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A Cross-Country Perspective on Irish Enterprise Investment: Do Fundamentals or Constraints Matter?

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Abstract: Numerous research papers have used Irish-only data to test for the presence of an investment gap for small- and medium-sized enterprises (SMEs). In this paper, we use cross-country firm-level survey data from the World Bank Enterprise Surveys to explore the investment patterns of Irish enterprises in a cross-country context and test whether an investment gap is present when compared to other countries. We use an accelerator model of investment which links capital expenditure to firm output growth and test the sensitivity of investment to this key fundamental for Ireland and other countries. We then estimate whether Irish firms face an investment gap relative to their European peers. We test whether any differences in cross-country patterns are driven by variation in financial factors (such as credit access or indebtedness) or firm quality (managerial experience, website usage, operating profitability). We find that Ireland's investment in fixed tangible assets is relatively well explained by these factors whereas a clear underinvestment in research and development expenditure emerges. Factors associated with investment in research and development include the degree of foreign technology usage, digitalisation and internationalisation.

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I INTRODUCTION

Investment in capital assets is a critical determinant of long-term firm productivity growth and there is an expansive literature which explores the determinants of investment decisions (Gilchrist and Himmelberg, 1995; Whited, 1992) and the constraints that limit investment activity. Traditionally, a major constraint on investment in fixed capital has been access to credit and the requirement to finance capital acquisitions by external funding. There is a voluminous literature internationally which explores the financing structure of small enterprises (Beck *et al*., 2008; Berger and Udell, 1998) and the impact on investment (Hennessy *et al*., 2007; O'Toole and Newman, 2017). In a global and Irish context, a considerable number of academic studies have explored these questions in the context of the 2007 Global Financial Crisis and found a notable impact of financing challenges (both access to credit but also from debt overhang) on investment and other economic outcomes such as employment growth (Campello *et al*., 2010; Gerlach-Kristen *et al*., 2015; Lawless *et al*., 2015; Martinez-Cillero *et al*., 2020).

However, while the global and Irish economies have recovered from the extreme financial shock of the international banking crisis, investment has remained relatively muted. A number of papers have attempted to explain this investment-less growth (Banerjee *et al*., 2015; Bussiere *et al*., 2017; Fay *et al*., 2017; Islamaj *et al*., 2019) with various financial and non-financial explanations put forward. For Ireland, a further layer to the complexity of investment dynamics has been the pivot away from external financing towards heavy internal financing of capital expenditure. Gargan *et al*. (2018) and Lawless *et al*. (2020) provide empirical evidence on the financing structure of Irish SMEs and show that Irish firms' financing activity is more heavily oriented towards internal funds than their European peers.

The combination of sluggish investment in the post Global Financial Crisis era and the low external financing activity for Irish SMEs has raised questions as to what are the causal factors and whether the Irish investment activity can be explained by binding constraints on activity or demand-side factors such as the firms' risk appetite and outlook. Internationally, various explanations have been put forward; for example some research (Gutiérrez and Philippon, 2017; Doettling *et al*., 2017) suggested that competition or industry changes were at play, while other research points to misallocation effects across firms (Gorodnichenko *et al*., 2018). From an Irish perspective, the existing research has mostly attempted to explore the traditional role of access to finance constraints in a single country context without exploring the extent to which Irish firms compare to their international peers (Lawless *et al*., 2021).

This research paper attempts to bridge this gap in the existing literature. Our aim is to address the following research questions: (a) does Irish enterprise investment differ from other countries in particular for comparable groups of firms

(age, size, sector)?; (b) do 'fundamentals' drive investment or can any observed differences be explained by financial factors or firm quality?; (c) What would Irish enterprise investment look like if they invested in a similar manner to other countries? In our measure of investment, we focus on both investment in business fixed tangible capital expenditure (including machinery and equipment and other tangible investment activity, defined as tangible fixed assets or TFA) as well as investment in research and development (R&D).

To address these questions, we use cross-country firm-level data from the World Bank Enterprise Surveys (WBES). The data are cross-sectional in nature and were collected in the years 2018-2020 (depending on the country). Our comparison includes a broad group of Northern European countries including Austria, Belgium, Denmark, Finland, France, the Netherlands, and Sweden, as well as a group of Mediterranean countries consisting of Greece, Italy, Spain, and Portugal. We therefore compare the investment levels of Irish enterprises to a group of firms in other European countries.

As small firm investment is often lumpy and infrequent, our key dependent variables for both TFA and R&D are characterised by a considerable number of zeros where firms do not invest in a given year. Our methodological approach draws on both a simple probit model to model the probability of investing as well as a double-hurdle model to deal with the level of investment in a second stage. As a conceptual framework, we are limited in the deployment of more sophisticated models such as a Tobin's Q approach or an Euler equation due to the cross-sectional nature of our data. We therefore draw on a simple output accelerator approach to measure fundamentals. The output accelerator approach is a neoclassical investment model (first linked to the work of Jorgenson, 1967) which indicates that firms will adjust their capital stock to maintain a fixed proportion relative to output. Therefore increases in investment will occur in line with changes in output. This captures the fundamental drivers of investment: capital stocks grow in line with firm sales growth. In practical terms, this means investment is a function of the change in sales.

Our empirical strategy is as follows: we estimate the accelerator model including firm-level controls (for example age, size, sector) and importantly country-specific indicators which capture how different investment is in each specific jurisdiction relative to Ireland. Our interest is in determining whether Irish firm investment activity is indeed different once we control for the fundamentals of the firm and the firm-specific characteristics. We then test whether Irish firms have a different sensitivity to investment by interacting the output accelerator variable with an Irish indicator. We then append variables capturing financing factors (such as access to credit and indebtedness) and firm quality (experience, profitability, internationalisation and digitalisation) to test whether these factors explain cross-country patterns. Finally, we use the coefficients from models estimated excluding Ireland to predict a counterfactual Irish growth level i.e. if Irish

firms invested using the sensitivity to their characteristics based on other countries, what level would Irish investment be?

The empirical approach in this paper differs from a traditional study that would consider the cross-country determinants of investment. We place a comparison relative to Ireland at the centre of our research. We therefore focus on exploring differences across countries relative to Ireland by focusing on each country's marginal effect compared to Ireland and by interacting key variables with an Ireland dummy to test for Irish-specific effects. We also explore whether country differences relative to Ireland change if we control for different baskets of firm-level factors such as access to credit or firm quality. The main aim of the research is to explore if Irish investment differs from other countries. In this regard, we explicitly limit the set of comparator countries to peer economies in Western Europe that are EU Member States and therefore share many legal and other constraints, are at a similar point in their economic development, and can be potentially useful comparisons for Ireland in terms of learnings for policy.[1]

A number of findings emerge from our analysis. First, considering investment in TFA, we look at both whether firms are investing, and if they invest, the level of investment. We do not find a dramatically lower share of Irish enterprises investing relative to all other countries. However, there are some Northern European countries (Sweden and Denmark) which have a higher share of firms investing. In terms of the level of investment (in euro terms), Ireland has a lower level than that of Denmark, Sweden, and Austria, although it is higher than the levels in France, Greece, Italy, Portugal and Spain.

Turning to expenditures on R&D, Irish firms are statistically less likely to invest compared to firms in Austria, Belgium, Denmark, the Netherlands and Sweden. These findings control for firm size and therefore hold across the size distribution in the data. Furthermore, if Irish firms do invest, they also invest in smaller amounts than similar firms in these countries. The opposite is the case when comparing Irish firms to those in Italy, Portugal, Spain and Greece. This suggests a clear underinvestment in research and development is evident for Irish enterprises when compared with a broad group of other Northern European economies. This finding is likely to have an impact on the relative productivity of Irish domestic firms as compared to comparator firms in these countries if these patterns were to persist over a prolonged period of time. We do not find any major differences in the sensitivity of investment to output growth for Irish firms for TFA, i.e. a 1 per cent change in firm sales for an Irish firm has a similar impact on investment as compared to other countries.

To understand better the drivers of investment, and to explore what may cause any differences across countries if they are identified, we test whether country

[1] We do not include Eastern European economies as they may be in an different part of the investment cycle due to their transition from centrally-planned economic structures.

differences could be explained by either financial factors or indicators of the quality of the firm that are unexplained by the simple output accelerator. In general, we find financially constrained firms, and those with high indebtedness relative to income, have notably lower investment in fixed assets. In terms of investment in R&D, financial factors do not appear to be as major a barrier as for investment in TFA. In terms of indicators of firm quality, the variables relating to internationalisation (domestic share of sales), not having a website and not using foreign technology are all negative and significant in the research and development regressions suggesting they lower investment expenditures. These findings suggest that domestic-focused firms, both those without basic digital offerings and those not relying on foreign technology are much less likely to invest in research and development. Also if they do invest, the level of investment will be lower. This is a notable finding and provides an economic rationale for policy supports to boost internationalisation and digitalisation.

We also find some evidence that both financial factors and quality factors explain some, but not all, of the country-specific differences identified above for both investment in TFA and R&D; i.e. when these factors are accounted for, Ireland is no longer statistically different from some countries. The specific countries differ by asset class, control variable set and whether the probability of, or level of, investment is considered.

Finally, we estimate counterfactual investment scenarios for Irish firms using the group of Northern European countries as a comparison. This is the calculation of predicted investment levels of Irish firms if they displayed the same tendency to invest as their Northern European counterparts. The results of these counterfactuals differ across TFA and R&D. For TFA, the share of firms investing in Ireland is in line with the counterfactual scenario. Some differences emerge for small, young firms but generally the other country coefficients predict the Irish actual investment well. However, in terms of the level of investment for those firms who invested, the counterfactual scenarios are higher (particularly for industrial, large and foreign firms) which suggests investment would be higher if Irish firms reacted in a manner similar to their European peers. For R&D, the counterfactuals on the share of investors are higher than the actual, indicating an investment gap. This gap is most prominent for industrial firms and those in the 'other service' sector. Domestic-focused sectors also have a counterfactual quite close to the actual including construction, wholesale and retail and hotels and restaurants. However, comparing the counterfactual level of investment to the realised level, the predicted level of R&D is higher than the actual, especially for older, medium sized firms. Of particular note is that other service firms and foreign firms have an actual level of investment that exceeds the counterfactual. As this group of firms would include FDI and IT services firms who would be highly R&D intensive, this finding is not surprising.

