.62 <sup>(*)</sup>	8.70
<b>TURBULENCE</b>	25.9 <sup>(*)</sup> (§)	12.6 <sup>(**)</sup> (§)	19.10 <sup>(*)</sup>	19.47
<b>GROWTH</b>	27.88 <sup>(*)</sup> (§)	-8.41 <sup>(*)</sup> (§§)	4.53 <sup>(*)</sup>	7.77
<b>VOLATILITY</b>	2.70 <sup>(*)</sup> (§)	1.89 <sup>(*)</sup> (§)	1.84 <sup>(*)</sup> (§)	2.02
<b>EXIT3</b>	6.3 <sup>(*)</sup> (§)	2.4 <sup>(*)</sup> (§)	5.24 <sup>(*)</sup>	5.16
<b>EXIT4</b>	3.8 <sup>(*)</sup>	4.6 <sup>(*)</sup> (§§§)	3.90 <sup>(*)</sup>	3.96
Equality of variances with the full sample (all industries) rejected with the rest of the population at 1% <sup>(*)</sup> , 5% <sup>(**)</sup> or 10% <sup>(***)</sup> significance level.				
Equality of variances with the full sample (all industries) rejected with the rest of the population at 1% <sup>(§)</sup> , 5% <sup>(§§)</sup> or 10% <sup>(§§§)</sup> significance level.				

**Table 3: Variable correlations**

Variables	TURBULENCE	PLANTS	MES	MICRO-SHARE	CONCENTRATION	CDR	INDUSTRY SIZE	VARHERF	GROWTH	VOLATILITY	ENTRY	EXIT3	EXIT4	YEARDM
TURBULENCE <sup>17</sup>	1.00													
PLANTS	-0.15	1.00												
MES	-0.05	0.76	1.00											
MICROSHARE	0.33	-0.26	0.17	1.00										
CONCENTRATION	-0.09	0.34	0.30	-0.36	1.00									
CDR	0.05	-0.20	0.22	0.12	-0.11	1.00								
INDUSTRY SIZE	0.04	0.15	0.19	-0.05	-0.27	0.22	1.00							
VARHERF	-0.05	0.00	0.01	0.02	0.09	0.15	-0.03	1.00						
GROWTH	0.22	0.00	0.00	0.05	0.10	0.01	-0.03	0.37	1.00					
VOLATILITY	0.23	-0.10	0.13	-0.03	0.41	0.21	-0.27	0.10	0.25	1.00				
ENTRY	0.41	-0.07	0.01	0.25	-0.05	0.03	0.05	-0.04	0.08	0.14	1.00			
EXIT3	0.29	-0.17	0.11	0.27	-0.06	0.11	0.00	-0.01	0.07	0.08	0.33	1.00		
EXIT4	0.18	-0.11	0.10	0.13	-0.12	0.04	0.00	0.02	-0.01	0.04	0.05	0.02	1.00	
YEARDM	0.28	-0.02	0.03	-0.04	0.05	0.06	0.00	-0.06	0.07	0.35	0.22	-0.06	0.07	1.00

<sup>17</sup> The correlation coefficient between entry and exit rates is +0.20.



**Table 4: Estimation results - all industrial sectors**

<i>Prais-Winsten OLS for panel data</i>				<i>FGLS</i>		
# Observations	2218			2217		
Groups	319			319		
	Wald Chi(2)	607.52		Wald Chi(2)	3667.18	
	Prob>F	0.0		Prob>F	0.0	
	R <sup>2</sup> = 0.29			Log Likelihood = -7362.75		
	<b>Coef.</b>	<b>z value</b>	<b>p value</b>	<b>Coef.</b>	<b>z value</b>	<b>p value</b>
PLANTS	-1.053	-1.04	0.30	-1.972	-5.02	0.00
MICROSHARE	0.171	8.30	0.00	0.119	16.6	0.00
CONCENTRATION	0.000	0.01	0.99	-0.017	-2.14	0.03
CDR	-8.288	-2.55	0.01	-9.443	-7.26	0.00
INDUSTRY SIZE	1.524	3.81	0.00	1.053	4.71	0.00
VARHERF	-0.044	-4.71	0.00	-0.026	-7.34	0.00
GROWTH	0.065	4.07	0.00	0.058	7.81	0.00
VOLATILITY	1.932	4.54	0.00	1.434	8.28	0.00
ENTRY	0.180	3.41	0.00	0.288	15.6	0.00
EXIT3	0.438	3.41	0.00	0.593	12.25	0.00
EXIT4	0.295	2.68	0.01	0.316	6.35	0.00
YEARDM	5.580	8.27	0.00	5.153	19.61	0.00
CONSTANT	2.494	1.60	0.11	3.931	7.11	0.00

