The Effect of Real Exchange Rate Movements on the Life Expectancy of Manufacturing Plants in Ireland, 1973-94

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specific effects (R&D intensity of the sector, the employment intensity of the sector, the existence of plant turnover and turbulence in the sector and macroeconomic effects, (real exchange rate movements and other aggregate shocks), on the life expectancy of plants born after 1973 which are operating in the Irish Manufacturing sector between 1980 to 1994 a period when Ireland was a member of the EMS.

In section II we review the literature. In section III we discuss the data set and in section IV applying the work of Davis and Haltiwanger (1992) we document the heterogeneity of plant employment performance and structural change that took place in Irish manufacturing since the 1970s. We discuss the econometric model and the results in section V. In Section VI we outline our the conclusions of the paper.

Section II

Recent empirical literature has taken a keen interest modelling the post-entry performance of new firms relating the entry and exit patterns of plants to firm size and scale economies (Dunne, Roberts and Samuelson, 1988,1989). In the context of the ‘growth of firms’ literature testing Gibrat’s law of proportionate growth, Evans (1987a,b) among others found not only that small firms have significantly higher growth rates, but also that failure rates tend to decrease with size and age\(^1\) (see Sutton, 1997 for an overview).

Another stylised fact that emerges from the work of Audretsch (1991), Evans and Siegfried (1992), Austin and Rosenbaum (1991) and Geroski and Schwalbach (1991), is the variation in survival rates across industries. This can be partly explained by the conditions of demand and technology in an industry. One interesting point is that new entry does not seem to be deterred in capital intensive industries exhibiting scale economies, even in the presence of high ex-post entry failure rates. One might assume, as in Winter (1984), due to their advanced information regarding demand and research into technology, that incumbent firms have the advantage in high-tech industries. Why does this not act as an effective barrier to entry? Audretsch (1991) asserted that new firms can have an innovative advantage in R&D industries which increases their likelihood of survival. Initial assessment of the risks, at the entry stage, of introducing a product with new technology can be difficult which may lead to an optimal entry and a subsequent exit. Sutton (1991, 1996) models optimal entry decisions under full information in endogenous sunk cost, R&D, industries. Entry takes place in order to exploit ex-post entry profit opportunities that do exist. However, subsequent entry can trigger an escalation in R&D competition and cause subsequent exit of firms. These models suggest that high entry rates in high-tech industries are not irrational outcomes.

None of the above studies had data sets rich enough to estimate hazard duration models. This was due either to overly long time intervals between data collection on plant performance, or due to the data being aggregated up from the plant level. Audretsch and Mahmood (1995), using U.S. plant level data, were the first to link the actual post-entry performance of individual establishments to establishment-specific characteristics such as ownership structure and size. They find, in addition to the above sectoral effects, that the structure of ownership (independent plants, plants that are branches or subsidiaries of bigger

\(^1\) The following studies find that survival rates of establishments are positively related to the size and age of the plant. This is one of the best known stylised facts of industry dynamics: See Audretsch (1991), Baldwin and Geroski (1991), Dunne, Roberts and Samuelson (1988, 1989), Evans (1987a,b), Hall (1987) and Philips and Kirchhoff (1989).
organisations) and start-up size shape establishment level survival rates. Plants that enter at a size below minimum efficient scale decrease their probability of survival. One might question a plant's decision to enter at a size that leads to a competitive disadvantage. Jovanovic's (1982) learning model suggests that some plants can only reveal their true learning ability ex-post entry. Ex-ante over-estimation of a plant's ability can lead to subsequent exit after entry. Another theory is based on the presence of capital market imperfections which force plants to enter at a sub-optimal level due to the lack of available capital. Plants that enter as part of a bigger organisation are estimated to have higher probabilities of survival due to the abundant supply of capital and knowledge. Another explanation for Ireland is why some plants seem to enter at sizes below minimum efficient scale, as suggested by Ruane and McGibney (1991), is that programmes, such as the Small Industry Programme and the New Industries Programme, providing grants to new firms have caused increased firm turnover rates. Similar establishment specific effects are found in Mata and Portugal (1994) which use data from Portugal and Konings, Roodhoft, and Van De Gucht (1996) using data for Belgium.

The above literature focuses on plant and sector specific effects on the life expectancy of establishments with little concern to general macroeconomic conditions, except then some control for the business cycle and time. The time dimension of data sets are normally too short to "disentangle complicated links between the macroeconomic environment and microeconomic performance at the level of the individual establishment" (Audretsch and Mahmood (1995)). Yet, clearly we would expect that the macroeconomic environment could influence firm performance in a non-trivial way. This is the thesis of this paper.

