Extent and Intensity of Investment with Multiple Capital Goods

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1. Introduction

The intermittent behavior of investment decisions arising due to non-convexities in the adjustment cost function such as irreversibility and fixed costs has been firmly explained by economic theory (McDonald and Siegel 1986; Pindyck 1988; Dixit and Pindyck 1994; Caballero and Engel 1999)[1] and also empirically verified (Doms and Dunne 1998; Barnett and Sakellaris 1999; Gelos and Isgut 2001; Nilsen and Schiantarelli 2003; Bontempi *et al.* 2004; Sakellaris 2004; Wilson 2004; Cooper and Haltiwanger 2006; Letterie and Pfann 2006). In such contexts, the business fixed investment state-space corresponds to three regimes where the decision maker either initiates positive or negative investment or stays put (Abel and Eberly 1994, 1996; Abel *et al*. 1996).

However, in the presence of multiple heterogeneous capital goods overall investment maybe partitioned into the extent and intensity of investment, where the former refers to the number of capital goods for which positive investment triggering occurs, and the latter refers to the depth of investment conditional on triggering (Eberly 1997). It is straightforward to see that the same will hold for negative investment where total disinvestment maybe decomposed into the product of the reductive and intensive margins. In this setup, the agents' investment decisions become multi-dimensional since they have to design an optimal strategy for each asset type (Eberly and Mieghem 1997; Harrison and Mieghem 1999).

Focusing on aggregate investment might mask important differences across capital goods that belie the aggregate changes. Utilizing aggregate investment changes cannot convey any information regarding potential variations in the extent and/or intensity of investment which might differ quite markedly. For instance, as far as capital goods are heterogeneous, it is plausible that decision makers may find it

optimal to initiate investment only for a subset of capital goods while choose inactivity for others or even trigger investment in different directions (i.e. positive investment for some goods and negative for others). In addition, heterogeneity may also manifest in diverse magnitudes of reaction to fundamentals across capital goods. Another important issue is how the extent and intensity of investment decisions relate to each other since they jointly shape total investment. In particular, given a shock in fundamentals, the response of total investment would be substantially dissimilar depending on the sign of extent and intensity correlation. For instance, if the extent and intensity changed in the same direction the investment's response to the shock would be convex, while if they changed in opposite directions would be concave.

To this end, of special importance for the current study is a recent seminal paper by Bloom *et al*. (2007) that focuses on the impact of uncertainty when capital goods are characterized by different degrees of irreversibility[2]. The authors show that, with (partial) irreversibility, the effect on investment of a given firm-level demand shock tends to be weaker for firms that are subject to a higher level of uncertainty. They also show that the response of investment to demand shocks tends to be convex, as larger shocks induce firms to invest in more types of capital and at more production units (the extensive margin). This in turn induces more adjustment at the intensive margin, with these aggregation effects being reinforced by supermodularity[3] in the production technology. Thus, a basic implication of their research is that variations in uncertainty should be mapped to variations in both the extensive and intensive margins. In other words, they conclude that as the number of capital goods for which investment triggering is rendered optimal increases, so does the depth of investment per capital good.

In the present paper we conduct an empirical investigation of this hypothesis, namely that the intensity of investment increases as its extent increases. Moreover, in order to provide a complete picture we explore this linkage both for positive and negative investment decisions. The subsequent econometric analysis employs a large panel dataset on plant-level investment decisions for various capital goods. The richness of the dataset is vital for it avoids, to some extent, two of the main aggregation biases[4] that usually hamper empirical analyses. Firstly, using plant level information overcomes the spatial aggregation (i.e over production units) problem that results when investment decisions are observed at a higher aggregation level such as the firm. Secondly, observing decisions across various capital types reduces the bias that results when one considers overall investment decisions (i.e over types of capital). Thus utilizing plant level data by type of capital makes it more likely that zeroes (investment inaction) will be observed, and in that way permits testing some of the irreversible investment literature's predictions. We utilize a large panel of plant-level data from 21 manufacturing industries in Greece over the period 1994-2005 for which investment decisions across multiple capital goods are available.

The closed-form models constructed project the intensive margins on the extensive and reductive margins controlling for a wide set of plant-specific characteristics. Estimation is done employing the System-GMM estimator (Arellano and Bover 1995; Blundell and Bond 1998).

2. Decomposing Total Investment: Extent and Intensity

Suppose there are 3 capital goods: (i) Buildings; (B), (ii) Machinery and Equipment; (ME), and (iii) Motors and Vehicles; (V). The decision unit (i) in period (t) chooses its optimal investment, $I_{i,t}$, for each capital good among three

mutually exclusive possible choices: positive investment, negative investment, or inaction. Then the total investment expenditure is given by summing investment expenditures across capital goods:

$$\left(I_{i,t}^{T}\right) = I_{i,t,B} + I_{i,t,ME} + I_{i,t,V} \quad \textbf{(1)}$$