The rest of this paper is structured as follows: Section II presents the data and summary statistics. Section III presents the conceptual framework and empirical model. Section IV considers the relationship between fundamentals and investment. Section V attempts to explain the cross-country differences. Section VI presents the counterfactual scenarios, Section VII discusses the policy implications for Ireland and Section VIII concludes.

II DATA AND SUMMARY STATISTICS

2.1 Data Overview and Indicators

The World Bank Enterprise Survey (WBES) provides a cross-country database which compiles information on a range of indicators covering firm performance and activity. The aim of the survey is to consistently collate information which can be used to explore the constraints to firm performance. The data are collected approximately every 3-5 years. This survey gathers information on different firms over a range of categories, such as sales and supplies, competition, innovation, finance, labour etc. The questions vary notably – many are answered in levels such as 'During fiscal year [Insert last complete fiscal year], how much did this establishment spend on research and development activities, either in-house or contracted with other companies?', whereas other questions offer a set of responses which have been allocated a number, such as 'To what degree is Access to Finance an obstacle to the current operations of this establishment?'. The surveys from each country and year were cleaned and merged to create the current dataset. Additionally, many variables were found to have outliers, and so in order to prevent distortion by these observations, the bottom and top 1 per cent of values were dropped for a range of variables.

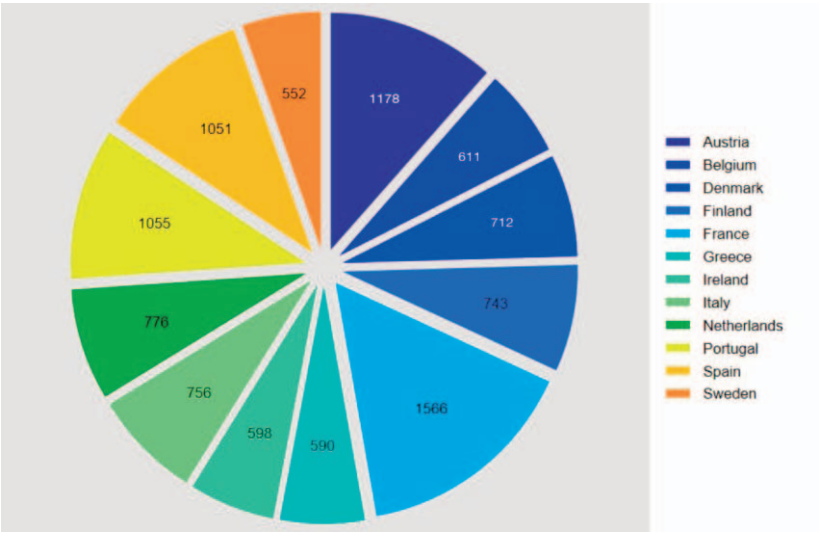
The sample used in this paper covers approximately 9,000 firms which are observed across a range of sectors, but a large proportion of respondents were industrial sector firms. Nevertheless firms do differ in sector, age, firm size and legal status. These are valuable control variables, as will be discussed.

Table 1: Country Groups

Northern Europe	*Mediterranean*
Austria	Greece
Belgium	Italy
Denmark	Portugal
France	Spain
Finland	
Netherlands	
Sweden	
5,395	3,452

Source: WBES Microdata.

Figure 1: Observations Across Countries



Source: Authors' calculations using WBES database.

This dataset looks at firms across five sectors: Industry; Construction; Wholesale and retail; Hotels and restaurants; and Other. Across the sample, 55 per cent of firms are Industry sector firms. The sectoral breakdown is more balanced in Ireland, but is skewed towards Industry in total. The distributions of sector, firm size and age group are shown in Figure 2 for the country groups. The distribution of age is more balanced than sector. There are, however, more mature and old firms across the distribution. Young firms are defined as those operating for ten years or less. Mature firms are defined as those operating for 11-30 years. Old firms are defined as those operating for over 30 years.

The distribution of firm size has a clear pattern across the country groups in that the number of observations is decreasing in firm size. Firm size is calculated based on the number of employees a company has. Small firms are those with 5-19 employees; medium firms are those with 20-99 employees; and large firms are those with 100 employees or more.

There are two main indicators used in this paper to examine investment. The first deals with investment into tangible fixed assets, whereas the second is a measure of R&D investment. The definitions of these variables as well as other constraint and control variables are outlined in Table 2.[2]

- Purchase of tangible fixed assets – "*did this establishment purchase any new or used fixed assets, such as machinery, vehicles, equipment, land or buildings, including expansion and renovations of existing structures?"* This

[2] Observations for which no investment is reported have been maintained in the sample as a zero value.

measure is provided in the form of a binary variable as well as the level in euro or Local Currency Units.

- Expenditure on R&D – "*did this establishment spend on research and development activities, either in-house or contracted with other companies, excluding market research surveys?"* This measure is provided in the form of a binary variable as well as the level in euro or Local Currency Units.

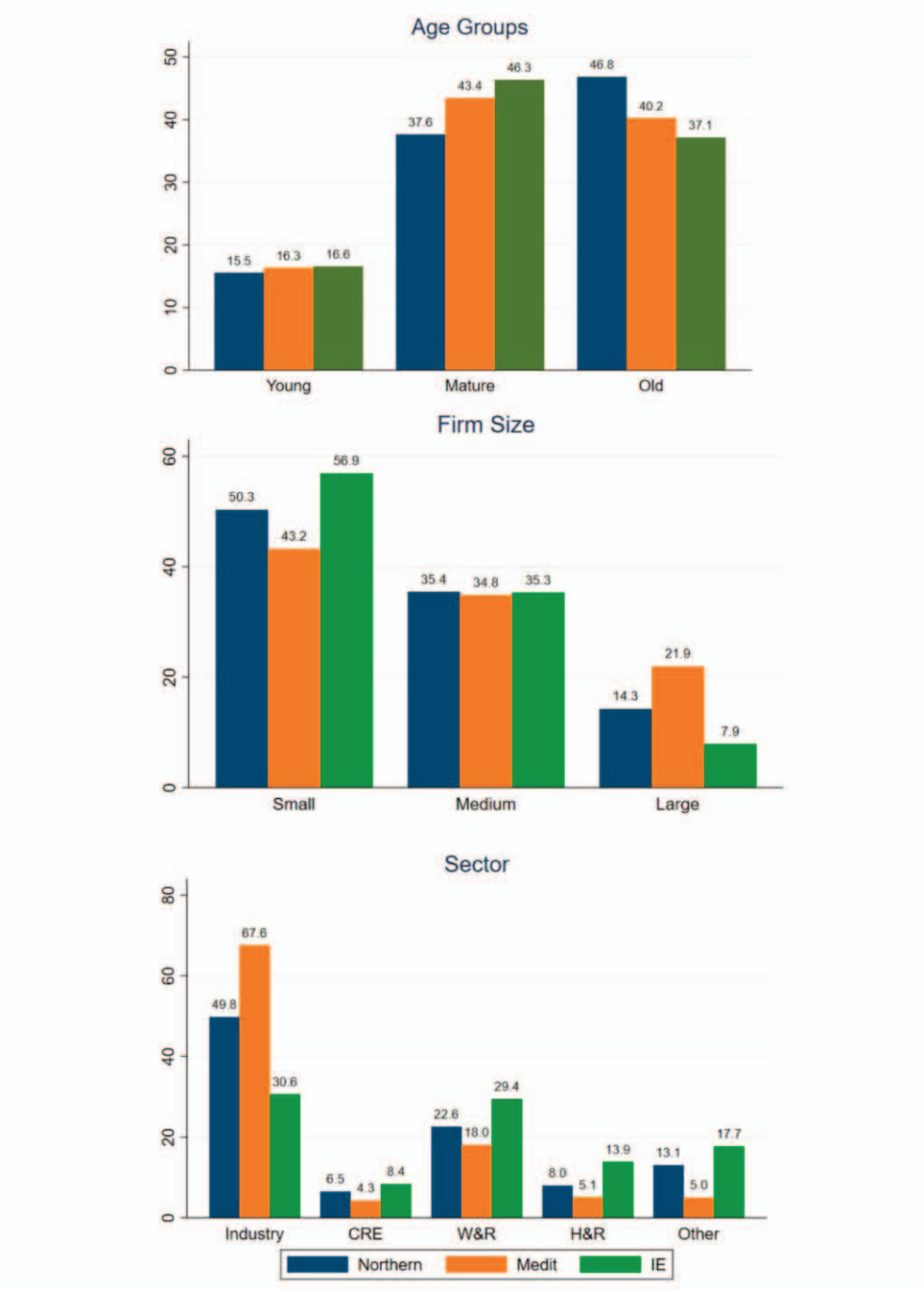
Table 2: Summary Statistics

Variable	*Definition*	*Mean*	*St Deviation*
TFA Investment	Any fixed assets purchased in the last fiscal year?	0.572	0.49
R&D Investment	Any R&D expenditure in the last fiscal year?	0.287	0.453
R&D Investment/ Employee	Amount spent on R&D in last fiscal year as a proportion of labour force	2,395.29	8,928.87
TFA Investment/ Capital Stock	Amount spent on fixed assets in last fiscal year as a proportion of capital stock	0.203	0.327
R&D Investment/ Capital Stock	Amount spent on R&D in last fiscal year as a proportion of capital stock	0.137	0.862
Exporter	Whether or not firm exports	0.429	0.494
Private Ownership	% Owned by private foreign entities	9.483	28.237
Growth in sales	Rate of growth in sales	0.202	0.495
Experience Top Manager	No. years experience of top manager at the firm	26.1	12.24
Access to finance	Difficult/Not difficult to access finance	0.186	0.389
Market Share	Firm sales as a proportion of total sales in given country and sector	0.006	0.024

Source: Authors' calculations using WBES database.