Section III

Our data source is the annual employment survey carried out by Forfás since 1973, which covers all known active manufacturing companies. The response rate to this survey has on average been over 99 per cent. The unit of observation is the individual plant for which the number of permanent full time staff is reported. Each plant is identified, amongst other things, by nationality of ownership (firms are classified as domestic where at least 50 per cent of share holdings are Irish owned) and industrial Nace three digit classification. The data set is superior to most other countries where the data sets suffer either from sample size, establishment size or period of coverage restrictions. In 1973, there were 4681 plants with an average employment of 48 workers, by 1994, the number of plants increased to 6109 and average employment declined to 34 workers. The classification of plants in our data by foreign or domestic ownership is particularly valuable for our study. Most foreign plants can be considered a different species to home plants in terms of their characteristics. They tend to be part of a multinational operation, dominant in high-technology sectors, larger in size, and operate independently of domestic capital or inputs. We observe virtually all new plants that entered Irish manufacturing during the period 1973-94. We classify entry of a plant with their first appearance in the data. Similarly exit is defined as the plant disappearance from the data set, i.e. employment of zero. A few instances occurred in which we observed a plant exiting the data and reappearing a year later. In this case the missing employment observation was filled by taking the average between the two years. In case that the plant disappeared from the dataset for more than one year, it was simply deleted from our observations.
Mergers or acquisitions cannot be observed in the data but we expect this will we only cause negligible distortions in our results. One structural break in the collection of data is worth to mention. From 1994 onward, and to a lesser extent in 1993, most plant births of less than 20 employees were dropped from the survey. Another distorting feature is the inability to capture entry and exit of a plant within a year. In addition, birth dates can underestimate a plants age by a day or up to a year. The record of a plant death in annual surveys can also have the same problem. Despite these unavoidable distortions, we feel the duration of plant life is well captured by the data.

Section IV

Before analysing the survival of plants in Ireland, it is important to illustrate the heterogeneity of plant performance and the structural change that took place in Irish Manufacturing since 1973. This will motivate the plant and sectoral controls we use in our regression analysis in the next section. To undertake such an exercise we apply the recent work of Davis and Haltiwanger (1992) which shows that interesting macro economic employment dynamics are determined by a surprising amount of heterogeneous firm behaviour at the micro level. The same exercise was undertaken by Konings (1995a) for the U.K. and Barry Strobl and Walsh (1996) ². The “stylized” facts that come from this literature are two fold, first at all phases of the business cycle and even within narrowly defined sectors, regions or firm sizes, there exists simultaneous creation and destruction of jobs, indicating heterogeneous firm behaviour and secondly, the gross job reallocation rate (the sum of job creation and destruction) is counter cyclical. The latter inspired some Schumpeterian theory of creative destruction (Aghion and Howitt, 1992).

Ultimately, however, it is clear that macro employment flows are driven to a great extent by heterogeneous economic behaviour as discussed by Blanchflower and Burgess (1996) and Konings (1995b). If the agenda is to model macro outcomes one needs to control for the heterogeneous nature of firm behaviour. It is also our ascertain that if would wishes to understand the impact of a macro variable such as the real exchange rate, in a small open economy, on outcomes in an economy one may have to control for the microeconomic environment to avoid the Lucas Critique in the presence of structural change and heterogeneous plant behaviour. This paper takes a step in that direction by modelling the life cycle of plants in the Irish Manufacturing sector.

To measure heterogeneity in plant employment performance we construct the gross job flows in the spirit of Davis and Haltiwanger (1990) as applied to Ireland by Barry, Strobl and Walsh (1996). A plant’s size at time \( t \), \( x_t \), is defined as its average employment (n) between \( t-1 \) and \( t \).

\[
x_t = \frac{n_t + n_{t-1}}{2}
\]

(1)

We define the employment growth rate of a plant as follows:

\[
g_t = \frac{n_t - n_{t-1}}{x_t}
\]

(2)

This measure is symmetric about zero and lies in the closed interval [-2,2]. The endpoints correspond to the growth rate of a plant
death to the growth rate of a plant birth, respectively. The growth rate above is monotonically related to the conventional growth rate where these two measures are approximately equal for small values.

To obtain the aggregate job creation and job destruction rates, in (3) and (4) respectively, the growth rate of each plant was computed, categorized as either positive or negative\(^3\), size-weighted and then summed within this category:\(^4\):

\[
\text{POS}_t = \sum_{x \in E_t \cap \Delta > 0} \frac{X_t}{X_0} g_x
\]

\[
\text{NEG}_t = \sum_{x \in E_t \cap \Delta < 0} \frac{X_t}{X_0} |g_x|
\]

where \(E_t\) can be the whole manufacturing sector at time \(t\) or a defined subset of plants in the manufacturing sector; \(X_t\) is the (average) size of the whole manufacturing sector over the period \(t-1\) to \(t\), and \(\text{POS}_t\) and \(\text{NEG}_t\) are the job creation and job destruction rate, respectively. This leads to three further identities:

\[
\text{SUM}_t = \text{POS}_t + \text{NEG}_t \tag{6}
\]

\[
\text{NET}_t = \text{POS}_t - \text{NEG}_t \tag{7}
\]

\[
\text{RES}_t = \text{SUM}_t - |\text{NEG}_t| \tag{8}
\]

where \(\text{NET}_t\) is the net employment growth rate of the manufacturing sector and \(\text{SUM}_t\), commonly termed the job reallocation rate, is a measure of total job turnover in the manufacturing sector between \(t-1\) and \(t\). \(\text{RES}_t\), an index of heterogeneity, demonstrates the excess turnover above that necessary to generate observed aggregate changes in net employment growth.

The computed gross job flows for the Irish manufacturing sector as a whole are shown in fig. 1. The magnitude of simultaneous job creation and job destruction over the entire period is striking. Over the period 1974-1994, the average job creation rate was 8.4 per cent and the average job destruction rate was 8.9 per cent. The average net employment rate declined by 0.5 per cent while the excess job reallocation rate was on average 15 per cent in each year over the entire period. On average, job reallocation was accounted for by 60 per cent of the existing plants at each point in time. In addition, plant entry (EN) and exit (EX) contribute in a substantial way to overall job creation and destruction rate. Both exits and contractions of existing plants are counter-cyclical. Expansions are pro-cyclical while job creation due to new entry is a-cyclical. These figures show that plants are very heterogeneous in their employment decisions and that a lot of job churning is taking place at all phases of the business cycle. Compared to the US, job reallocation is about 10 percentage points lower on average, while job reallocation in Belgium, for instance, is also estimated at 15 percent on average (Konings, Roodhooft and Van De Gucht, 1996).