Clearly the sign and magnitude of $\left(I_{i,t}^{T}\right)$ is shaped by the following factors: (i) the number of capital goods for which positive investment is triggered, (ii) the number of capital goods for which negative investment is triggered, and (iii) the amount of positive or negative investment expenditure per asset type. These factors identify the following notions respectively: the **extensive margin**; $F_{i,t}^{+}$, the **reductive margin**; $F_{i,t}^{-}$ and the **intensive margins**; $\phi_{i,t}^{+}$ and $\phi_{i,t}^{-}$. In order to formally discuss these notions we first define six indicators for each asset type, with the first three identifying positive investment and the remaining three, disinvestment:

$$I_{i,t,B}^{+} = \begin{cases} 1 \text{ if gross investment in buildings } > 0 \\ 0 \text{ otherwise} \end{cases} \quad \textbf{(2)}$$

$$I_{i,t,ME}^{+} = \begin{cases} 1 \text{ if gross investment in machinery and equipment } > 0 \\ 0 \text{ otherwise} \end{cases} \quad \textbf{(3)}$$

$$I_{i,t,V}^{+} = \begin{cases} 1 \text{ if gross investment in motors and vehicles } > 0 \\ 0 \text{ otherwise} \end{cases} \quad \textbf{(4)}$$

$$I_{i,t,B}^{-} = \begin{cases} 1 \text{ if gross investment in buildings } < 0 \\ 0 \text{ otherwise} \end{cases} \quad \textbf{(5)}$$

$$I_{i,t,ME}^{-} = \begin{cases} 1 \text{ if gross investment in machinery and equipment } < 0 \\ 0 \text{ otherwise} \end{cases} \quad \textbf{(6)}$$

$$I_{i,t,V}^{-} = \begin{cases} 1 \text{ if gross investment in motors and vehicles } > 0 \\ 0 \text{ otherwise} \end{cases} \quad \textbf{(7)}$$

The extensive, $F_{i,t}^{+}$, is defined as the count of capital types for which plant (i) has positive gross investment expenditure in a given time period (t):

$$F_{i,t}^{+} = I_{i,t,B}^{+} + I_{i,t,ME}^{+} + I_{i,t,V}^{+} \quad \textbf{(8)}$$

Similarly, the reductive margin is defined as the number of capital goods for which the decision maker chooses to disinvest in a given time period as follows:

$$F_{i,t}^{-} = I_{i,t,B}^{-} + I_{i,t,ME}^{-} + I_{i,t,V}^{-} \quad \textbf{(9)}$$

It becomes immediately apparent that $F_{i,t}^{+} \in [0,3]$ and $F_{i,t}^{-} \in [0,3]$. Also given that the possible investment choices are mutually exclusive the following restriction must hold:

$$F_{i,t}^{+} + F_{i,t}^{-} \in [0,3] \quad \textbf{(10)}$$

In instances that either $F_{i,t}^{+} > 0$ or $F_{i,t}^{-} > 0$, there is positive or negative investment outlay in at least one type of capital good. Thus, conditional on triggering positive or negative investment, its depth is measured by the corresponding intensive margins as follows:

$$\phi_{i,t}^{+} = \left[\frac{I_{i,t}^{T}}{F_{i,t}^{+}} \right]_{F_{i,t}^{+}>0 \wedge I_{i,t}^{T}>0} \quad \textbf{(11)}$$

$$\phi_{i,t}^{-} = \left[\frac{I_{i,t}^{T}}{F_{i,t}^{-}} \right]_{F(n)_{i,t}^{-}>0 \wedge I_{i,t}^{T}<0} \quad \textbf{(12)}$$

Then total investment may be rewritten as (Eberly 1997):

$$\left(I_{i,t}^{T}\right) = \left[F_{i,t}^{+} \times \phi_{i,t}^{+}\right] + \left[F_{i,t}^{-} \times \phi_{i,t}^{-}\right] \quad \textbf{(13)}$$

The above expression is very important since it highlights the complexity that underlines total investment which usually is ignored when the researcher utilizes total investment. Consider for instance the investment-uncertainty nexus which is one of the most widely studied issues in modern investment literature. The sign and also the absolute magnitude of total investment sensitivity to uncertainty are jointly shaped by the four factors mentioned earlier. Aggregation may hide variations across asset types

with regards to direction and size of responses to uncertainty. For instance different capital types may respond in opposite directions, or to the same direction, but with a different magnitude to a given uncertainty shock due to diverse irreversibility and adjustment costs.

3. Data Issues

Plant-level data are utilized from the Annual Industrial Survey (AIS) for Greece provided by the National Statistical Service of Greece. The resulting dataset is an unbalanced panel of plants built from cross section data collected in the 12 AIS's for the period 1994 to 2005. The AIS surveys plants belonging to all firms with more than 10 employees across 21 manufacturing industries[5]. Note that participation of firms in the survey is mandated in official statistics law and also that the data are strictly confidential[6]. The total number of plant-year observations is 51881 and the average cross section of plants is 4,323. Graph 1 shows the time trajectory of number of plants. It becomes apparent that there is a decreasing trend, reflecting the de-industrialization of Greek economy, in which like many other European countries the production mix shifts towards services.

------*Insert Graph 1 about here*------

An important feature of the AIS is the provision of (gross) values for acquisitions (AQ) and disposals (DIS) by plant for the following fixed asset types: (i) Buildings; (B), (ii) Machinery and Equipment; (ME), and (iii) Motors and Vehicles; (V)[7]. Thus using previous notation we are dealing with three distinct capital goods (B), (ME) and (V). For each asset type we construct gross investment as the difference between acquisitions and disposals:

Table 1 summarizes the episodes of zero investment, positive (acquisitions exceeding disposals) and negative investment (disposals exceeding acquisitions). For all three capital goods inactivity is quite large with Machinery showing the lowest percentage of inaction (38.42 on average) and Vehicles the highest (84.12 on average). Machinery stands out as the asset type with the highest percentage of positive investment triggering. Disinvestment is quite low and is 1.37 percent for Buildings, 4.97 percent for Machinery and 12.64 for Vehicles. Similar evidence has been reported in Caballero *et al*. (1995), Doms and Dunne (1998), Barnett and Sakellaris (1999), Gelos and Isgut (2001), Nilsen and Schiantarelli (2003), Bontempi *et al*. (2004), Sakellaris (2004) and Wilson (2004). The information in disinvestment episodes is indicative for partial reversibility. In other words, although plants have the ability to resale installed capital (giving rise to capital disposals) this ability seems rather limited and consequently capital exhibits a considerable degree of irreversibility. Furthermore, a comparison of disinvestment occurrences between asset types shows that for Vehicles they are more than double compared to that for Machinery and also exceed that for Buildings by 9 to 1. A plausible interpretation of these is that assets have differential degrees of irreversibility with Vehicles emerging as the asset type with the highest degree of reversibility and Buildings with the lowest. Evidence for differential irreversibility across capital goods has also been documented in previous studies (Guiso and Parigi 1999; Goel and Ram 1999, 2001; Bulan 2005; Drakos 2006; Driver *et al*. 2006).

------*Insert Table 1 about here*------

Table 2 reports the sample distribution of the extensive by year and industry. The extensive margin shows significant time variation and in a typical year the sample distribution is unimodal peaking either at inaction (zero extensive margin) for

the period 1994-2000 or at positive investment in one capital good (extensive margin equal to unity) for the period 2001-2005. Positive investment in all three types of capital is by far the least frequently observed outcome ranging between 0.79 and 1.46 percent. Substantial variation is encountered when one considers the extensive margin across industries. There is not a discernible pattern in sample distributions within industries since peaks vary with 9 industries peaking at inaction, 6 peaking at positive investment in one capital good and 6 peaking in positive investment in two asset types. However, a common feature across industries is that positive investment in all asset types is a rare phenomenon ranging between 0 and 2.13 percent.

------*Insert Table 2 about here*------

Table 3 reports the sample distributions of the reductive margin by year and industry. The overall sample behavior for the reductive margin is quite different compared to the extensive margin. For the vast majority of years the sample distribution for reductive margin peaks at zero (disinvestment for none of the capital goods) ranging from about 75 to 87 percent, followed by disinvestment in one asset type (11 to 21 percent) and then disinvestment in two asset types (1.3 to 3.5 percent). Disinvestment in all three capital goods is an extremely rare occurrence ranging between 0.1 to 0.5 percent. When considering the sample distributions of reductive margins by industry a similar picture emerges although inter-industry variation is more substantial.

------*Insert Table 3 about here*------

Table 4 summarizes the sample means of the two intensive margins by year and industry. Note that the actual measurement divides the numerators in (13) and (14) by value added for normalization purposes. So the formal interpretation of the numerators is in terms of investment rate per asset type. The intensive margin $\phi_{i,t}^{+}$

associated with positive investment attains its lowest value of 10 percent in 2003 and its highest of 20 percent in 2000. Again one immediately observes sizeable differences across industries. The industries with the highest intensity of positive investment are Paper and Paper Products (21.2 percent), Basic Metals (20.7 percent), Textiles (19.7 percent) and Chemicals (19.6 percent). At the other extreme the industries with the lowest intensive margins are Tobacco (5.4 percent), Petroleum and Coal Products (8.7 percent), Machines and Equipment Articles (10.1 percent) and Leather and Footwear (10.6 percent).

The intensive margin $\phi_{i,t}^{-}$ associated with disinvestment attains its lowest value of 5.5 percent in 1995 and its highest of 35 percent in 1997. The industries that exhibited the deepest disinvestment rates are Leather and Footwear (29 percent), Clothing (25 percent), Rubber Articles and Plastics (23 percent) and Furniture (19 percent). In contrast the lowest disinvestment rates are encountered in Radio, TV and Communications Appliances (1 percent), Other Transport Equipment (2.8 percent), Petroleum and Coal Products (3.1 percent), Chemicals and Transport Equipment (both with 4.7 percent).

------*Insert Table 4 about here*------

4. Econometric Methodology and Empirical Results

We present two reduced-form models within which the potential relationships between the intensity and extent of positive and negative investment will be investigated. The models control for a wide set of plant-specific characteristics as well as fixed year[8] and industry effects. The plant-specific variables are as follows[9]: (SL) the ratio of sales to value added, (CF) the ratio of cash flow (gross operating profit) to value added[10], (EQ) the ratio of equity to value added, (LO) the ratio of bank

loans to value added[11] and finally (EMP) the logarithm of the number of employees[12].

The estimation of parameters is based on the System-GMM model (Arellano and Bover 1995; Blundell and Bond 1998) which uses equations in first-differences with the levels of the dependent variable and the independent variables as instruments, which are combined with equations in levels and the lagged differences in the dependent variable and the independent variables used as instruments. This technique circumvents the endogeneity problem and also tackles the potential weak instruments problem that the original Arellano-Bond GMM estimator in first-differences (Arellano and Bond 1991) might suffer from. In addition, the inclusion of the extensive and reductive margins in the left-hand side variables is susceptible to severe endogeneity so we also estimate the model by taking this explicitly into account. The model for the intensive margin in positive investment takes the following form:

$$\phi_{i,t}^{+} = \alpha_0 + \sum_{l=1}^{L} \gamma_l \times \phi_{i,t-l}^{+} + \alpha_1 \left[F_{i,t}^{+} \right] + \alpha_2 \left(SL_{i,t-1} \right) + \alpha_3 \left(CF_{i,t-1} \right) + \alpha_4 \left(EMP_{i,t-1} \right) + \\ + \alpha_5 \left(EQ_{i,t-1} \right) + \alpha_6 \left(LO_{i,t-1} \right) + \sum_{m=1}^{12} \lambda_m \left(time_m \right) + \sum_{s=1}^{20} \kappa_s \left(ind_s \right) + \varepsilon_{i,t} \qquad \textbf{(14)}$$

where $\gamma's$, $\alpha's$, $\lambda's$, and $\kappa's$ are unknown parameters to be estimated, $(time_m)$ and (ind_s) are sets of time and industry dummies and $\varepsilon_{i,t}$ is an unobserved random disturbance.