The summary measures of these indicators are shown below, where the mean and/or median of each of these indicators for Irish firms are compared to firms from the Northern Europe (NE) and Mediterranean regions. As can be seen, Ireland has

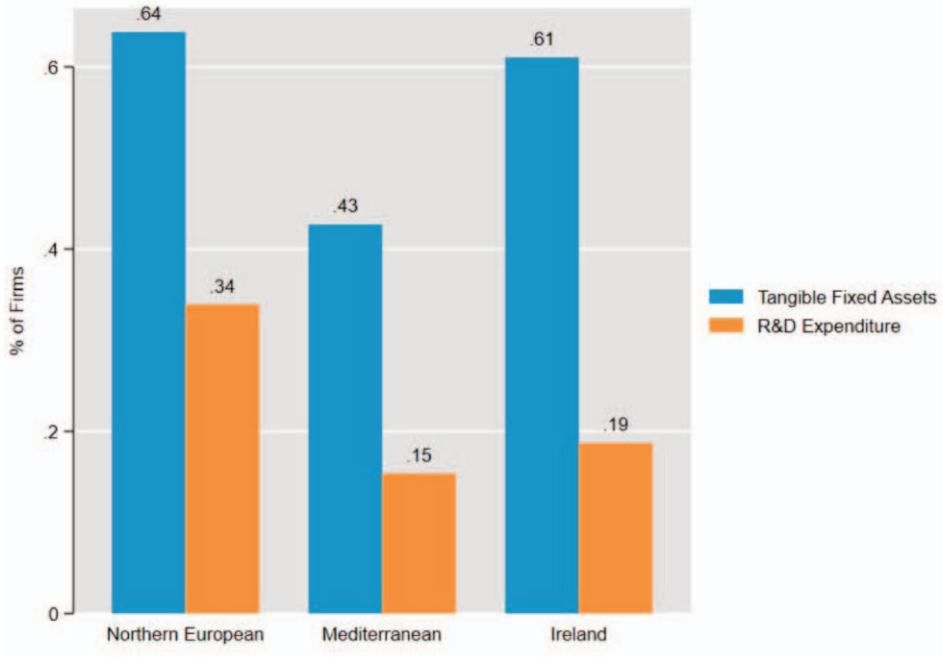
Figure 2: Main Firm Groups and Sectors



Source: Authors' calculations using WBES data.

a lower mean TFA investment rate than NE firms, but has a higher rate of TFA investment than Mediterranean firms (Figure 3). This lower investment rate is, however, much starker when examining the investment rate in research and development. Irish firms have a much lower R&D investment rate than firms from NE but it is higher than the Mediterranean countries. This is a significant finding and the results throughout this paper follow this pattern. However, it is not simply the rate of investment among Irish firms that is below that of non-Irish firms.

Figure 3: Proportion of Firms Investing in Tangible Fixed Assets and R&D



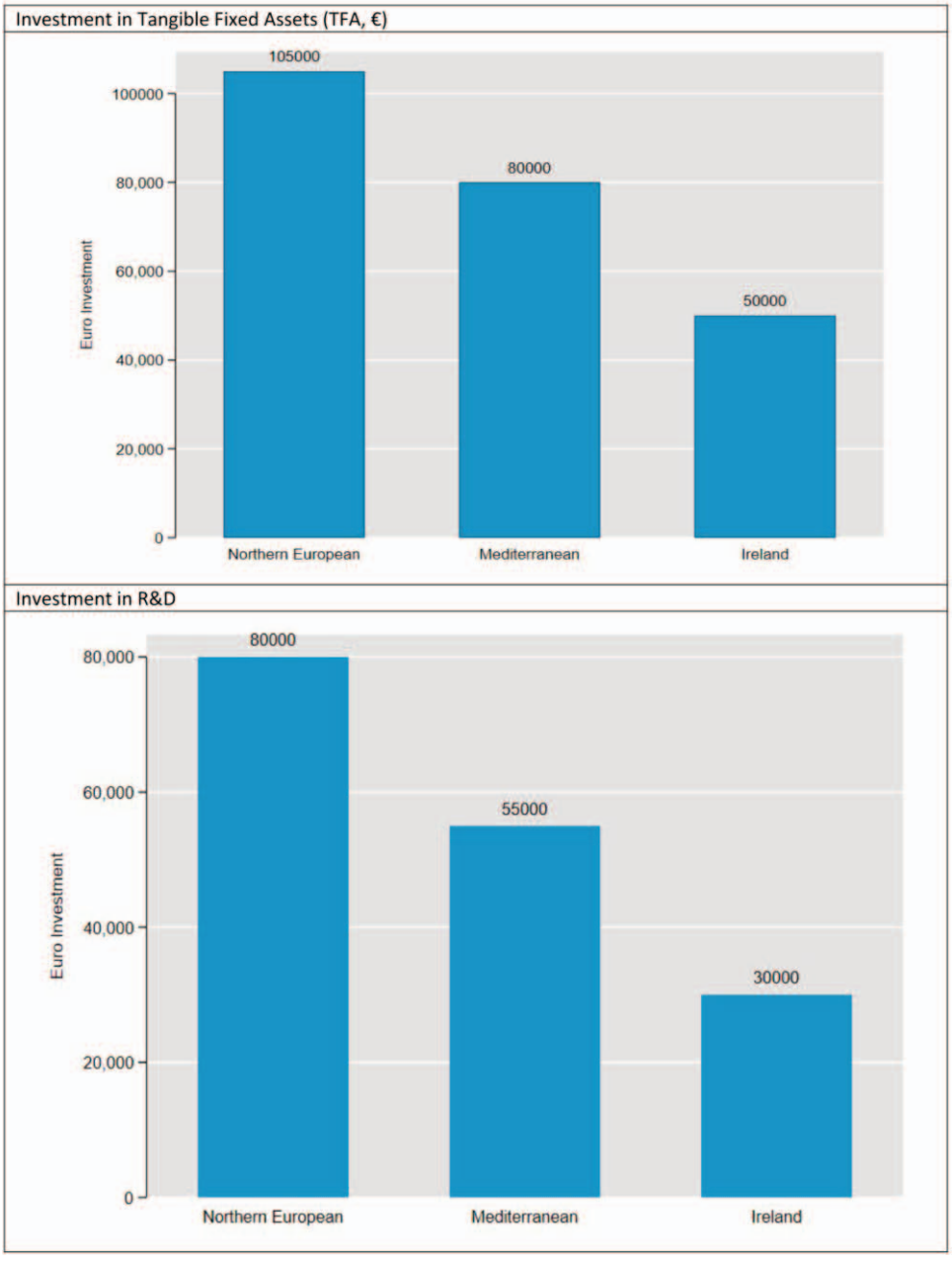
Source: Authors' calculations using WBES database.

The graphs in Figure 4 show that median levels of investment are lower in Ireland compared to firms in the identified regions. Although unlike the rate of investment, levels of investment are lower for both TFA investment and R&D investment.

The lower investment levels for Irish firms are illustrated further in Figure 5. The Irish firm investment distribution lies to the left of the other regional distributions showing a higher proportion of firms in Ireland investing at lower levels for both TFA and R&D.

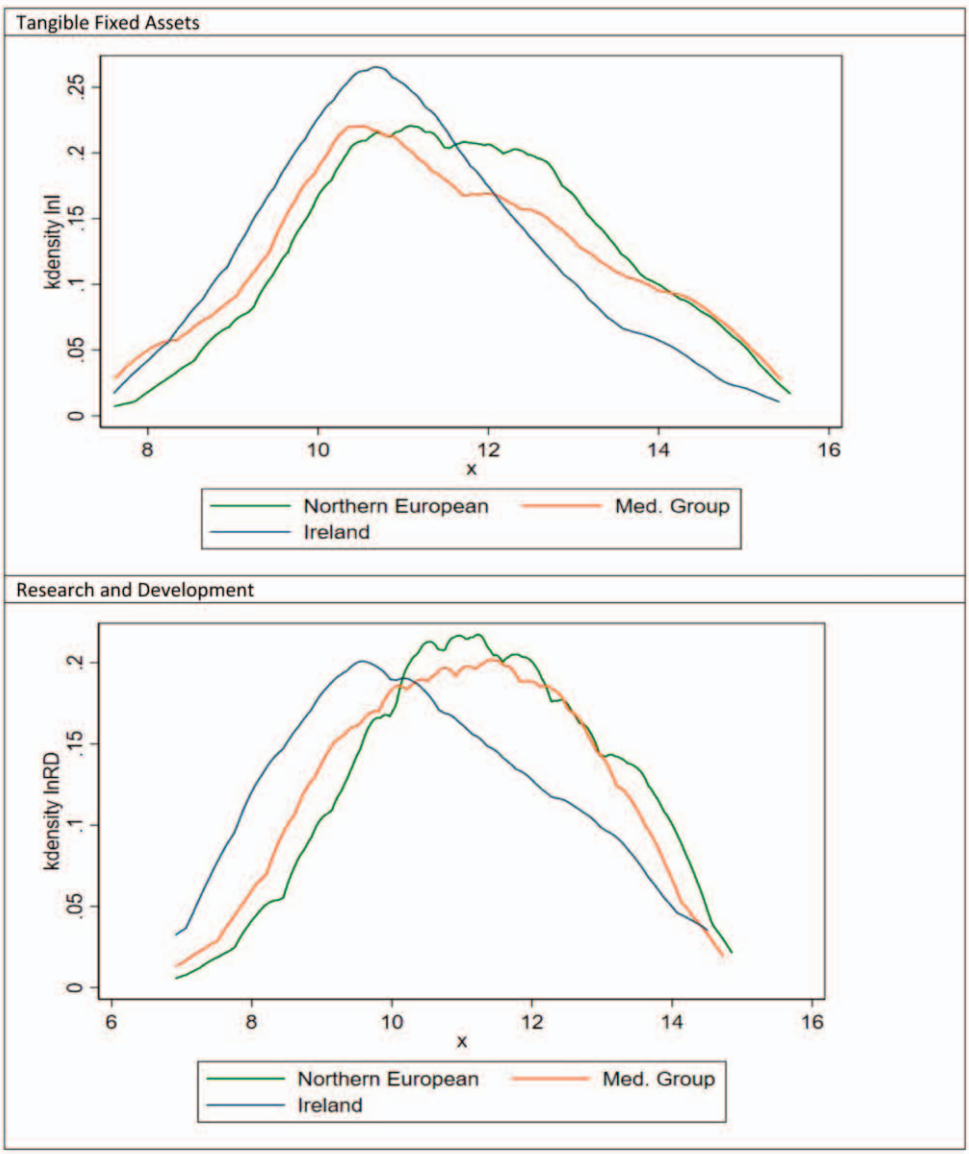
While these figures clearly show lower investment activity among Irish enterprises compared to non-Irish enterprises, it is important to investigate these trends further. As part of this investigation, the proportion of firms investing across the two asset classes, as well as the level of investment for firms that do invest, is

Figure 4: Median Level of Investment – Tangible Fixed Assets and R&D



Source: Authors' calculations using WBES database.