**Table 5: Estimation results - high growth industries**

	<i>Prais-Winsten OLS for panel data</i>			<i>FGLS</i>			<i>Prais-Winsten OLS for panel data</i>			<i>FGLS</i>		
# Observs	501			501			439			439		
Groups	64			64			64			64		
	Wald			Wald			Wald			Wald		
	Chi(2)	206.06		Chi(2)	668.42		Chi(2)	175.30		Chi(2)	496.18	
	Prob>F	0.0		Prob>F	0.0		Prob>F	0.0		Prob>F	0.0	
	R <sup>2</sup> = 0.34			Log Likelihood = -1893.07			R <sup>2</sup> = 0.34			Log Likelihood = -1653.86		
	Coef.	z value	p value	Coef.	z value	p value	Coef.	z value	p value	Coef.	z value	p value
PLANTS	-1.794	-0.76	0.45	-3.076	-1.99	0.05	-1.082	-0.42	0.67	-2.568	-1.50	0.14
MICROSHARE	0.142	2.72	0.01	0.147	5.92	0.00	0.113	2.10	0.04	0.143	5.25	0.00
CONCENTRATION	-0.063	-1.46	0.14	-0.047	-2.02	0.04	-0.116	-2.61	0.01	-0.076	-2.96	0.00
CDR	-6.883	-0.98	0.33	-6.967	-1.66	0.10	-10.94	-1.45	0.15	-8.914	-1.87	0.06
INDUSTRY SIZE	0.170	0.07	0.95	1.927	1.55	0.12	-1.720	-0.62	0.54	1.074	0.76	0.45
VARHERF	-0.077	-3.37	0.00	-0.039	-3.65	0.00	-0.078	-3.28	0.00	-0.043	-3.78	0.00
GROWTH	0.076	3.43	0.00	0.054	4.69	0.00	0.074	3.23	0.00	0.049	4.20	0.00
VOLATILITY	1.371	1.74	0.08	1.102	2.59	0.01	1.952	2.32	0.02	1.551	3.22	0.00
ENTRY	0.291	4.00	0.00	0.311	10.86	0.00	0.248	2.62	0.01	0.273	6.33	0.00
EXIT	0.448	2.63	0.01	0.465	5.54	0.00						
EXIT3							0.355	1.71	0.09	0.327	2.90	0.00
EXIT4							0.606	2.69	0.01	0.598	3.95	0.00
YEARDM	7.130	4.24	0.00	7.688	9.66	0.00	6.732	3.73	0.00	7.405	7.91	0.00
CONST.	6.782	1.64	0.10	4.298	1.97	0.05	11.05	2.59	0.01	6.355	2.53	0.01

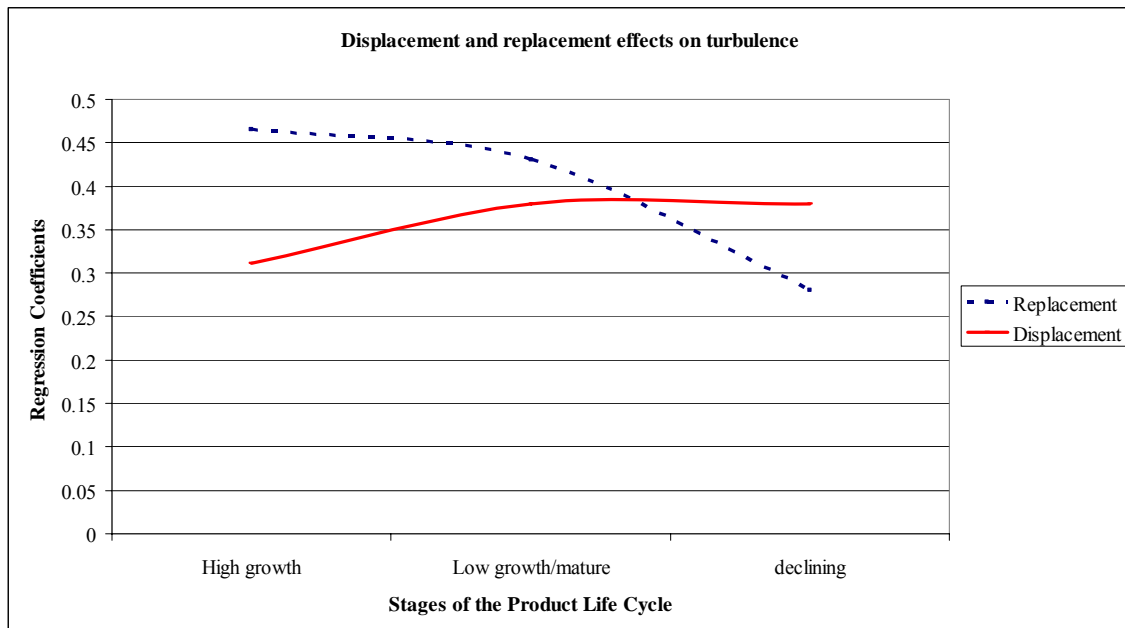
**Table 6: Estimation results - declining industries**