One aspect of the Irish manufacturing sector that this aggregate analysis ignores is dualism. The issue of the classification and the presence of dualism have been discussed by many, [see Baker (1988), Bradley, Fitz Gerald and Kearney (1993), O’Sullivan (1995), O’Malley

\(^3\) Plants experiencing zero growth over a time interval do not add to the gross job flows.

\(^4\) Alternatively, the number of jobs created (destroyed) could have been summed and then divided by the average size of the sector in question in order to obtain the aggregate job creation (destruction) rate.
(1989), Ruane and McGibney (1991) and Strobl (1997)]. To study dualism we split the sample into R&D intensive versus low R&D intensive sectors and look at the employment evolution both domestic and foreign plants. In fig. 2 we use Davies and Lyons' (1994) classification of three digit NACE industrial codes by R&D intensity and plot the evolution of employment for home and foreign owned firms in sectors with high R&D intensity and sectors of low R&D intensity. An appendix provides a list of the R&D intensive sectors. In fig. 2 and table 1 we observe the evolution of employment levels and shares, respectively, by ownership in the sub-sectors. It is striking to observe the decline of employment in the more traditional sectors (low R&D intensive) of manufacturing and the rise of employment in the "high-technology" sectors, irrespective of nationality of ownership. In table 2, taken from Ruane and Goerg (1997), we observe that the 82 percent of the decline in foreign employment in the traditional sectors was due to the withdrawal of U.K. plants while 81 per cent of the expansion of foreign employment in the high-tech sector was induced by the expansion of U.S. plants into Ireland.

In table 3 and 4, we investigate whether the heterogeneity observed in aggregate job flows is still present within these sub-sectors. Using the formulae (1) to (8) we calculate the gross job flows interacting plant size (number of employees), foreign and domestic ownership and sectors of low and high R&D intensity. We observe that heterogeneity in plant employment performance is present within all the more refined subgroups. We also see that job reallocation declines with size in all sub-sectors as do net employment growth rates. These patterns are more pronounced for foreign plants compared to home plants particular in the R&D sector.

Strobl et al (1996), undertook a sectoral decomposition of the aggregate job reallocation rate. They found that 57 per cent of the overall turnover is generated by employment turnover within the 4 to 5 digit NACE sectors. Showing a lot of turnover within very narrowly defined sectors. The total turnover in the manufacturing is in part determined by the aggregate net growth rate. The remainder can be decomposed into flows between sectors and within defined sectors. The relative contribution of these three elements to overall turnover can be computed as follows,

\[
\text{SUM}_i = \left| NET_i \right| \times \left[ \sum_j \left| NET_{ij} \right| \times \left| NET_i \right| \right] + \sum\left| SUM_{ii} \right| \times \left| NET_i \right| \quad (9)
\]

where measures on the right hand side refer to the aggregate net growth rate, inter-sector and intra-sector contributions respectively. If one undertakes an exercise with the four sub-sectors in our dualism one finds that 65 % of the aggregate turnover, averaged over the period 1973-1994, can be explained by flows between these sub-sectors, 21% is within and the rest is explained by aggregate movements in the sector. Hence we identify a key structural change in Irish Manufacturing in the rise of the high-tech sector and the fall of the traditional sector which explains a substantial amount of the turnover. Yet, the above analysis still shows the need to control for as many plant characteristics as possible in our modelling as heterogeneity of plant experience within our dualism is still an important aspect of the data.

In what follows we further investigate the presence of structural change. The plant population was 4,696 in 1973 and 6,134 in 1994. Only 1,759 of the plants in 1994 survived from the sample in 1973. The average plant turnover during each year over the sample period was 13 per cent. This ensured the data set covered 13,718 different plants over
the sample period 1973-1994. We define the entry rate of plants in category i as all plants that entered between t and t-1 divided by the total number of plants in category i in t-1. The exit rate is defined similarly. In Fig. 3 we graph the entry and exit rates by low and high R&D sectors. The entry rate in the low R&D sector exceeds the exit rate up to 1985, resulting in a large expansion in the number of plants. Over the late 1980s and 1990s plant numbers have been declining. In the high-tech sector the population size grew steadily up to 1990 and has stabilised since. These outcomes have been induced by generally declining entry rates and increasing exit rates over the 1980s and 1990s. One should note that the high-tech sectors, with higher barriers to entry, had both greater entry and exit rates compared to the traditional sector. This is in line with international experience.

In Fig. 4 and Fig. 5 we graph the entry and exit rates by ownership and R&D sector. The entry rates have followed a downward and similar trend for all categories. Up to 1990 the entry rates have been generally higher for domestic plants within the low and high R&D sectors as compared with foreign plants. Since then there has been a convergence. The exit rates follow a similar trend for all categories. One exception to this general statement are the spikes in the exit rate for domestic plants in both low and high R&D sectors during the period 1989-1990 and 1992-1993.

In summary, plant turnover was substantial in every year over the entire period. Plant turnover is higher in the high-tech sector as compared to the traditional sector for both domestic and foreign plants. Domestic plant turnover within the R&D and traditional sector is generally greater than plant turnover generated by foreign firms.