Figure 5: Kernal Density Plot of Level of Investment in Logs

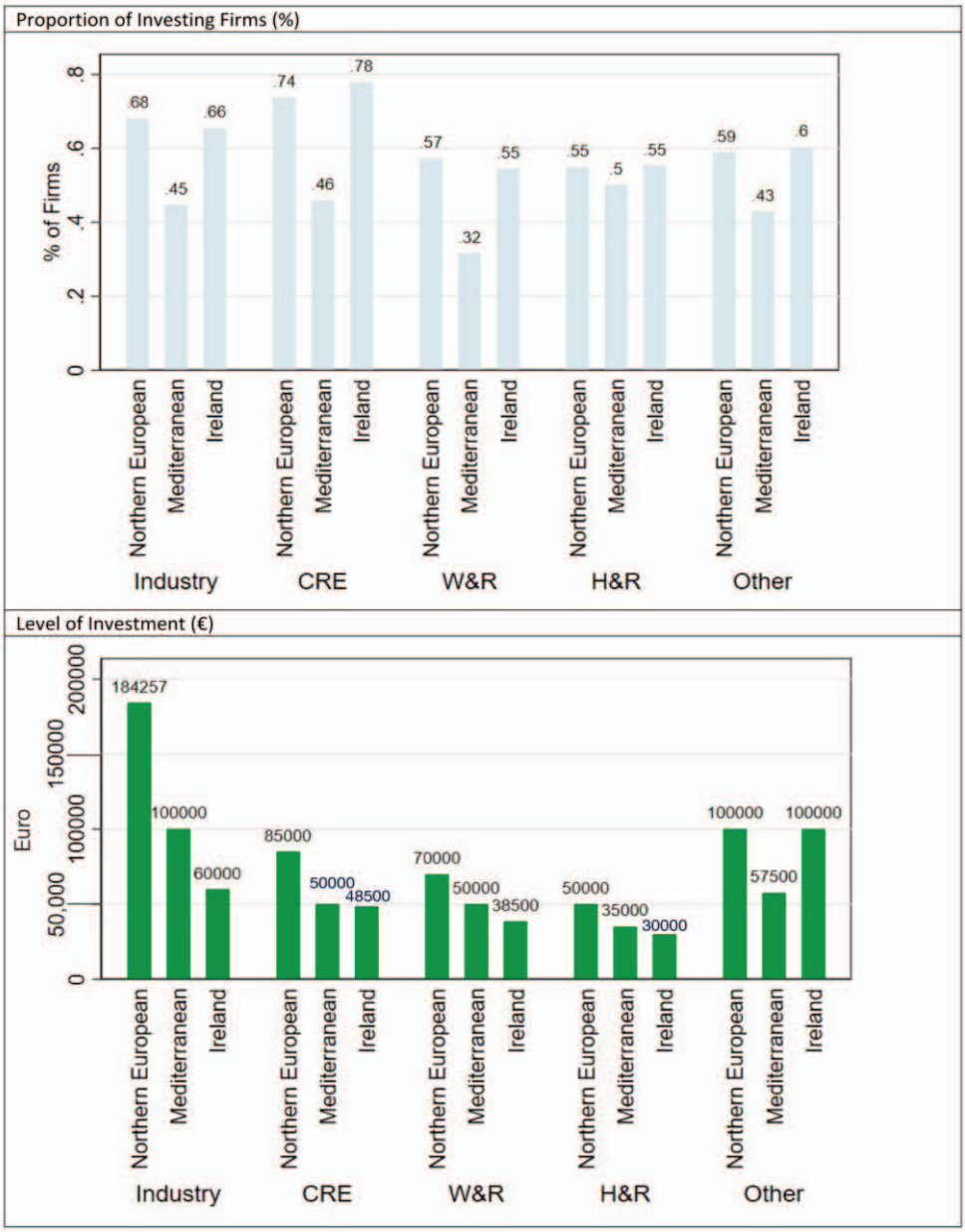


Source: Authors' calculations using WBES database.

examined across sectors. The results are broadly comparable, with similar proportions of firms investing in tangible fixed assets but lower proportions of Irish firms investing in R&D activities and lower levels of investment across the two types of investment. One point of note is that this trend does not hold in the 'other' sector. In this sector, although the proportion of firms investing in R&D is indeed lower than firms in other regions, the investing firms in this sector committed

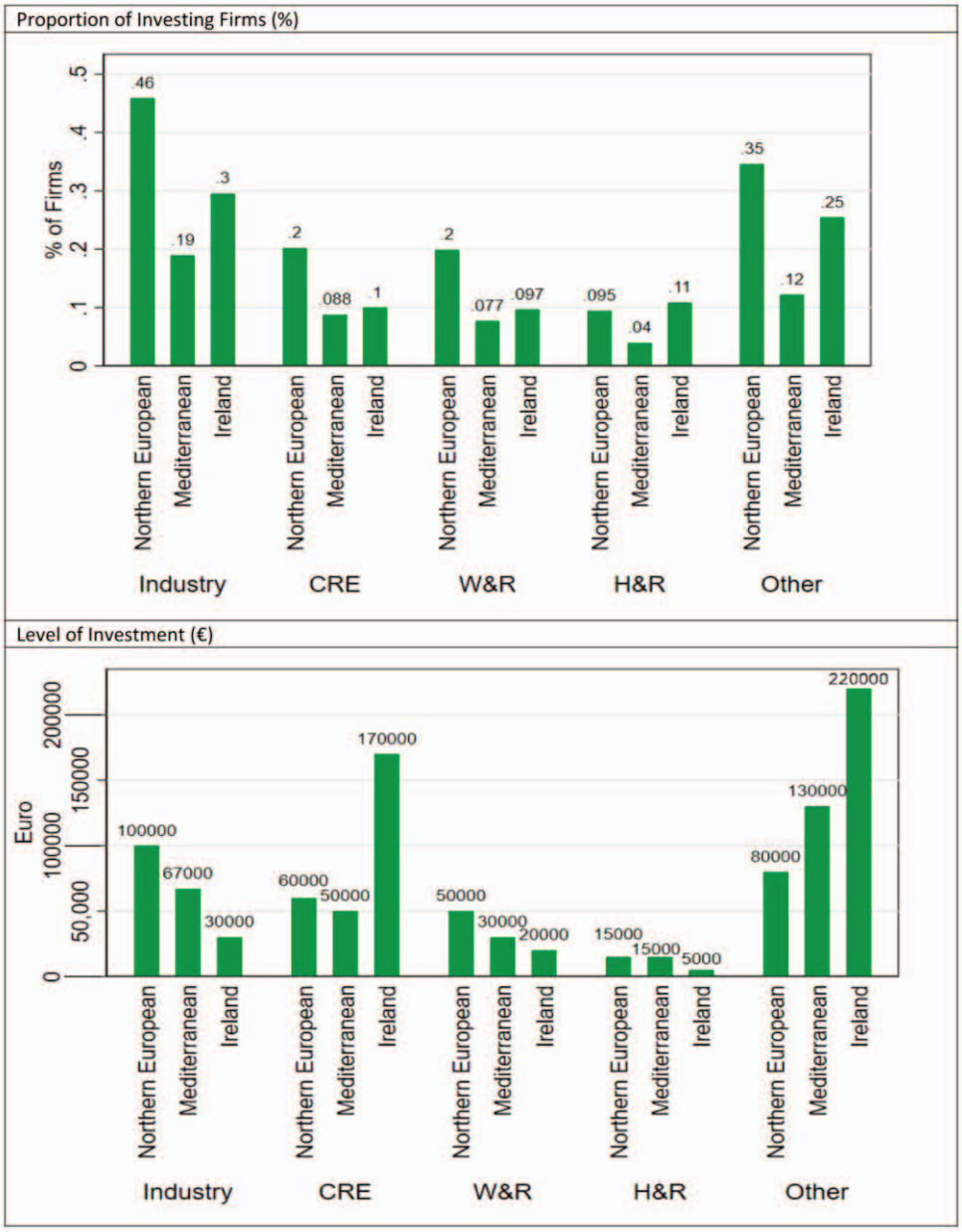
greater levels of funds to that investment, as can be seen in Figure 6. Nevertheless, the general pattern holds across all other sectors and hence the findings discussed thus far do not seem to be sector-specific.

Figure 6: Main Statistics Across Sectors – Tangible Fixed Assets



Source: Authors' calculations using WBES database.

Figure 7: Main Statistics Across Sectors – Research and Development



Source: Authors' calculations using WBES database.

This analysis shows that Irish enterprise investments are more targeted towards tangible fixed assets compared to R&D. This is shown through the proportion of firms investing, with similar proportions of Irish firms investing as firms in NE and

the Mediterranean when it comes to TFA. However, there is clearly a lower frequency of R&D investment, with a much lower proportion of Irish firms investing in R&D compared to firms across the identified regions.

Additionally, when the data for those firms who do invest are examined, it is clear that even when Irish firms do invest, they tend to invest lower levels than their international counterparts. Therefore, several questions arise from these summary statistics. First of all, what is driving the low rate of R&D investment among Irish enterprises? Secondly, why are Irish firms' investments at a lower level than non-Irish firms' investments? These issues may be explained by lower investment demand, credit constraints, lower levels of firm performance, or firm characteristics.

Therefore this paper will investigate fundamentals such as sales and profits, firm characteristics such as sector, age, and firm size, as well as certain constraints such as obstacles to finance and market competition. The following section outlines the methodology used to reach this objective.

III EMPIRICAL APPROACH

3.1 Conceptual Framework

While there is a range of models for investment activity such as the Q or Euler approach (Whited, 1992; Erickson and Whited, 2000; Love, 2003), the limitations of our cross-sectional data require us, in practical terms, to select a model that can be deployed in that context. To do so, we use the simple accelerator approach which is motivated by Jorgenson (1967) and used in investment modelling by O'Toole *et al*. (2014), amongst others.

In this conceptual framework, we outline a simple foundation based on the theoretical model of firm maximisation. The rest of this conceptual section presents this model in brief so as to motivate and explain the choice. The theoretical construct of this model relies on a fixed relationship between the capital stock and output i.e. firms invest in such a manner as to keep a constant desired capital-output ratio. The model implies that firms maintain these fixed proportions:

$$K_{it} = \gamma Y_{it} \tag{1}$$

where K is the capital stock of firm i in period t and Y is output of the firm i in period t. We assume that firms accumulate capital in the traditional manner with investment expenditures plus the current capital stock minus depreciation equal to the next period capital:

$$K_{it+1} = (1 - \delta)K_{it} + I_{it+1} \tag{2}$$

For simplicity, we assume that the depreciation rate δ equals zero. Substituting Equation (1) into Equation (2), we get:

$$I_{it} = \gamma \Delta Y_{it+1} \tag{3}$$

This states that investment is equal to a constant share of future output growth. Given that future output growth is not observed, we must treat this as an expectation. We assume that the past performance of the firm is the best guide for future performance so therefore use historical observed values in the current period i.e. firms expect the change in output in the future period to be the same as the change in the existing period $E_t(Y_{t+1} - Y_t) = (Y_t - Y_{t-1})$:

$$I_{it} = \gamma \Delta Y_{it} \tag{4}$$

In our analysis, we focus on both investment in research and development and investment in tangible fixed assets, treating them both as having fixed proportions to output, but these may differ across the two asset classes.