The corresponding model for the intensive margin of negative investment is as follows:

$$\phi_{i,t}^{-} = \beta_0 + \sum_{p=1}^{P} \delta_p \times \phi_{i,t-p}^{-} + \beta_1 \left[F_{i,t}^{-} \right] + \beta_2 \left(SL_{i,t-1} \right) + \beta_3 \left(CF_{i,t-1} \right) + \beta_4 \left(EMP_{i,t-1} \right) + \\ \beta_5 \left(EQ_{i,t-1} \right) + \beta_6 \left(LO_{i,t-1} \right) + \sum_{m=1}^{12} \psi_m \left(time_m \right) + \sum_{s=1}^{20} \xi_s \left(ind_s \right) + u_{i,t} \qquad \textbf{(15)}$$

where $\delta's$, $\beta's$, $\psi's$, and $\xi's$ are unknown parameters to be estimated, $(time_m)$ and (ind_s) as before and $u_{i,t}$ is an unobserved random disturbance.

The adequacy of model specifications is based on the absence of second-order serial correlation in the residuals[13] and non-rejection of the over-identification restrictions that denotes instrument validity (Sargan test). The choice of the autoregressive orders (L) and (P) was based on removing second-order autocorrelation in the residuals.

4.1 Main Results: The Extent and Intensity Relationship

In table 5 we report the estimation results from the System-GMM model for $\phi^{+}_{i,t}$ from two alternative specifications. In particular, column (A) refers to equation (15), while column (B) augments the baseline model by the inclusion of the extensive margin's square in order to explore possible non-linearity. The null hypothesis that the coefficient of the square term is zero was not rejected and therefore we base our discussion on the baseline specification.

The model satisfies both the no second-order autocorrelation requirement (p-value 0.28) as well as the instrument validity test (p-value 0.57) and can therefore be used to conduct inferences. Note that in order to remove residual autocorrelation the model includes two lags of the dependent variable. This suggests that the intensive margin exhibits significant persistence overtime which might be generated from time-to-build effects. As it regards to the control variables, plants with higher cash flow and equity tend to have higher intensive margins. The positive effect of cash flow and equity on investment is a recurring finding in the literature and maybe attributed either to a signal for the future investment opportunity set or to credit constraints (Fazzari *et al.*, 1988). In contrast, plants with more loans and higher employment

level show lower intensity in positive investment. The former may be explained due to a higher level of debt that implies a higher cost of external finance or create debt overhang that eventually constraints investment, while the latter suggests that investment propensity falls with plant size.

As far as the parameter of main interest is concerned the data support a strong positive effect of the extensive margin on the intensive margin. In other words, plants that initiate investment in more types of capital exhibit a higher investment rate per asset type.

------*Insert Table 5 about here*------

Table 6 reports the estimation results from the System-GMM model for $\phi_{i,t}^{-}$, where columns (A) and (B) correspond to the baseline model as appears in equation (16) and the augmented version by the reductive margin's square. In this case the null of a zero coefficient on the reductive margin's square was rejected and therefore we base our discussion on the augmented version.

The specification 'passes' the second-order autocorrelation test (p-value 0.10) and the over-identifying restrictions (p-value 0.99). A strong time persistence in disinvestment intensity is also uncovered although of a shorter time dimension (one year lag) and of larger magnitude. The disinvestment intensive margin is found to depend negatively on cash flow, employment and loans.

According to our results the reductive margin exerts a positive but decreasing impact on the intensive margin. Thus, plants triggering disinvestment in more capital types tend to also disinvest more deeply, although the incremental disinvestment takes place at a decreasing rate. Also note the negative effect of size (proxied by employment) on disinvestment rate. Previous literature has shown that larger firms may invest more in absolute magnitude, but usually exhibit a lower investment rate

(see Hall 1987; Evans 1987).. Usually this finding is attributed to the maturity of the firm (i.e larger firms typically are older and in their 'mature' phase, while smaller firms are 'young' and growing faster). This result, in the light of this explanation, indicates that the 'maturity' explanation may apply both to positive and negative investment rates.

------*Insert Table 6 about here*------

All in all, our results indicate a strong linkage between the extent and intensity of investment decisions finding which holds both for positive and negative investment. This linkage suggests that the decision on how many capital types to initiate (positive or negative) investment is closely connected to the decision regarding the depth of investment expenditures. These findings are in line with the Bloom *et al*. (2007) prediction of a reinforcing effect between the extent and intensity of investment generated by the interrelationship of uncertainty and irreversibility.