We know that the plant population changed over the sample period. This in itself is likely to alter the structural characteristics of the plant population by age, size, sector and ownership over time. Yet, if new entrants and incumbents of different durations were involved in generating the plant turnover, we should expect substantial structural change in the characteristics of the plant population. In what follows we document change by sectoral composition, employment size distribution and age distribution.

In 1973 plants operated in 106 different 4 to 5 digit sub-sectors. By 1994, 4 sectors had vanished, and another 102 emerged. In Fig. 6 and Fig. 7 we examine the size distribution of plants in terms of log employment by ownership and R&D sector in the years 1980 and 1990. In the traditional sector one can observe a large swing towards smaller domestic plants. Even though there was quite an expansion in the population of plants in the traditional sector, the downsizing of plants led to a fall in aggregate domestic employment in this sector. Foreign firms in this sector are generally much larger and no downsizing effect is evident. These patterns are also present in the high-tech sector. The growing numbers of small plants and their employment share is not unique to Irish Manufacturing: See Loveman and Sengenberger (1991), Schwalbach (1994) and Robson and Gallagher (1994).

In Fig. 8 we graph the average size of plants at different ages by ownership. We observe that plants tend to grow with age and that the size of foreign plants is larger than the size of domestic ones, irrespective of age.

To summarize, this section has shown that there exists substantial heterogeneity in plants’ employment behaviour in Irish manufacturing between 1973-94. It seems that there exists a clear difference in
performance of foreign and domestic plants. In addition a distinction should also be made between R&D intensive and non R&D intensive sectors, what we have called the traditional sector. It is however also important to view these figures in the light of the exchange rate regime that Ireland was in. We expect that performance and the competitive position of firms is likely to be affected by real exchange rate movements\(^5\). In particular, we test whether foreign and home plants responses in the different sectors respond to real exchange rate appreciations, during Ireland's membership of the European Monetary System from 1980 onwards, are different.

Section V.

Our aim is to model the hazard rate of a plant in a defined age category as a function of plant specific, sectoral and aggregate factors. In particular, let the random variable \( T \) denote the time between firm entry and exit, a spell length, with an associated probability density function \( f(t) \) and a cumulative density function \( F(t) = \text{Prob}(T \leq t) \). The hazard is the conditional probability of a plant leaving the manufacturing sector at duration \( t \).

\[
\begin{align*}
    h(t) &= \lim_{\Delta \to 0} \frac{\text{Prob}(t \leq T \leq t + \Delta | T \geq t)}{\Delta} \\
    h(t) &= \lim_{\Delta \to 0} \frac{F(t + \Delta) - F(t)}{\Delta S(t)} \\
    h(t) &= \frac{f(t)}{1 - F(t)} = f(t) / S(t)
\end{align*}
\]

(10)

The hazard rate is the rate at which plants exit during period \( t \) given they have not done so the previous (t-1) periods since entry. Given that the spell has lasted until time \( t \), what is the probability that it will end in the next short interval. \( S(t) \) is the probability that the spell is of length at least \( t \). It is a monotonic non-increasing left continuous function with \( S(0) = 1 \) and \( \lim_{t \to \infty} S(t) = 0 \).

To model (10) as a function of explanatory variables we use the duration model introduced by Cox (1972, 1975). The following proportional hazard duration model is designed to deal with problems of censoring, duration heterogeneity and covariates,

\[
h(t) = h_0(t)e^{\beta_1 x + \cdots + \beta_k x_k}
\]

(11)

where the vector of explanatory variables and associated coefficients can be fixed or time varying at the level of the plant, the sector or in aggregate. The baseline hazard rate, \( h_0(t) \), is not estimated, but it is possible to recover an estimate of it along with the baseline survivor function, \( S_0(t) \).

Let \( X_j \) be the row vector of covariates for the time interval \((t_{ij}, t_{ij}^+)\) for the jth observation in the dataset \( (j = 1, \ldots, N) \). The proportional hazard model obtains parameter estimates of the vector of \( B \) in equation (11) by using a method of partial likelihood. In particular it maximises the following partial log-likelihood function,

\[
\ln L = \sum_{i=1}^{N} \sum_{t_{ij}} x_i \beta - d \ln \{ \sum_{i=1}^{N} \exp(x_i \beta) \}
\]

(12)

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\(^5\) There exists an increasing literature that illustrates the importance of exchange rates and exchange rate pass through that determines the competitive position of firms (e.g. Knetter, 1989; 1993)
where \( i \) indexes the ordered failure times \( t(i) \) \((i=1,\ldots,n)\), \( D_i \) is the set of observations \( k \) that fail at \( t(i) \), and \( R_i \) is the set of observations \( j \) that are at risk at time \( t(i) \), for all \( j \) such that \( t_{0j} < t(i) < t_j \).

A non-parametric maximum-likelihood estimate of the baseline survivor function can be undertaken using Kapan and Meier (1958):

\[
\hat{S}(t) = \prod_{\mu \in D_i} \frac{n_i - d_{\mu}}{n_i}
\]

(13)

Let \( n_t \) be the population alive at time \( t \) and \( d_t \) the number of failures. The survivor function in (13) is the baseline survivor estimate \( \hat{S}(t) \) which can be retrieved from (11), and can be adjusted for the estimated effects of each of the explanatory variables. What follows is a brief overview of our plant specific, sector specific and aggregate explanatory variables, respectively.