3.2 Empirical methods

While the above conceptual framework allows us to link the firms' fundamental factors to their investment activity, there are a number of complexities with small firms that require an empirical model to deal with a specific econometric issue. Small firm investment is often lumpy and infrequent i.e. some firms do not invest every year and then if they do, the amounts can vary notably. As the research aims to consider both whether firms invest (the extensive margin decision) and the level of investment (intensive margin), we require a framework which can deal with such behaviour. To address this issue, we specify the following latent investment variable I^*:

$$I^* = \begin{cases} 1, \textit{ if } lnI > 0 \\ 0, \textit{ otherwise} \end{cases}$$

where I^* is positive if firms have some investments and 0 otherwise. We can therefore deploy a double-hurdle model which allows a determination of both the level of investment (*lnI*) and the probability of investment. These models are used when studying bounded outcomes, such as investment. They are useful in this context as they provide two equations for the bounded and unbounded outcomes. They assume the unbounded outcomes are a result of clearing the initial hurdle, i.e. the decision to invest. When the hurdle is not cleared, bounded outcomes result, i.e. when a firm does not invest, the amount invested is fixed at zero. We therefore need to use an empirical approach that can deal with this issue. Using a hurdle model approach ensures that the binary investment stage (do firms invest?) can be modelled simultaneously with the second stage (the level of investment). In our analysis, we also use probit models to explore the probability of firms investing as a separate exercise.

In terms of the determinants of investment, the key variable of interest is ΔY_{it} which is the change in output between period t and $t-1$. This is the accelerator variable. In terms of additional control variables, we also include firm age (in year groups), firm size (in categories), the percentage of ownership that is held by foreign entities, whether the firm is an exporter, and the legal status of the firm.

$$lnI^{*}_{it} = \text{f}(size,\ age,\ sector,\ foreign,\ legal\ status,\ \Delta Y_{it},\ exporter,\ country,\ time)$$

These variables should control for the structure of enterprises in each of the countries and, by their inclusion as fixed effects, purge any variation in investment that could be a result of differential effects across groups of firms. As one of our key aims in this research is to explore the extent to which Irish firms are investing relative to similar peer firms, we include a full set of country-fixed effects alongside the general control variables. The coefficient on these variables should capture the residual variation that is left in the data for firms in each country that is unexplained by the enterprise-specific characteristics. Therefore if we see differences emerging for Ireland relative to other countries that are unexplained by the firm characteristics, then this is a clear sign that Irish firms are making capital expenditure choices in a different manner to similar firms abroad.

In our model, we estimate a probit approach and a double-hurdle model for both tangible fixed asset investment as well as investment in research and development. One final assumption must be made when deploying a double hurdle approach: an instrument must be included in the selection equation (binary decision to invest) that is not included in the second stage of the level of investment. Finding a variable that can satisfy this condition relating to firm investment is extremely difficult as these decisions are likely to be jointly determined. However, to satisfy this exclusion criterion, we draw on a question on the survey relating to the extent to which firms expend effort to meet their production targets. We assume that this is correlated with whether or not they invest, but not the level. We find it is significant in the first stage but insignificant in a simple equation on the second stage, thus we feel it can be deployed as an exclusion variable.

IV UNDERSTANDING INVESTMENT DYNAMICS

In this section, we present the results of the main analysis. We first present the estimates from both the probit model on the decision to invest and the hurdle model which captures both the level and the first stage. Our main coefficients of interest to understand the differences between Ireland and other countries are the dummy variables for each country. We test whether the sensitivity of investment to the output change accelerator is different in Ireland compared to other countries. All the results are presented separately for investment in tangible fixed assets and

research and development. Finally, we test whether financial factors and additional indicators for firm quality can explain some of the differences across countries.

4.1 Main Estimates and Differences Across Countries

Table 3 presents the marginal effects from the probit model for both the tangible fixed asset investment as well as research and development expenditure. It is clear that the key variable on the output accelerator is positive and significant in both cases. The main coefficient is 0.22 in the TFA regression (column 2) and 0.12 in the R&D regression (column 1); the sensitivity of investment to the output growth is higher for fixed capital than R&D. Looking across the other control variables which are presented to provide some understanding of the patterns across firms, we see that investment increases with firm size across both TFA and R&D (medium and large firm dummies are positive and significant relative to the reference category of small firms). There are no consistent impacts across firm age, but for TFA, mature firms appear to invest less than young firms. The marginal effect for exporting firms is positive and significant indicating that these firms invest in greater proportions than non-exporters. We also find notable statistically significant impacts across industries; focusing on TFA, relative to the reference category of industry, construction firms are more likely to invest and wholesale and retail firms less likely to invest; focusing on R&D, relative to industrial firms, construction, wholesale and retail firms, and hotels and restaurants all invest less frequently. It is clear that, even controlling for differences in output growth, heterogeneous investment patterns across groups of firms and industries are evident.

Table 3: Main Firm Characteristics – Marginal Effects Probits Model

	(1) – TFA		*(2) – R&D*	
ΔY_{it}	0.229***	(0.023)	0.125***	(0.019)
Medium	0.121***	(0.012)	0.093***	(0.011)
Large	0.233***	(0.016)	0.201***	(0.017)
Mature	–0.036**	(0.017)	0.008	(0.016)
Old	–0.001	(0.017)	–0.022	(0.016)
CRE	0.116***	(0.022)	–0.146***	(0.018)
W&R	–0.087***	(0.015)	–0.152 ***	(0.012)
H&R	0.019	(0.024)	–0.167 ***	(0.02)
Other	–0.032	(0.02)	–0.032*	(0.018)
Exporter	0.049***	(0.012)	0.219***	(0.011)
Foreign Owned	–0.000*	(0.000)	–0.000	(0.000)
Observations	8,941		8,941	
Legal Structure FE	Yes		Yes	

Source: Authors' calculations using WBES database.
Note: Standard errors in parenthesis; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4 presents the results from the hurdle model for the level of investment equation including the same set of covariates as included in the probit model. It must be noted that the coefficients are different in magnitude due to the dependent variable being a log level (rather than the binary probability in the probit approach). Similar findings can be seen with the direction and statistical significance of these variables. For the key output accelerator variable, it is positive and statistically significant in both equations for R&D and TFA. The magnitude of the coefficient is again larger for the TFA equation. In both equations, the level of investment is increasing with firm size: the dummies on medium and large categories are statistically significant and positive relative to the small firm reference category. Again, no notable differences are identified across firm age. Exporters have higher level investments than non-exporters for both R&D and TFA (both coefficients are positive and significant at the 1 per cent level). Differential patterns are again identified across sectors. For the level of TFA, the coefficient on construction and real estate is positive and significant indicating that firms in this sector have higher level investments than industrial firms; the coefficient on wholesale and retail firms is negative and significant indicating that these firms have lower value investments than those in industry, as do other service firms. For R&D, firms in all sectors except other services had statistically lower levels of investment than firms in the industrial sector. It is not unsurprising to find notable differences in capital structures across sectors as the production technologies are extremely different, with plant, machinery, buildings and other capital all having notable industry-specific requirements.

Table 4: Main Firm Characteristics – Marginal Effects Hurdle Model

	(1) – TFA		*(2) – R&D*	
ΔY_{it}	2.779***	(0.264)	1.240***	(0.199)
Medium	1.851***	(0.144)	1.097***	(0.111)
Large	3.998***	(0.214)	2.517***	(0.199)
Mature	–0.364*	(0.199)	0.111	(0.164)
Old	0.113	(0.203)	–0.142	(0.163)
Construction and Real Estate	1.276***	(0.261)	–1.425***	(0.186)
Wholesale and Retail	–1.212***	(0.175)	–1.578***	(0.12)
Hotels and Restaurants	0.020	(0.275)	–1.712***	(0.189)
Other services	–0.451*	(0.231)	–0.130	(0.196)
Exporter	0.776***	(0.144)	2.340***	(0.116)
Foreign Owned	–0.004*	(0.002)	–0.002	(0.002)
Observations	8,724		8,660	
Legal Structure FE	Yes		Yes	

Source: Authors' calculations using WBES database.
Note: Standard errors in parenthesis; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Having reviewed the key firm and economic characteristics, we turn our attention to the country-specific marginal effects. These are presented in Figures 8 and 9. They combine TFA and R&D charts from both models to keep each asset class separate. For all of the charts, we present the following information: the point estimate of the marginal effect (blue dot) and the 95 per cent confidence interval. The red dashed line indicates 0; if the confidence interval lies fully either side of the 0 line, there is a statistically significant effect identified. These marginal effects should be interpreted as indicating whether the probability, or level, of investment is statistically significant and different from the level seen in Ireland. Each country effect is presented as a row on the chart.