4.2 The Extent and Intensity Relationship by Plant Size

In this section we investigate potential dependence of the intensity-extent elasticity on plant size, where the latter is proxied by the number of total employees. The models used are augmented versions of the previous ones allowing for interaction terms between the level of employment and the extensive and reductive margins:

$$\phi_{i,t}^{+} = \alpha_0^* + \sum_{l=1}^{L} \gamma_l^* \times \phi_{i,t-l}^{+} + \alpha_1^* \left[F_{i,t}^{+} \right] + \alpha_2^* \left[F_{i,t}^{+} \times \left(EMP_{i,t-1} \right) \right] + \alpha_3^* \left(SL_{i,t-1} \right) + \alpha_4^* \left(CF_{i,t-1} \right) + \alpha_5^* \left(EQ_{i,t-1} \right) + \alpha_6^* \left(LO_{i,t-1} \right) + \sum_{m=1}^{12} \lambda_m^* \left(time_m \right) + \sum_{s=1}^{20} \kappa_s^* \left(ind_s \right) + \varepsilon_{i,t}^* \quad \textbf{(16)}$$

and

$$\phi_{i,t}^{-} = \beta_0^* + \sum_{p=1}^{P} \delta_p^* \times \phi_{i,t-p}^{-} + \beta_1^* \left[F_{i,t}^{-} \right] + \beta_2^* \left[F_{i,t}^{-} \times \left(EMP_{i,t-1} \right) \right] + \beta_3^* \left(SL_{i,t-1} \right) + \beta_4^* \left(CF_{i,t-1} \right) + \beta_5^* \left(EQ_{i,t-1} \right) + \beta_6^* \left(LO_{i,t-1} \right) + \sum_{m=1}^{12} \psi_m^* \left(time_m \right) + \sum_{s=1}^{20} \xi_s^* \left(ind_s \right) + u_{i,t}^* \quad \textbf{(17)}$$

The results from this exercise are reported in Table 7 and support substantial dependence of the intensity-extent relationship on plant size. In particular, the intensity-extent derivative remains positive but its magnitude decreases with plant size. Recall that the linkage between extent and intensity of investment decisions increases with the degree of complementarity between capital goods. Thus, our results provide indirect evidence for higher complementarity between capital types for small plants.

------*Insert Table 7 about here*------

Graph 2 offers a diagrammatic representation of the estimated relationships where we observe that the sensitivity of disinvestment's depth to the reductive margin is higher for the up to 95th percentile of plant size distribution. For very large plants (above the 95th percentile) the magnitudes of these derivatives are reversed with positive investment being more sensitive to the extensive margin.

------*Insert Graph 2 about here*------

5. Conclusions

In the present paper we conducted an empirical investigation of the hypothesis that the intensity of investment increases as its extent increases considering both positive and negative investment decisions. We utilized a large panel of plant-level data for which investment decisions across multiple capital goods were available, estimating two closed-form models; one for the relationship between the intensive and the extensive margins and another for the intensive and reductive margins.

Our results indicate a strong linkage between the extent and intensity of investment decisions finding which holds both for positive and negative investment. This linkage suggests that the decision on how many capital types to initiate (positive or negative) investment is closely connected to the decision regarding the depth of

investment expenditures. Moreover, the intensity-extent derivative remains positive but its magnitude decreases with plant size providing indirect evidence for higher complementarity between capital types for smaller plants.

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Endnotes

[1] For an excellent review of the literature on factor adjustment costs see Hamermesh and Pfann, (1996).

[2] An irreversible investment opportunity is analogous to a financial call option where the holder has the right, but not the obligation, within a specified time period to pay an exercise price and receive in return the underlying asset. Exercising ('killing') the option is irreversible in the sense that although the underlying asset maybe resold the investor cannot retrieve the option.

[3] Supemodularity of a production function suggests that increases in a given input raise the marginal product of the other inputs. In other words the inputs are complementary or cooperant (Topkis 1978; Milgrom and Shannon 1994). Algebraically assuming a production function with N capital inputs $F(K_1, K_2, ..., K_N)$ the marginal product of any individual input is increasing in the other inputs. This implies that: $\frac{\partial F_{K_i}}{\partial K_j} > 0, \forall\, i \neq j$. The Cobb-Douglas and Constant Elasticity of Substitution (CES) production functions satisfy these properties (see Dixit 1997; Bloom et al. 2007).

[4] The temporal aggregation bias is rather harder to surpass.

[5] The industries are: (1) Food and Beverages, (2) Tobacco, (3) Textiles, (4) Clothing, (5) Leather and Footwear, (6) Wood and Cork, (7) Paper and Paper Products, (8) Printing and Publishing, (9) Petroleum and Coal Products, (10) Chemicals, (11) Rubber Articles and Plastics, (12) Non-Metallic Minerals, (13) Basic Metals, (14) Manufacture of Final Metallic Products, (15) Machines and Equipment Articles, (16) Electrical Machines, Apparatus etc, (17) Radio, TV, Communications Appliances, (18) Medical and Accuracy Instruments, (19) Transport Equipment, (20) Other Transport Equipment, and (21) Furniture and Other Industries. Data for the industries Office Accounting and Computing Machinery and Recycling were not available due to confidentiality.

[6] The relevant laws are 3627/1956, 2392/1996, and 3470/2006.

[7] The AIS also provide information on Land and Furniture. The current analysis ignores Land since (dis-)investment in Land denotes a change in the number of production units (see Bloom *et al*. 2007). Similarly (dis-)investment in Furniture is ignored for it does not directly relate to the production process.

[8] Following Bond *et al*. (2003) industry and year effects are included to capture variations in the user-cost of capital for which direct information is not available. Furthermore, year effects capture overall macroeconomic-systematic effects affecting all plants.

[9] Division by value added is done for normalization purposes.

[10] Sales are included in order to proxy the investment opportunity set motivated by the Sales Accelerator model (Abel and Blanchard, 1986). Cash flow is intended to capture any additional information not embodied in Sales and is motivated by the capital market imperfections literature (Fazzari *et al*., 1988).

[11] Equity and Bank Loans are proxies for financing mix and credit availability.