We measure start-up size as the number of employees reported in the first year and minimum efficient scale is taken to be the sunk cost of entering an industry measured at the two digit sectoral level. We measure sunk cost as in Sutton (1991), by the median number of employees in a particular sector and year. It is usually assumed that new firms have better survival chances in industries with low minimum efficient scale (e.g. Audretsch, 1995). The learning models of Jovanovic (1982) and Pakes and Ericson (1987) suggest that firms may enter an industry at a sub-optimal scale and as a result are unable to learn about their underlying efficiency level and subsequently expand. We take the ratio of start-up size relative to minimum efficient scale to proxy inefficient learning, lack of available capital or the cost-disadvantage that firms may face by entering at a level below minimum efficient scale. We expect a negative relationship between the probability of plant failure and the ratio of start-up size relative to minimum efficient scale.

We also control for plant ownership and R&D intensity at the sectoral level by using standard dummy variables. Ownership takes a value of one for home ownership and zero otherwise. Our R&D dummy takes a value of one if the plant is operating in an R&D intensive sector. This is defined at the three digit NACE level and is taken from Davies and Lyons (1994). There is an endogenous sunk cost of locating a plant in Ireland or entering a sector with R&D competition. As in the stage-game approach of Sutton (1991) potential entrants try to anticipate the ex-post entry profit stream and the potential sunk cost outlays. Sunk costs are high in location and R&D decisions making sub-optimal entry decisions very costly. High sunk costs can act as a very efficient barrier to entry. Once a firm has entered these can act as an exit barrier. We would expect exit of foreign plants and R&D intensive plants to be lower for this reason. More careful self-selection in the decision to base in the Irish Manufacturing sector should result. As we saw in the last section, the size and age distribution of foreign and domestic plants in high R&D and low R&D sectors are very different. One result that comes out strongly in the literature on the ex-post performance of plants is that the probability of plant exit decreases with size and age. In addition, diversifying or multi-plant firms also have a lower probability of exit. For these reasons we might expect multi-nationals sector to have a lower probability of failure.

Gort and Klepper (1982) suggested that higher exit rates should be observed in industries that are more unsettled. We measure sectoral turbulence by the excess job reallocation rate in a particular 2 digit sector defined by RES\(_l\) in equation (8). This measure picks up excess job
turnover in a sector that is driven by simultaneous entry and exit rates and asymmetric expansions and contractions of employment in other plants in that sector. Plants may be having asymmetric experiences as a result of different export markets and different competition faced in their product segments. We cannot control for the domestic and international market structure a firm faces nor the intensity of price and non-price competition they face within these structures. Yet, we expect a positive correlation between turbulence in the plants based in Ireland producing in the same sector and plant survival.

We also include net employment growth of a sector and expect that in expanding sectors firms are less likely to fail. However, output may be expanding in sectors that are becoming more capital intensive due to technology improvements. A declining net employment growth rate in a sector may indicate optimal downsizing of labour in that sector. This could indicate stronger competition and decrease a plants chance of surviving another year. Net employment growth rates could also be a product of the international business cycles that different plants face. Plants may be subject to very different competitors and competition forces. Even so, general sectoral growth rates should be negatively related to the probability of plant failure.

Turning to the aggregate variables, we include the real effective exchange rate normalized by unit labour costs, taken from the IMF’s International Financial Statistics written in terms of the national currency. The Irish manufacturing sector is extremely export oriented and depends very much on the world business cycle and the competitiveness of its plants relative to their main trading partners. The real exchange rate captures the relative competitiveness of the economy in terms of all factor markets including the non-traded sector and the nominal exchange rate. The nominal exchange rate movements can act as a tax or subsidy on imports and exports which add to or subtract from the general competitiveness of the economy. Irish plants in particular are also dependent on the relative efficiency of domestic factor markets, including the non-traded sector for inputs and capital, for their competitiveness. Relative inefficiencies of this nature will be captured by real exchange rate movements.

On the other hand foreign owned plants, that are part of a multinational operation, are not as dependent on domestic factors that determine the Irish real exchange rate. The exchange rate expectations, among other factors, may determine location choice, but production ex-post entry should not be greatly affected by instantaneous exchange rate movements. Compared to small and young domestic plants with low profit margins, multi-nationals are, by their size and nature, more capable of absorbing exchange rate shocks by reducing profit margins, in a process known as exchange rate pass through. For these reasons we expect movements in the components of the real exchange rate to play no role in the re-location of foreign plants.

We interact the effect of ownership with the real exchange rate to estimate whether there is an asymmetric impact, i.e. no impact on foreign plants and a positive effect on domestic plants, on plant survival by ownership structure. In addition we interact domestic ownership with the high R&D sector and the real exchange rate to estimate whether the effect of the real exchange rate on the survival rate of domestic plants operating in high-tech sectors is different to domestic firms operating in the traditional sector.

We present the results of six models in tables 5 to 7. The regressions were run from 1980 onwards. In our sample we include all
incumbent firms and all new entrants since 1980, controlling for their age. Model (1), in table 5, reports the basic model, excluding the R&D expenditure dummy and time dummies. As in other studies, initial size relative to minimum efficient scale and sectoral growth are negatively related to the probability of plant exit and sectoral turbulence is positively associated to the probability of plant exit. As expected domestic firms, holding other factors constant, have a higher probability of exiting than foreign firms. We allow the real exchange rate to increase or decrease the probability of plant exit directly and through ownership. The real exchange rate is only significant through its impact on the exit behaviour of domestic plants. Model (2) shows the model is robust to including time dummies and aggregate unemployment rate. This allows us to control for aggregate effects other than real exchange rate movements.