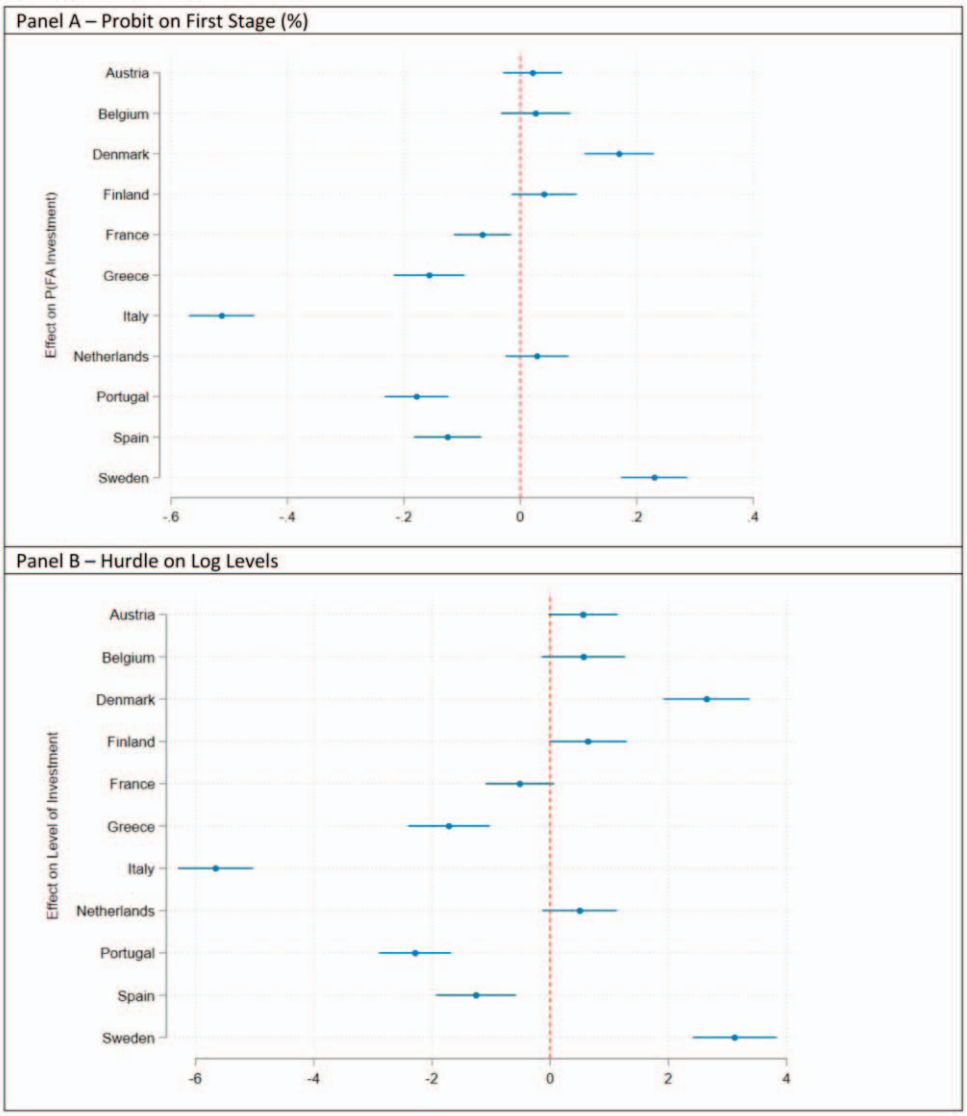
In Figure 8, we present the marginal effect of each of the country dummies relative to the base category of Ireland for the probit and hurdle models. For the probit model (panel A), only Denmark and Sweden have statistically significant and positive coefficients, meaning higher investment rates. Indeed, Ireland is similar to Austria, Belgium, France and the Netherlands in that no statistically significant difference is identified. France, Greece, Italy, Portugal and Spain have negative and significant country effects indicating firms in those countries have a lower probability of investing relative to Irish firms. Focusing on the hurdle model output (panel B), a similar picture emerges. Firms in Denmark and Sweden clearly have a higher investment probability, however the marginal effects for Austria and Finland are also positive and significant. Ireland again has higher investment levels as compared to France, Greece, Italy, Portugal and Spain.

In Figure 9, we present the marginal effect of each of the country dummies relative to the base category of Ireland for the probit and hurdle models focusing on R&D expenditures. There appears to be a clearer set of findings emerging, with a broader group of countries having higher investment probabilities in R&D investment than Irish enterprises. More specifically, firms in Austria, Belgium, Denmark, France, Netherlands and Sweden all had statistically significant and higher investment probabilities than firms in Ireland. Investment probabilities were statistically significantly lower in Italy and Portugal than in Ireland. A similar finding emerges in relation to the hurdle model on the log levels. Irish firms have statistically lower levels of investment than firms in Austria, Belgium, Denmark, Netherlands and Sweden.

4.2 Are There Different Capital Sensitivities?

One factor possibly explaining some of the differences outlined in the section above could be a different relationship between firm fundamentals in Ireland and other countries. For example, given the country-specific factors in each jurisdiction, firms may react differently in terms of their capital choices as their enterprises grow or shrink i.e. as fundamentals change, firms may not respond the same way across countries. To test this particular possibility, we re-estimate both of the models above

Figure 8: Marginal Effects – Tangible Fixed Assets



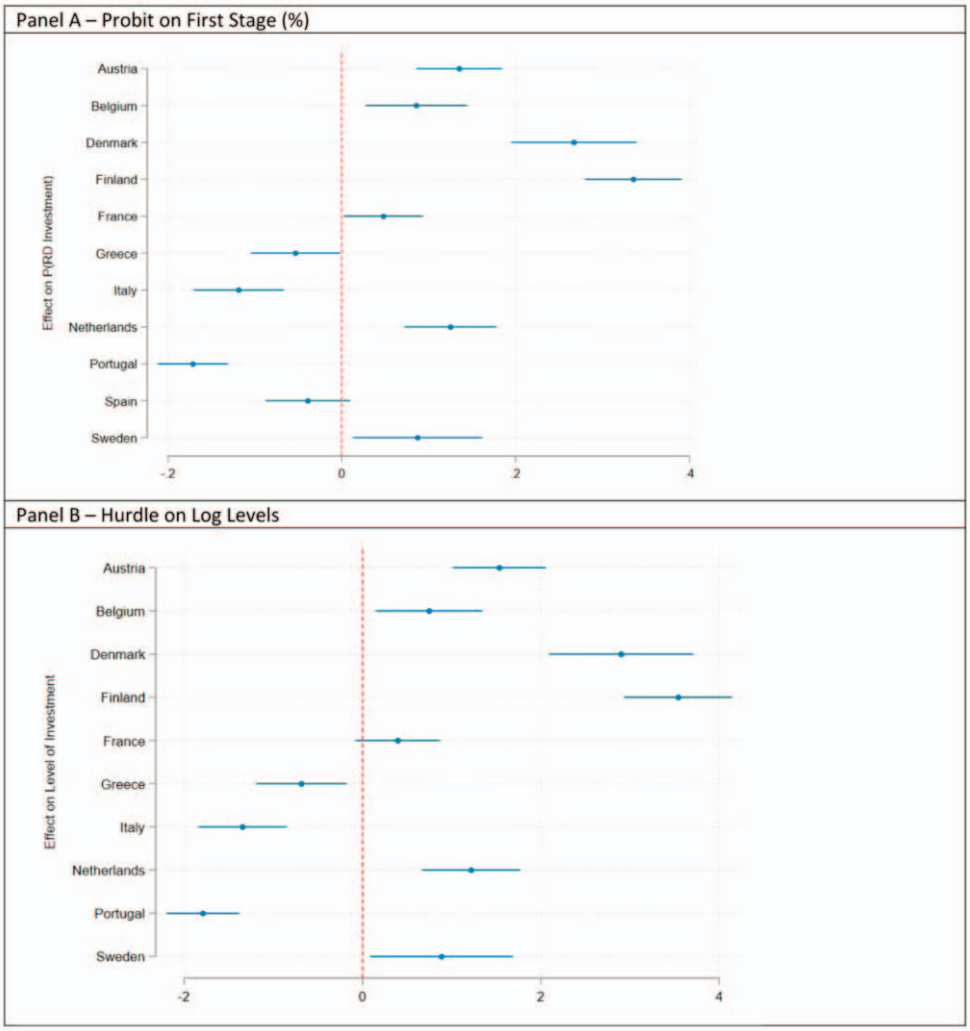
Source: Authors' calculations using WBES database.

but instead of country dummies, we include an Ireland-only dummy. We then interact this dummy with the output accelerator (ΔY_{it}):

$$lnI^{*}_{it} = f(\boldsymbol{X}, \Delta Y_{it}, IE, \Delta Y_{it} \chi IE)$$

where $\boldsymbol{X}$ is the vector of firm controls as previously deployed. The interaction term allows us to explore how different Ireland is relative to the other countries. We can

Figure 9: Marginal Effects – Research and Development



Source: Authors' calculations using WBES database.

then determine the marginal effect of the output accelerator for Irish and non-Irish firms. If there are notable differences in this sensitivity, it will provide important insights into whether Ireland's enterprises react differently to growth. We undertake this exercise for both the research and development investment and tangible fixed asset investment across the binary (probit) and level models (hurdle). The results for the binary model are presented in Table 5. Focusing first on the coefficient of the accelerator for tangible fixed assets, it is clear Irish firms' sensitivity is similar to other countries; a 1 per cent increase in sales growth leads to a 0.24 per cent increase in investment probabilities in Ireland whereas the effect is only 0.22 for other countries. A clear difference arises in relation to the sensitivity of R&D

investment to sales growth. For the Irish enterprises, no statistically significant effects are found while for other countries the sensitivity is 0.12; a 1 per cent increase in output growth leads to a 0.12 per cent increase in the probability of investment. It is notable that the sensitivity is lower for R&D than for TFA. As R&D is riskier in terms of risk-returns, it is not unsurprising that enterprises are slower to expand spending on this type of capital as they grow. However, it is very noticeable that Irish enterprises do not appear to have an established statistical link between fundamentals and R&D investment propensity.

Table 5: Sensitivity of Sales Growth to Investment – Binary Probit Model

	(1) – TFA	*(2) – R&D*
ΔY_{it}		
Other Countries	0.227***	0.127***
	(0.023)	(0.020)
Ireland	0.243***	0.096
	(0.078)	(0.078)
Observations	8,941	8,941

Source: Authors' calculations using WBES database.
Note: Standard errors in parenthesis; * p < 0.1, ** p < 0.05, *** p < 0.01.

The results for the level of investment are presented in Table 6. Focusing first on the coefficient of the accelerator for tangible fixed assets, as was the case for the binary probit model, it is clear Irish firms' sensitivity is similar to other countries; both coefficients are statistically significant at the 1 per cent level and the magnitude is similar (2.7) for each. However, a clear difference exists with the sensitivity to the sales growth for the R&D level model. The coefficients for both Ireland and the other countries are statistically significant at the 1 per cent level and positive. The coefficient for Irish firms is in fact larger than that for other countries suggesting that when Irish firms do invest, the reaction to a unit change in sales growth is higher than that for other countries.

Table 6: Sensitivity of Sales Growth to Investment – Hurdle

	(1) – TFA	*(2) – R&D*
ΔY_{it}		
Other Countries	2.775 ***	1.233 ***
	(0.265)	(0.199)
Ireland	2.819 ***	1.361 ***
	(0.308)	(0.226)
Observations	8,724	8,660

Source: Authors' calculations using WBES database.
Note: Standard errors in parenthesis; * p < 0.1, ** p < 0.05, *** p < 0.01.