[12] Employment level is used as a proxy for plant size.

[13] First-order autocorrelation will be present by construction.

Tables

Table 1. Episodes of Inactivity, Positive Investment and Disinvestment by Type of Capital and Year			
Buildings			
Year	**Inactivity**	**Positive Investment**	**Disinvestment**
1994	73.10	25.95	0.95
1995	71.51	27.26	1.22
1996	75.70	23.59	0.71
1997	71.98	26.81	1.21
1998	70.34	28.39	1.27
1999	68.83	29.71	1.47
2000	70.72	27.97	1.32
2001	59.71	38.38	1.92
2002	59.71	39.05	1.25
2003	58.36	39.32	2.32
2004	62.45	35.72	1.83
2005	55.27	41.69	3.04
All years	68.39	30.23	1.37
Machinery and Equipment			
1994	44.37	51.68	3.95
1995	40.81	54.40	4.79
1996	40.91	54.21	4.88
1997	43.00	52.25	4.74
1998	40.36	54.87	4.78
1999	39.21	55.87	4.93
2000	38.19	56.85	4.96
2001	30.95	63.68	5.37
2002	31.21	63.21	5.57
2003	30.04	63.09	6.87
2004	28.63	65.36	6.01
2005	28.64	64.71	6.66
All years	38.42	56.60	4.97
Motors and Vehicles			
1994	87.17	3.59	9.24
1995	85.91	3.49	10.60
1996	85.54	3.65	10.82
1997	86.43	3.13	10.44
1998	85.36	2.76	11.88
1999	85.79	2.47	11.73
2000	84.78	2.68	12.55
2001	82.04	3.34	14.63
2002	80.39	3.42	16.19
2003	79.04	3.36	17.60
2004	77.79	3.07	19.14
2005	77.05	2.97	19.97
All years	84.12	3.25	12.64

Table 2. Sample Distribution of Extensive Margin				
	$F^+ = 0$	$F^+ = 1$	$F^+ = 2$	$F^+ = 3$
By Year				
1994	44.17	31.90	22.47	1.46
1995	40.94	34.21	23.61	1.24
1996	41.85	36.10	20.79	1.25
1997	43.69	31.56	23.62	1.13
1998	41.21	32.58	25.19	1.02
1999	39.60	3.54	26.07	0.79
2000	38.82	35.78	24.48	0.92
2001	31.06	33.90	33.62	1.42
2002	30.98	33.90	33.56	1.56
2003	30.97	33.57	34.18	1.28
2004	29.42	38.22	31.16	1.20
2005	28.44	35.13	35.04	1.39
By Industry				
Food and Beverages	33.75	29.21	35.15	1.89
Tobacco	4.76	22.22	73.02	0.00
Textiles	39.32	34.52	24.95	1.21
Clothing	52.82	32.71	13.87	0.60
Leather and Footwear	47.36	38.30	13.72	0.62
Wood and Cork	44.11	36.21	18.61	1.07
Paper and Paper Products	29.04	33.25	36.39	1.32
Printing and Publishing	41.50	37.39	20.50	0.62
Petroleum and Coal Products	11.82	27.27	60.91	0.00
Chemicals	21.92	29.14	47.45	1.49
Rubber Articles And Plastics	24.56	39.27	34.94	1.24
Non-Metallic Minerals	38.97	30.25	28.65	2.13
Basic Metals	18.90	34.12	44.97	2.01
Manufacture of Final Metallic Products	29.29	42.18	27.29	1.24
Machines and Equipment Articles	38.79	39.04	21.69	0.47
Electrical Machines, Apparatus etc	28.99	38.62	31.56	0.83
Radio, TV, Communications Appliances	36.43	37.55	26.02	0.00
Medical and Accuracy Instruments	57.97	25.72	16.30	0.00
Transport Equipment	37.56	39.33	22.00	1.11
Other Transport Equipment	52.78	34.20	12.84	0.18
Furniture and Other Industries	46.10	34.49	18.68	0.73
All years & industries	37.88	34.04	26.87	1.21

Table 3. Sample Distribution of Reductive Margin				
	$F^- = 0$	$F^- = 1$	$F^- = 2$	$F^- = 3$
By Year				
1994	87.39	11.19	1.31	0.11
1995	85.45	12.68	1.69	0.19
1996	85.52	12.69	1.66	0.14
1997	85.34	13.06	1.45	0.14
1998	84.24	13.80	1.76	0.20
1999	84.46	13.24	2.01	0.28
2000	83.61	14.10	2.13	0.15
2001	80.98	16.57	2.00	0.44
2002	79.80	17.63	2.35	0.23
2003	77.18	19.16	3.33	0.32
2004	76.87	19.58	3.23	0.32
2005	74.98	20.91	3.56	0.55
By Industry				
Food and Beverages	83.28	14.65	1.81	0.26
Tobacco	38.10	52.38	7.94	1.59
Textiles	80.12	17.04	2.70	0.15
Clothing	83.97	13.32	2.48	0.23
Leather and Footwear	87.68	10.74	1.46	0.11
Wood and Cork	85.14	12.99	1.74	0.13
Paper and Paper Products	77.23	18.81	3.63	0.33
Printing and Publishing	80.51	16.54	2.67	0.27
Petroleum and Coal Products	78.18	19.09	2.73	0.00
Chemicals	70.97	25.18	3.30	0.55
Rubber Articles and Plastics	82.20	15.52	1.93	0.35
Non-Metallic Minerals	81.70	15.79	2.31	0.20
Basic Metals	75.94	20.82	2.71	0.52
Manufacture of Final Metallic Products	84.12	14.07	1.73	0.08
Machines and Equipment Articles	87.97	10.86	1.08	0.09
Electrical Machines, Apparatus etc	80.55	16.15	2.84	0.46
Radio, TV, Communications Appliances	86.99	11.52	1.12	0.37
Medical and Accuracy Instruments	89.86	8.70	1.09	0.36
Transport Equipment	82.00	16.67	0.89	0.44
Other Transport Equipment	89.86	8.98	1.08	0.09
Furniture and Other Industries	89.43	9.30	1.10	0.17
All years & industries	82.90	14.79	2.08	0.24