In model 4 we introduce the R&D expenditure dummy with and without other aggregate controls. The results show that plants with R&D expenditures have a lower probability of exit compared to those in traditional sectors. Comparing model (4) to model (2) we see that the coefficients and significance of the other variables presented in model (2) are robust to the inclusion of the R&D expenditure dummy.

In model 5 we investigate, using interaction dummies, whether domestic plants with R&D expenditures have a lower probability of exit and in addition we investigate whether the impact of real exchange rate movements is different for this group. The results show that domestic plants operating with R&D expenditures have a significantly higher probability of survival compared to domestic plants operating in the traditional sectors. This is consistent with the results of Schwalbach (1994). In a cross-country study of the performance of small firms he finds that small plants do better in high-tech sectors. Real exchange rate movements have a slightly less but significant effect on domestic plants life expectancy when they operate in the high-R&D sectors compared to those domestic plants operating in the traditional sectors.

In fig. 9 we graph the Kaplan-Meier survival estimate for the recovered baseline hazards in the Cox model. In fig. 10 we graph the Kaplan-Meier survival estimate by ownership. This is the same as graphing the baseline survival estimates for each duration category from the cox regression and augmenting them by the estimated ownership effect. We observe that domestic plants in each age category have a lower probability of surviving another year compared to foreign plants. This is the same result estimated by Killen and Ruane (1993). In fig. 11 we adjust the survivor functions by ownership and R&D expenditures. We observe that the ownership effect is strongly offset by the presence of younger domestic plants operating in the R&D sectors. In fig. 12 we further adjust the survivor functions by including the real exchange rate effects. We observe that real exchange movements have a very notable impact on the survival probabilities of younger domestic plants in all sectors.

Conclusions

We estimate the factors that affect the life expectancy of plants operating in the Manufacturing sector of Ireland over the period 1980-1994. In particular we estimate the effect of real exchange rate movements on the probability of plant survival by age, domestic and foreign ownership, the presence of R&D expenditures while controlling for sectoral and other aggregate conditions. Our results suggest that the

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6 We also experimented with running the regressions from 1974 onwards, the results were largely unaffected.
real exchange rate appreciations have caused a great number of infant
moralities in domestic plants both in the traditional and high tech sectors.
Real effective exchange rate movements are estimated to have no effect
on the plant life expectancy of foreign owned fims. Domestic plants
operating in the high-tech sector are estimated to have a higher life
expectancy than those operating in the traditional sector over this period.
In addition, the real exchange rate effect on the survival rates of domestic
plants in the R&D intensive sectors even though significant is weaker
compared with the traditional sector.

These results tend to be consistent with our understanding of
multi-national and domestic plants characteristics and behaviour. Irish
plants tend to be highly dependent on Irish factor markets, including the
non-traded sector, for inputs. Appreciations in the real exchange rate
indicate a decline in relative competitiveness compared with main
trading partners of Ireland. It is not only determined by nominal (spot)
exchange rate movements, but by all relative prices in the Irish factor
markets. Appreciation of the nominal exchange rate and more export
orientation can expose the lack of competitiveness exhibited by the non-
traded sector and imperfections in labour and capital markets. These
sectors seem to offer poor support to young and small domestic plants
operating in manufacturing. Foreign plants acting as part of a multi-
national operation do not have this strong dependency on Irish inputs and
as a result would not be as responsive to that component of real exchange
rate movements. Exchange rate movements may affect location choices
and profits, but once in operation are unlikely to force a re-location of a
foreign plant.

This paper should not be used to support a call for Ireland to stay
out of the EMU in the event that the UK does not enter, in order to avoid
the risk of nominal exchange rate appreciations of the EURO against
Sterling and the exit of domestic plants traditionally dependent on the
UK market. The prevention of future real exchange rate appreciations
can be best offset by introducing single market reforms (competition) in
a manner that brings the competitiveness of the Irish non-traded, capital
and labour markets into line with the rest of Europe. If the single market
reforms are successful, nominal exchange rate movements will become
less important as the real exchange rate between countries in EMU
should tend to one. In other words, we should observe similar relative
prices in labour, capital and services. The importance of reducing
structural deficiencies in these sectors is the key to increasing the
probability of domestic plant survival in EMU. As Neary and Thom
(1996) conclude, "Until these structural deficiencies are tackled directly
it seems foolish to risk temporary but severe losses of competitiveness
against our main trading partner". So lets tackle them.
Table 1: Employment Shares

<table>
<thead>
<tr>
<th></th>
<th>R&amp;D Intensive</th>
<th></th>
<th>Low R&amp;D intensive</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>domestic</td>
<td>foreign</td>
<td>domestic</td>
<td>foreign</td>
</tr>
<tr>
<td>1974</td>
<td>0.40</td>
<td>0.60</td>
<td>0.69</td>
<td>0.31</td>
</tr>
<tr>
<td>1980</td>
<td>0.31</td>
<td>0.69</td>
<td>0.66</td>
<td>0.34</td>
</tr>
<tr>
<td>1990</td>
<td>0.27</td>
<td>0.73</td>
<td>0.65</td>
<td>0.35</td>
</tr>
<tr>
<td>1994</td>
<td>0.26</td>
<td>0.74</td>
<td>0.65</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Table 2: Total Employment by Nationality