The analysis in this section has clearly indicated that Irish enterprises have similar sensitivities to output growth for tangible fixed assets relative to other countries i.e. if changes in output growth illicit similar reactions in terms of capital spending for Irish and other country enterprises. However, differences exist for research and development expenditure: first, we do not find any statistical link for Irish firms between output growth and R&D investment propensity (Table 5). This is likely an explanatory factor for the lower investment propensities seen in the section above; second, we find that the sensitivity is somewhat higher for Irish firms in terms of the level of investment i.e. when Irish firms do invest, the relationship between their growth and the level of spending on R&D is higher for Ireland than other countries.

V EXPLAINING DIFFERENCES ACROSS COUNTRIES

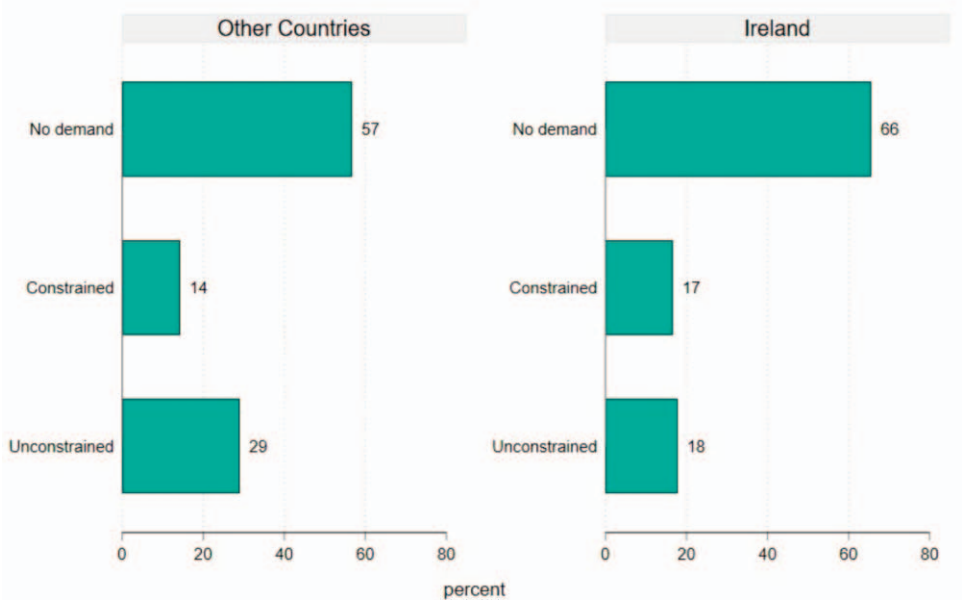
In this section, we attempt to provide a more detailed explanation of some of the cross-country patterns that we observed in the preceding sections. We do this by attempting to explain more of the variation than we have thus far been able to. Our method is to append additional controls to the firm-specific regressions and explore the extent to which the observed cross-country coefficients change with the inclusion of these additional factors. The first set of variables we include are those relating to financing factors, which have been shown in a multitude of studies to impact investment activity. The second set of variables are additional factors that might affect the quality of the firm which are not captured by the initial parsimonious output accelerator model.

5.1 Are Financial Frictions A Problem?

The existing literature suggests a range of financial factors that impact investment. Most prominent is direct access to credit (Gerlach-Kristen *et al*., 2015; Martinez-Cillero *et al*., 2020) and the second factor is indebtedness (Lawless *et al*., 2015). To measure these various factors, we include a range of indicators. First, we include the debt-to-income ratio as in Lawless *et al*. (2015) to capture how investment is affected by the debt overhang channel. We include this variable as a polynomial to capture any non-linear effects of extremely indebted firms. Second, we include an indicator on direct access to credit drawing from those firms who applied for credit. This variable allows us to group firms in the following manner: a) those firms who did not apply for credit and indicated they did not need a loan (classified as having no demand); b) those firms who applied for credit but were refused or those firms who did not apply as they feared rejection (constrained firms); and c) those firms who applied for and were granted credit (unconstrained). The summary statistics for this indicator are presented in Figure 10. While there do not appear to be major differences in the share of constrained firms in Ireland relative to other countries

(14 to 17 per cent) it is clear the level of credit demand is lower in Ireland as compared to other countries.

Figure 10: Credit Constraints



Source: Authors' calculations using WBES database.

To ensure we are sufficiently controlling for financial factors, we saturate the model with additional indicators. We include the following: an indicator for whether the firm has existing term loans and the number of loans, and we control for whether the firm has an overdraft. In terms of the latter variable, it is not necessarily our aim to link firms' overdrafts to investment, rather we are attempting to control for those firms who have limited access to finance in general and are therefore using these variables as a screener. The results of the marginal effects estimates from both the probit and the hurdle model for the financial factors are presented in Table 7. Also included are all the variables included in the above regressions (firm age, size, sector, exporting status, firm ownership etc).

Comparing across the various models, it is clear the results differ between the TFA and R&D regressions. Considering TFA findings in the first instance, it is clear that constrained firms invest less than those which are unconstrained or those with no credit demand: the coefficient on the variable is negative and significant. Unconstrained firms are the most likely to invest. These findings hold across both the binary propensity to invest model but also the hurdle model on the log levels. It is also clear that firms with more open lines of credit have a higher propensity and level of investment which is in line with the theory that looser credit conditions

Table 7: Financial Factors

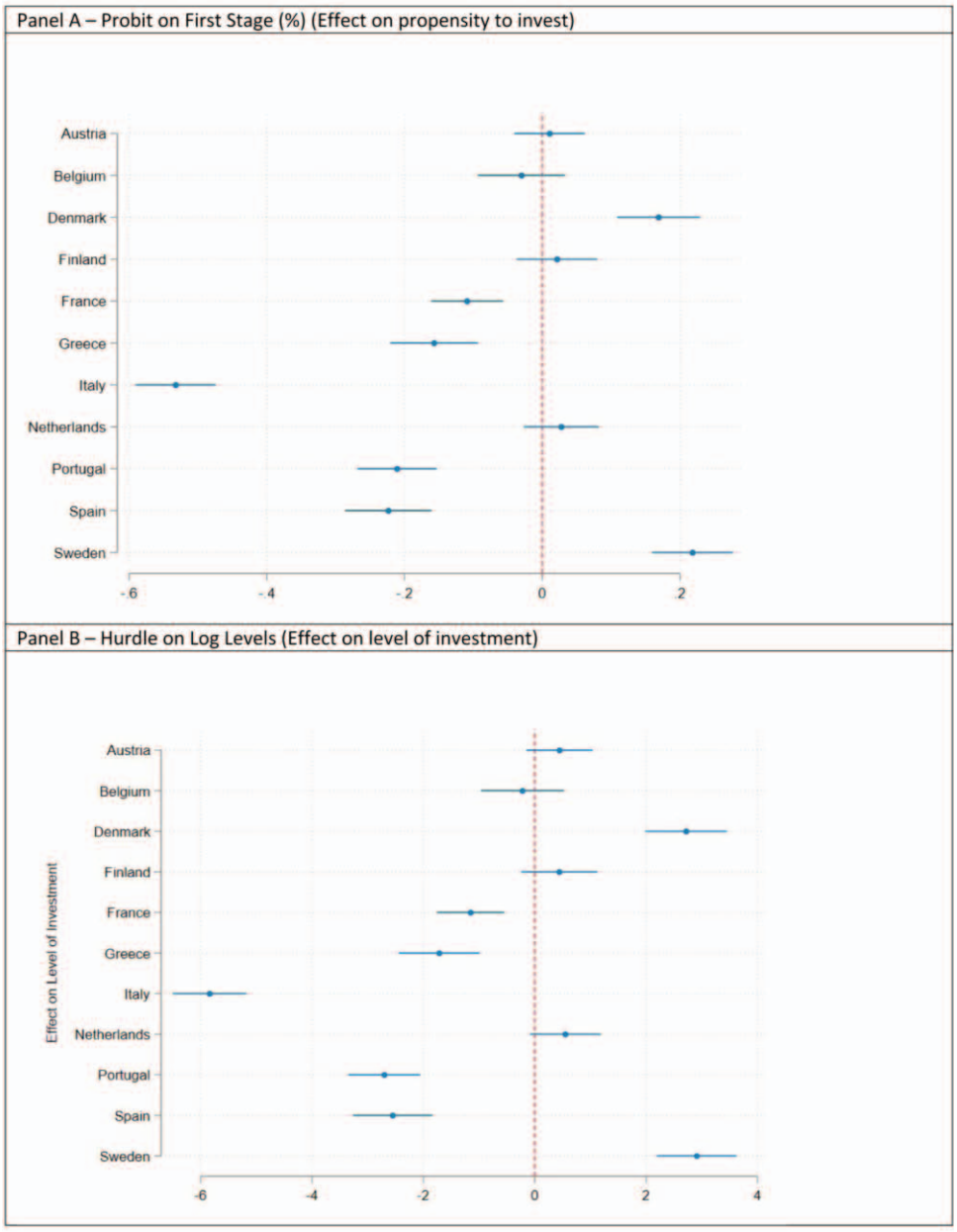
	(1) TFA – Probit	*(2) TFA – Hurdle*	*(3) R&D – Probit*	*(4) R&D – Hurdle*
Constrained	–0.039**	–0.551***	0.024	0.294*
	(0.018)	(0.207)	(0.016)	(0.169)
Unconstrained	0.131***	1.654***	0.034**	0.363**
	(0.016)	(0.188)	(0.015)	(0.151)
Number of Credit Lines/Loans	0.015***	0.212***	0.001	0.029
	(0.003)	(0.037)	(0.002)	(0.025)
DTI	–0.137***	–1.226**	0.041	0.625
	(0.047)	(0.553)	(0.039)	(0.407)
Overdraft	–0.026**	–0.357**	0.012	0.059
	(0.013)	(0.150)	(0.011)	(0.120)
Term Loans	0.013	0.165	0.016	0.077
	(0.017)	(0.198)	(0.015)	(0.156)
Observations	8,103	7,931	8,103	7,870

Source: Authors' calculations using WBES database.
Note: Standard errors in parenthesis; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

help investment expenditure. Firms with overdrafts appear to invest less, however there is likely to be a considerable correlation between this indicator and the number of loans. In terms of the indebtedness, the DTI (debt-to-income) variable is negative and statistically significant which indicates that highly indebted firms have a lower level of investment. This is consistent with the debt overhang literature as in Lawless *et al*. (2015). Moving to the findings for R&D, we do not find significant effects for the majority of financial factors. We do find that unconstrained firms have the highest investment levels but financial factors do not appear to be as major a barrier for investment in R&D relative to TFA.