	<i>Prais-Winsten OLS for panel data</i>			<i>FGLS</i>			<i>Prais-Winsten OLS for panel data</i>			<i>FGLS</i>		
# Observs	395			395			346			346		
Groups	50			50			50			50		
	Wald			Wald			Wald			Wald		
	Chi(2)	71.36		Chi(2)	71.36		Chi(2)	77.01		Chi(2)	223.23	
	Prob>F	0.0		Prob>F	0.0		Prob>F	0.0		Prob>F	0.0	
	R <sup>2</sup> = 0.21			Log Likelihood = -1341.05			R <sup>2</sup> = 0.23			Log Likelihood = -1173.39		
	Coef.	z value	p value	Coef.	z value	p value	Coef.	z value	p value	Coef.	z value	p value
PLANTS	-0.554	-0.33	0.74	-1.569	-2.26	0.02	-0.615	-0.34	0.74	-1.435	-1.87	0.06
MICROSHARE	0.150	2.52	0.01	0.107	3.43	0.00	0.149	2.33	0.02	0.104	3.13	0.00
CONCENTRATION	-0.040	-1.25	0.21	-0.040	-2.20	0.03	-0.043	-1.28	0.20	-0.037	-1.95	0.05
CDR	-14.90	-2.38	0.02	-6.335	-1.70	0.09	-21.08	-2.94	0.00	-8.387	-2.00	0.05
INDUSTRY SIZE	0.085	0.13	0.90	-0.169	-0.40	0.69	0.412	0.54	0.59	0.059	0.11	0.91
VARHERF	0.044	2.75	0.01	0.036	3.30	0.00	0.038	2.28	0.02	0.033	2.85	0.00
GROWTH	-0.191	-2.88	0.00	-0.112	-3.58	0.00	-0.186	-2.61	0.01	-0.107	-3.12	0.00
VOLATILITY	1.347	1.56	0.12	0.240	0.58	0.56	1.645	1.78	0.08	0.567	1.25	0.21
ENTRY	0.194	1.19	0.23	0.386	6.02	0.00	0.156	0.95	0.34	0.368	5.38	0.00
EXIT	0.207	1.63	0.10	0.280	4.05	0.00						
EXIT3							-0.111	-0.32	0.75	0.208	1.40	0.16
EXIT4							0.422	2.54	0.01	0.391	4.56	0.00
YEARDM	4.009	2.86	0.00	3.625	5.32	0.00	4.130	2.72	0.01	3.259	4.45	0.00
CONST	6.748	1.98	0.05	6.789	3.81	0.00	7.715	2.04	0.04	6.268	3.25	0.00

**Table 7: Estimation results – other (low growth/mature) industries**

	<i>Prais-Winsten OLS for panel data</i>			<i>FGLS</i>			<i>Prais-Winsten OLS for panel data</i>			<i>FGLS</i>		
# Observs	1637			1637			1433			1433		
Groups	205			205			205			205		
	Wald			Wald			Wald			Wald		
	Chi(2)	403.92		Chi(2)	3541.17		Chi(2)	557.06		Chi(2)	3633.71	
	Prob>F	0		Prob>F	0		Prob>F	0		Prob>F	0	
	R <sup>2</sup> = 0.25			Log Likelihood = -5165.92			R <sup>2</sup> = 0.37			Log Likelihood = -4442.2		
	Coef.	z value	p value	Coef.	z value	p value	Coef.	z value	p value	Coef.	z value	p value
PLANTS	-1.90	-1.92	0.06	-2.06	-5.0	0.00	-0.65	-0.7	0.486	-1.62	-3.78	0.00
MICROSHARE	0.17	7.6	0.00	0.10	15.8	0.00	0.13	6.75	0.00	0.09	12.98	0.00
CONCENTRATION	0.06	2.57	0.01	0.02	2.03	0.04	0.03	1.34	0.2	0.00	0.31	0.8
CDR	-9.53	-2.34	0.02	-8.36	-7.04	0.00	-9.27	-2.73	0.006	-8.81	-7.27	0.00
INDUSTRY SIZE	2.44	5.33	0.00	1.55	6.66	0.00	1.53	4.03	0.00	1.07	4.89	0.00
VARHERF	-0.04	-4.19	0.00	-0.02	-6.00	0.00	-0.04	-3.82	0.00	-0.02	-6.24	0.00
GROWTH	0.08	2.61	0.01	0.07	6.31	0.00	0.12	3.72	0.00	0.09	8.17	0.00
VOLATILITY	0.77	1.42	0.16	0.73	4.06	0.00	0.77	1.57	0.116	0.89	5.02	0.00
ENTRY	0.11	1.65	0.10	0.38	18.29	0.00	0.25	3.96	0.00	0.36	17.1	0.00
EXIT	0.36	2.98	0.00	0.43	13.71	0.00						
EXIT3							0.29	3.99	0.00	0.27	4.44	0.00
EXIT4							0.33	2.08	0.038	0.41	6.87	0.00
YEARDM	6.33	8.33	0.00	5.20	20.43	0.00	6.17	8.43	0.00	5.22	19.25	0.00
CONST.	2.36	1.13	0.26	2.44	4.54	0.00	2.18	1.22	0.221	2.87	5.19	0.00

**Figure 1**



**Figure 2**