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>absolute</td>
<td>in % of total</td>
<td>absolute</td>
</tr>
<tr>
<td>Ireland</td>
<td>143387</td>
<td>65.7 %</td>
<td>116273</td>
</tr>
<tr>
<td>UK</td>
<td>29669</td>
<td>13.6 %</td>
<td>12260</td>
</tr>
<tr>
<td>Germany</td>
<td>6074</td>
<td>2.8 %</td>
<td>9700</td>
</tr>
<tr>
<td>Other</td>
<td>17776</td>
<td>8.3 %</td>
<td>13929</td>
</tr>
<tr>
<td>European</td>
<td>18418</td>
<td>8.4 %</td>
<td>51615</td>
</tr>
<tr>
<td>US</td>
<td>2997</td>
<td>1.4 %</td>
<td>7395</td>
</tr>
<tr>
<td>Other non-European</td>
<td>74934</td>
<td>34.3 %</td>
<td>94899</td>
</tr>
</tbody>
</table>

Source: Ruane and Gore (1997)
### Table 3

<table>
<thead>
<tr>
<th>Cat</th>
<th>Domestic pos</th>
<th>Domestic neg</th>
<th>Domestic gross</th>
<th>Domestic net</th>
<th>Foreign pos</th>
<th>Foreign neg</th>
<th>Foreign gross</th>
<th>Foreign net</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>0.24</td>
<td>0.20</td>
<td>0.45</td>
<td>0.04</td>
<td>0.48</td>
<td>0.39</td>
<td>0.88</td>
<td>0.09</td>
</tr>
<tr>
<td>6-25</td>
<td>0.12</td>
<td>0.13</td>
<td>0.25</td>
<td>-0.01</td>
<td>0.23</td>
<td>0.21</td>
<td>0.44</td>
<td>-0.02</td>
</tr>
<tr>
<td>26-50</td>
<td>0.08</td>
<td>0.10</td>
<td>0.18</td>
<td>-0.01</td>
<td>0.15</td>
<td>0.15</td>
<td>0.30</td>
<td>-0.002</td>
</tr>
<tr>
<td>51-100</td>
<td>0.07</td>
<td>0.08</td>
<td>0.15</td>
<td>-0.02</td>
<td>0.10</td>
<td>0.10</td>
<td>0.20</td>
<td>-0.005</td>
</tr>
<tr>
<td>101-250</td>
<td>0.05</td>
<td>0.08</td>
<td>0.13</td>
<td>-0.03</td>
<td>0.07</td>
<td>0.08</td>
<td>0.15</td>
<td>-0.003</td>
</tr>
<tr>
<td>250+</td>
<td>0.05</td>
<td>0.06</td>
<td>0.06</td>
<td>-0.03</td>
<td>0.05</td>
<td>0.06</td>
<td>0.11</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Cat</th>
<th>Domestic pos</th>
<th>Domestic neg</th>
<th>Domestic gross</th>
<th>Domestic net</th>
<th>Foreign pos</th>
<th>Foreign neg</th>
<th>Foreign gross</th>
<th>Foreign net</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>0.38</td>
<td>0.21</td>
<td>0.59</td>
<td>0.18</td>
<td>0.79</td>
<td>0.33</td>
<td>1.12</td>
<td>0.46</td>
</tr>
<tr>
<td>6-25</td>
<td>0.16</td>
<td>0.13</td>
<td>0.27</td>
<td>0.05</td>
<td>0.31</td>
<td>0.16</td>
<td>0.47</td>
<td>0.15</td>
</tr>
<tr>
<td>26-50</td>
<td>0.11</td>
<td>0.10</td>
<td>0.21</td>
<td>0.01</td>
<td>0.24</td>
<td>0.10</td>
<td>0.34</td>
<td>0.13</td>
</tr>
<tr>
<td>51-100</td>
<td>0.08</td>
<td>0.09</td>
<td>0.17</td>
<td>-0.002</td>
<td>0.17</td>
<td>0.08</td>
<td>0.24</td>
<td>0.09</td>
</tr>
<tr>
<td>101-250</td>
<td>0.07</td>
<td>0.07</td>
<td>0.15</td>
<td>-0.003</td>
<td>0.11</td>
<td>0.07</td>
<td>0.18</td>
<td>0.04</td>
</tr>
<tr>
<td>250+</td>
<td>0.05</td>
<td>0.05</td>
<td>0.13</td>
<td>-0.02</td>
<td>0.07</td>
<td>0.05</td>
<td>0.13</td>
<td>0.02</td>
</tr>
</tbody>
</table>
### Table 5

**Cox Regression for the period 1980-1994**

**Model (1)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Size/M.E.S.</td>
<td>-0.028*</td>
<td>(-3.51)</td>
</tr>
<tr>
<td>Ownership</td>
<td>1.91*</td>
<td>(5.40)</td>
</tr>
<tr>
<td>Sectoral Net Growth Rate</td>
<td>-0.015*</td>
<td>(-5.73)</td>
</tr>
<tr>
<td>Sectoral Excess Turnover Rate</td>
<td>0.0219*</td>
<td>(7.17)</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>0.0095</td>
<td>(0.19)</td>
</tr>
</tbody>
</table>

**Interaction**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership/Real Exchange Rate</td>
<td>-0.016*</td>
<td>(-5.13)</td>
</tr>
</tbody>
</table>