Table 4. Sample Means for Intensive Margins		
	ϕ^+	ϕ^-
By Year		
1994	14.00	6.90
1995	16.40	5.50
1996	16.60	8.30
1997	16.70	34.60
1998	17.10	24.10
1999	16.80	16.10
2000	20.20	17.50
2001	16.70	7.00
2002	11.50	5.60
2003	10.70	10.50
2004	12.20	7.80
2005	13.60	14.40
By Industry		
Food and Beverages	17.10	14.00
Tobacco	5.40	6.10
Textiles	19.70	11.40
Clothing	11.50	25.10
Leather and Footwear	10.60	28.80
Wood and Cork	11.80	14.70
Paper and Paper Products	21.20	11.50
Printing and Publishing	12.70	9.90
Petroleum and Coal Products	8.70	3.10
Chemicals	19.60	4.70
Rubber Articles and Plastics	13.90	22.70
Non-Metallic Minerals	19.10	8.60
Basic Metals	20.70	5.60
Manufacture of Final Metallic Products	13.20	11.30
Machines and Equipment Articles	10.10	9.40
Electrical Machines, Apparatus etc	12.10	6.10
Radio, TV, Communications Appliances	17.50	1.00
Medical and Accuracy Instruments	12.30	10.90
Transport Equipment	18.00	4.70
Other Transport Equipment	11.50	2.80
Furniture and Other Industries	12.80	19.40
All years & industries	15.40	13.20

Table 5. System-GMM Dynamic Panel Results for $\phi_{i,t}^{+}$		
Regressor	**(A)**	**(B)**
$\phi_{i,t-1}^{+}$	0.103*** (6.23)	0.110*** (7.83)
$\phi_{i,t-2}^{+}$	0.018*** (6.30)	0.016*** (6.13)
$\left[F_{i,t}^{+}\right]$	0.081*** (7.77)	0.063*** (3.22)
$\left[F_{i,t}^{+}\right]^{2}$	-	-0.003 (-0.44)
$\left(SL_{i,t-1}\right)$	-0.009 (-0.83)	-0.005 (-0.61)
$\left(CF_{i,t-1}\right)$	0.027** (2.09)	0.015 (1.42)
$\left(EMP_{i,t-1}\right)$	-0.029* (-1.91)	-0.024* (-1.89)
$\left(EQ_{i,t-1}\right)$	0.011*** (2.52)	0.008** (2.15)
$\left(LO_{i,t-1}\right)$	-0.035*** (-2.95)	-0.045*** (-4.13)
Time dummies	Included	Included
Industry dummies	Included	Included
Diagnostics		
1st-order autocorrelation test	-7.04 [0.00]	-6.83 [0.00]
2nd-order autocorrelation test	-1.07 [0.28]	-0.77 [0.43]
Sargan test	121.54 [0.57]	180.51 [0.63]
Wald test	526.29***	537.60***
Cross-sectional units	4447	
Observations	23275	

Notes: Numbers in parentheses and brackets denote z-statistics and probability values respectively. One, two and three asterisks denote statistical significance at the 10, 5 and 1 percent respectively. The instruments list includes lagged levels of the independent variables dated $t-2$ and of the dependent dated $t-3$ and earlier.

Table 6. System-GMM Dynamic Panel Results for $\phi_{i,t}^{-}$		
Regressor	**(A)**	**(B)**
$\phi_{i,t-1}^{-}$	0.324*** (6.02)	0.360*** (7.95)
$\left[F_{i,t}^{-}\right]$	0.065*** (7.97)	0.082*** (6.15)
$\left[F_{i,t}^{-}\right]^2$	-	-0.013** (-2.41)
$\left(SL_{i,t-1}\right)$	-0.013 (-1.00)	-0.010 (-0.87)
$\left(CF_{i,t-1}\right)$	-0.030** (-2.33)	-0.035*** (-3.36)
$\left(EMP_{i,t-1}\right)$	-0.085*** (-3.28)	-0.084*** (-3.76)
$\left(EQ_{i,t-1}\right)$	0.003 (0.56)	-0.0001 (-0.04)
$\left(LO_{i,t-1}\right)$	-0.023*** (-11.22)	-0.022*** (-13.09)
Time dummies	Included	Included
Industry dummies	Included	Included
Diagnostics		
1st-order autocorrelation test	-1.92 [0.05]	-1.98 [0.04]
2nd-order autocorrelation test	1.41 [0.15]	1.63 [0.10]
Sargan test	91.01 [0.99]	127.02 [0.99]
Wald test	351.52***	798.88***
Cross-sectional units	2935	
Observations	7519	