**Model (2)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Size/M.E.S.</td>
<td>-0.029*</td>
<td>(-3.63)</td>
</tr>
<tr>
<td>Ownership</td>
<td>2.14*</td>
<td>(5.78)</td>
</tr>
<tr>
<td>Sectoral Net Growth Rate</td>
<td>-0.013*</td>
<td>(-4.85)</td>
</tr>
<tr>
<td>Sectoral Excess Turnover Rate</td>
<td>0.022*</td>
<td>(7.22)</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>0.003</td>
<td>(0.12)</td>
</tr>
</tbody>
</table>

**Interaction**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership/Real Exchange Rate</td>
<td>-0.018*</td>
<td>(-5.548)</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>0.082*</td>
<td>(8.384)</td>
</tr>
</tbody>
</table>

**Model (1) and Model (2)**

- No. of Subjects: 8,827
- No. of Failures: 4,473
- Time at Risk: 66,256

### Table 6

**Cox Regression for the period 1980-1994**

**Model (3)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Size/M.E.S.</td>
<td>-0.031*</td>
<td>(-3.694)</td>
</tr>
<tr>
<td>Ownership</td>
<td>1.84*</td>
<td>(5.126)</td>
</tr>
<tr>
<td>Sectoral Net Growth Rate</td>
<td>-0.012*</td>
<td>(-4.228)</td>
</tr>
<tr>
<td>Sectoral Excess Turnover Rate</td>
<td>0.021*</td>
<td>(6.965)</td>
</tr>
<tr>
<td>R&amp;D Expenditure</td>
<td>-0.19*</td>
<td>(-4.279)</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>0.0007</td>
<td>(0.244)</td>
</tr>
</tbody>
</table>

**Interaction**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership/Real Exchange Rate</td>
<td>-0.016*</td>
<td>(-5.014)</td>
</tr>
</tbody>
</table>

**Model (4)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Size/M.E.S.</td>
<td>-0.033*</td>
<td>(-3.81)</td>
</tr>
<tr>
<td>Ownership</td>
<td>2.07*</td>
<td>(5.51)</td>
</tr>
<tr>
<td>Sectoral Net Growth Rate</td>
<td>-0.009*</td>
<td>(-3.32)</td>
</tr>
<tr>
<td>Sectoral Excess Turnover Rate</td>
<td>0.021*</td>
<td>(6.98)</td>
</tr>
<tr>
<td>R&amp;D Expenditure</td>
<td>-0.20*</td>
<td>(-4.51)</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>0.0007</td>
<td>(0.230)</td>
</tr>
</tbody>
</table>

**Interaction**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership/Real Exchange Rate</td>
<td>-0.018*</td>
<td>(-5.44)</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>0.079*</td>
<td>(8.08)</td>
</tr>
</tbody>
</table>

**Model (3) and Model (4)**

- No. of Subjects: 8,462
- No. of Failures: 4,345
- Time at Risk: 64,158
Table 7: Cox Regression for the period 1980-1994

<table>
<thead>
<tr>
<th>Model (5)</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Size/M.E.S.</td>
<td>-0.032*</td>
<td>(-3.725)</td>
</tr>
<tr>
<td>Ownership</td>
<td>1.92*</td>
<td>(5.259)</td>
</tr>
<tr>
<td>Sectoral Net Growth Rate</td>
<td>-0.012*</td>
<td>(-4.352)</td>
</tr>
<tr>
<td>Sectoral Excess Turnover Rate</td>
<td>0.022*</td>
<td>(7.009)</td>
</tr>
<tr>
<td>R&amp;D Expenditure</td>
<td>-0.23*</td>
<td>(-2.368)</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>0.0006</td>
<td>(0.192)</td>
</tr>
</tbody>
</table>

Interaction
- Ownership/Real Exchange Rate | -0.017* | (-5.263) |
- Ownership/R&D Expenditure | -0.89* | (-2.508) |
- Ownership/R&D Expenditure/Real Exchange Rate | 0.009* | (2.817) |

<table>
<thead>
<tr>
<th>Model (6)</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Size/M.E.S.</td>
<td>-0.033*</td>
<td>(-3.84)</td>
</tr>
<tr>
<td>Ownership</td>
<td>2.14*</td>
<td>(5.61)</td>
</tr>
<tr>
<td>Sectoral Net Growth Rate</td>
<td>-0.01*</td>
<td>(-3.44)</td>
</tr>
<tr>
<td>Sectoral Excess Turnover Rate</td>
<td>0.022*</td>
<td>(7.032)</td>
</tr>
<tr>
<td>R&amp;D Sectors</td>
<td>-0.25*</td>
<td>(-2.539)</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>0.0005</td>
<td>(0.182)</td>
</tr>
</tbody>
</table>

Interaction
- Ownership/Real Exchange Rate | -0.019* | (-5.66) |
- Ownership/R&D Sectors | -0.83* | (-2.28) |
- Ownership/R&D Sectors/Real Exchange Rate | 0.008* | (2.58) |

Unemployment Rate | 0.078* | (8.019) |

Model (5) and Model (6)
- No. of Subjects | 8,462 |
- No. of Failures | 4,345 |
- Time at Risk | 64,158 |

Figure 1

Note: EXP - job creation rate of all expanding plants (excluding entry); CON - job destruction rate of all contracting plants (excluding exit); EN - job creation rate due to entry of new plants; EX - job destruction rate due to exit of plants

Job Flow Rates in the Irish Manufacturing Sector
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