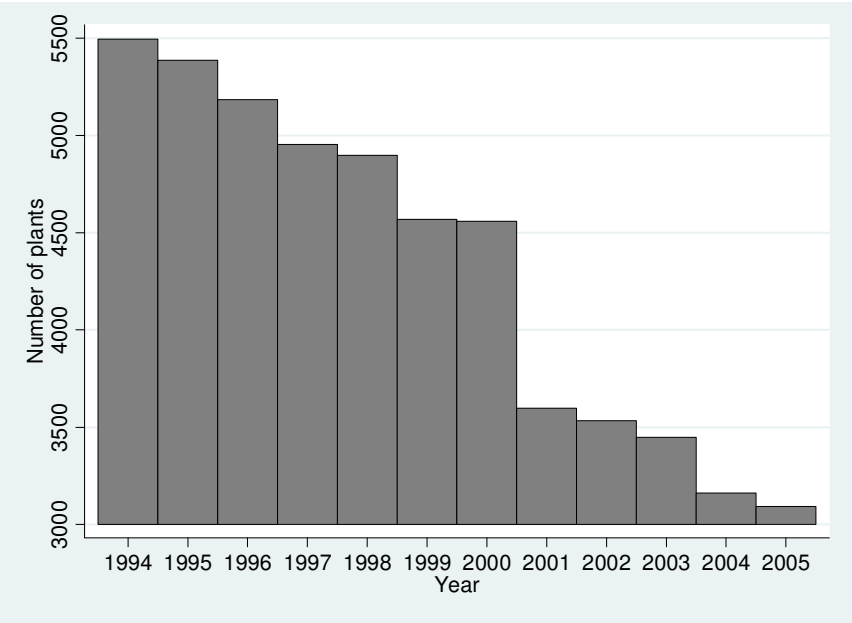
Notes: Numbers in parentheses and brackets denote z-statistics and probability values respectively. One, two and three asterisks denote statistical significance at the 10, 5 and 1 percent respectively. The instruments list includes lagged levels of the dependent variable and the independent variables dated $t-2$ and earlier.

Table 7. Intensity and Extent of Investment by Plant Size		
	Dependent variable	
Regressor	$\phi_{i,t}^{+}$	$\phi_{i,t}^{-}$
$\phi_{i,t-1}^{+}$	0.107*** (7.09)	-
$\phi_{i,t-2}^{+}$	0.017*** (6.89)	-
$\phi_{i,t-1}^{-}$	-	0.356*** (8.97)
$\left[F_{i,t}^{+}\right]$	0.128*** (5.17)	-
$F_{i,t}^{+}\times\left(EMP_{i,t-1}\right)$	-0.017*** (-2.66)	-
$\left[F_{i,t}^{-}\right]$	-	0.176*** (8.27)
$F_{i,t}^{-}\times\left(EMP_{i,t-1}\right)$	-	-0.027*** (-5.87)
$\left(SL_{i,t-1}\right)$	-0.017* (-1.83)	-0.014 (-1.32)
$\left(CF_{i,t-1}\right)$	0.038*** (3.79)	-0.029*** (2.76)
$\left(EQ_{i,t-1}\right)$	0.009** (2.51)	0.002 (0.57)
$\left(LO_{i,t-1}\right)$	-0.033*** (-3.15)	-0.012*** (-5.05)
Time dummies	Included	Included
Industry dummies	Included	Included
Diagnostics		
1st-order autocorrelation test	-7.03 [0.00]	-2.04 [0.04]
2nd-order autocorrelation test	-0.79 [0.42]	1.78 [0.07]
Sargan test	187.23 [0.50]	144.22 [0.99]
Wald test	658.10	246.40
Cross-sectional units	4447	2935
Observations	23275	7519

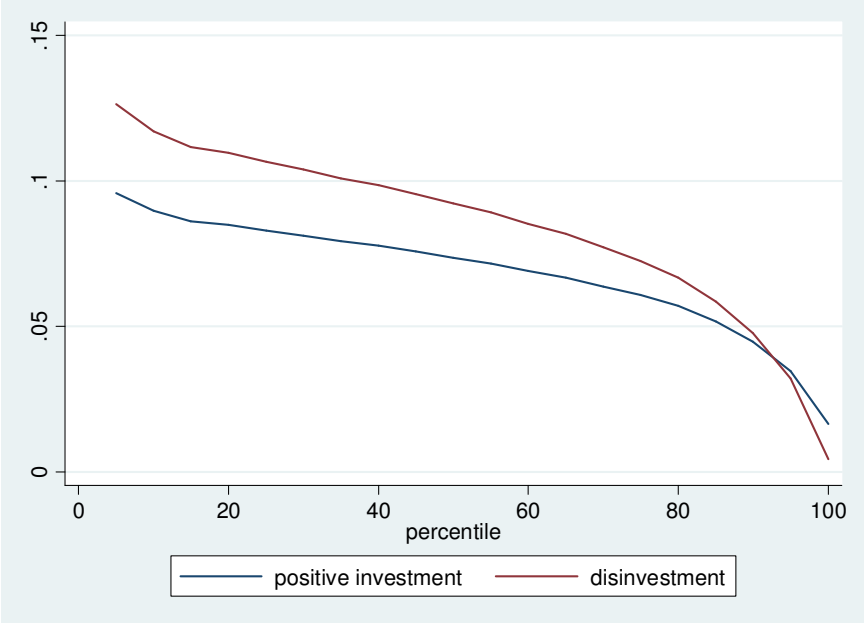
Notes: Numbers in parentheses and brackets denote z-statistics and probability values respectively. One, two and three asterisks denote statistical significance at the 10, 5 and 1 percent respectively.

Graphs

Graph 1. Number of plants by year



Graph 2. Estimated Intensity-Extent Derivative by Plant Size



Notes: The vertical axis measures the estimated derivative of intensity to extent of investment while the horizontal denotes the percentile of employment level's sample distribution.