While the estimates above apply to the overall sample, the aim of this section is to test whether the observed differences across countries could be explained at least partially by cross-country differences in financial factors. To explore whether this is the case, we extract the country-specific marginal effects from the regressions including the broad suite of financial factors. If we see any discernible differences as compared to the parsimonious specification outlined in the accelerator section above, this can provide evidence that financial factors are part of the cross-country explanations. The effects for TFA are presented in Figure 11. It is clear that financial factors can explain some of the differences across countries as now the only firms which have notably different effects for both the level and the hurdle model are Sweden and Denmark. This highlights the importance of differences in financial conditions for firm-level investment activity, in particular for expenditures on tangible fixed capital which are often reliant on external financing to fund.

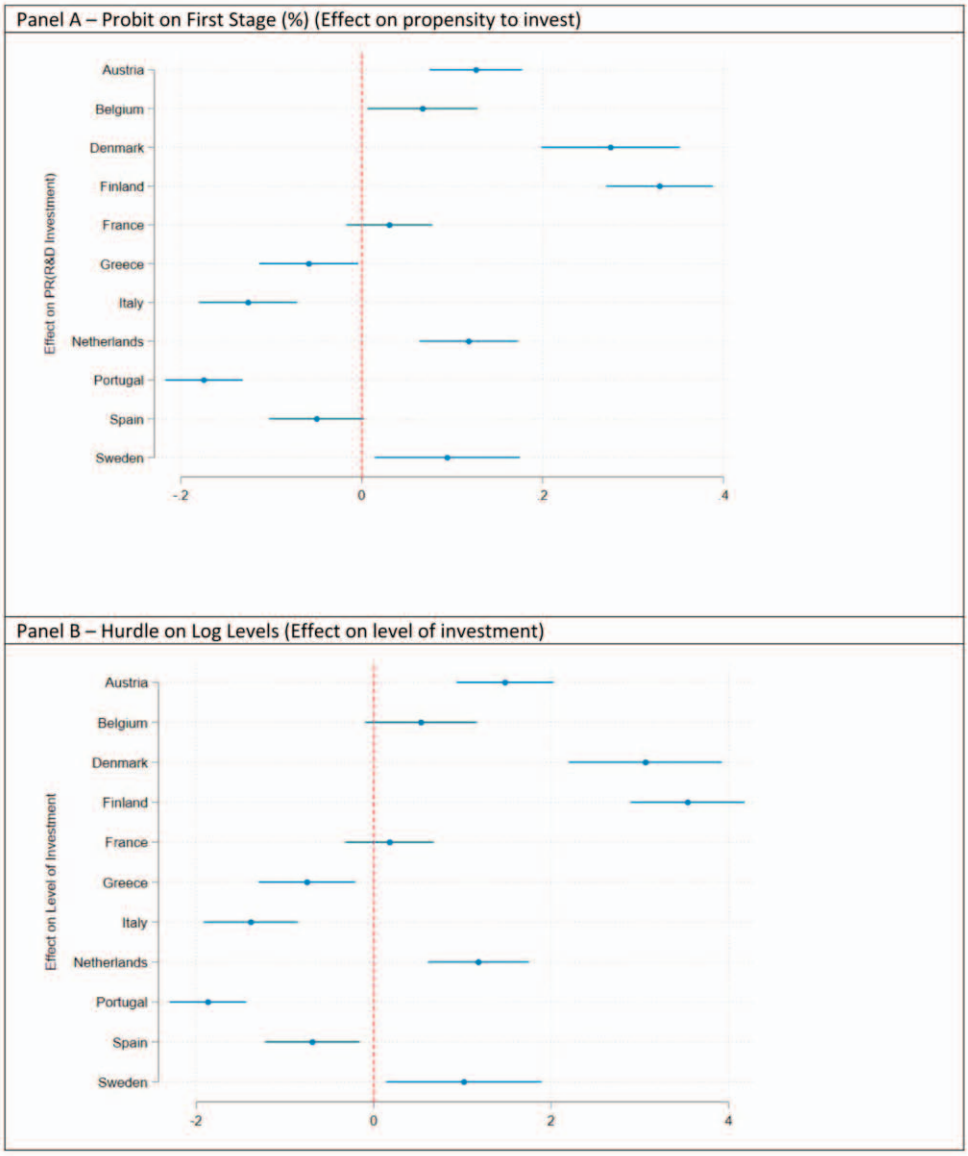
Figure 11: Marginal Effects – Tangible Fixed Assets with Financial Factors



Finally, we undertake a similar exercise for the country differences in R&D investment. The effects are presented in Figure 12. Financial factors do not appear to explain the differences compared to the high investing countries: the patterns identified earlier as the country-specific marginal effects appear to be similar in

both the binary probit models and the hurdle on the log levels, with Austria, Denmark, the Netherlands and Sweden having higher investment activity. It does appear to explain some of the lower investment in countries like Greece and Spain in terms of the probability of investing in R&D as the differences with Ireland are now insignificant.

Figure 12: Marginal Effects – R&D with Financial Factors



Source: Authors' calculations using WBES database.

5.2 Are We Controlling For Firm Quality?

While the output accelerator term included in the baseline specifications is aimed at capturing firm fundamentals, there may be other aspects of the quality of the firm that impact its investment but are not captured in this variable. This is a specific concern in relation to our research, as we do not have panel data which allow treatment of firm-specific time-invariant heterogeneity. The type of factors that we are pointing towards here are the quality of the decision making, the digitalising of the firms, the integration into international networks, and the operating profitability of the enterprise. To this point, these omitted variables are likely to be biasing the coefficients, including the country dummies. To attempt to address these considerations, we include the following indicators: the number of years' experience of the top manager; the operating margin of the firm; the domestic share of sales to capture internationalisation; whether the firm has a website as a basic digitalisation indicator; and whether the firm uses foreign technology in the production process, to capture the quality of the production activity. The variables are outlined in Table 8.

Table 8: Additional Quality Indicators

Manager Experience	The number of years experience of the top manager
Operating Margin	(Revenue - Operating Cost)[3] over Revenue
Dom Sales Share (%)	Percentage of revenues earned in the domestic market
No Website	Firm does not have a website
No Foreign Tech	Firm does not use foreign technology in its production processes

Source: Authors' calculations using WBES database.

The results of the regressions including these variables, along with the financial factors, firm controls and country dummies, are presented in Table 9. Neither managerial experience nor operating margins are statistically significant across any of the regressions presented. The variables relating to internationalisation (domestic share of sales), having a website and using foreign technology are all negative and significant in the research and development regressions. These findings suggest that domestic focused firms, those without basic digital offerings and those not relying on foreign technology, are less likely to invest in research and development. Even if they do invest, the level of investment will also be lower. This is a notable finding and indicates support for digitalisation and internationalisation.

[3] Operating costs are proxied using wages and salaries, utilities, fuel, communications services and raw materials costs.

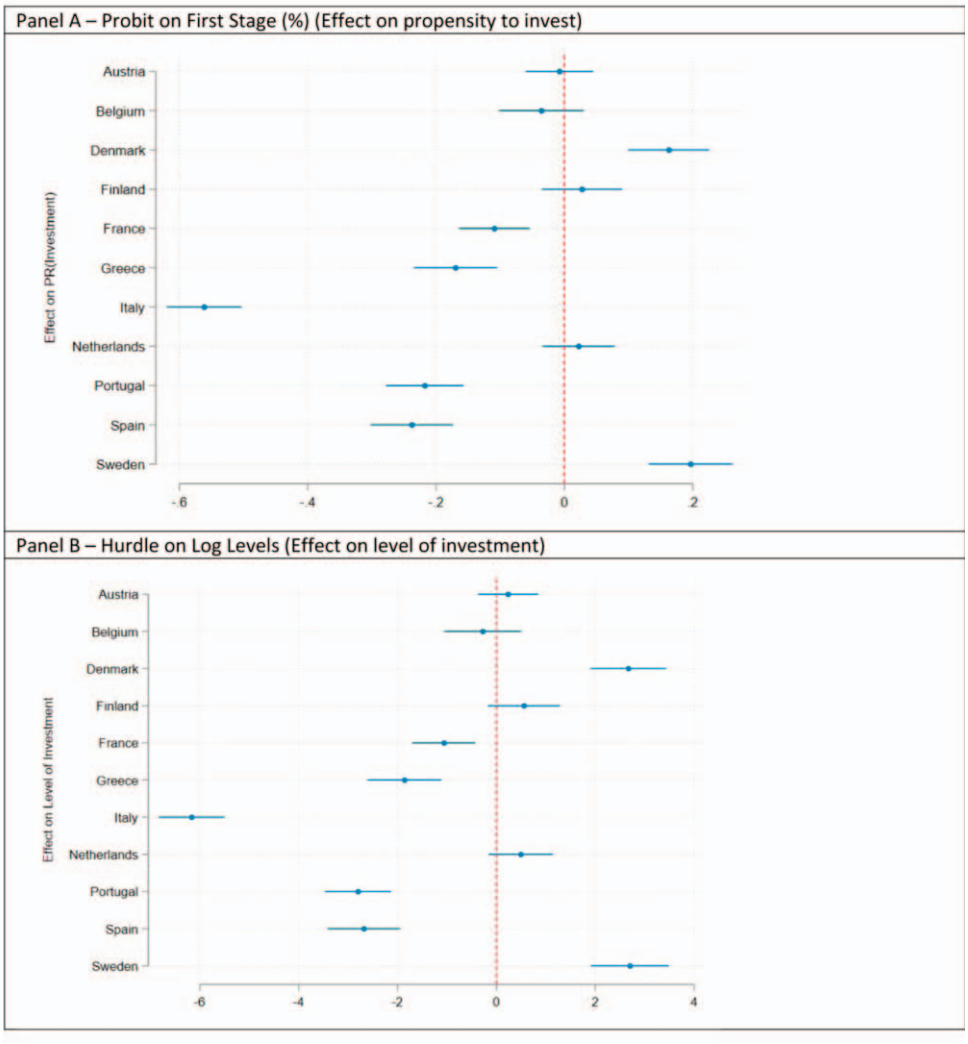
Table 9: Additional Firm Quality Controls

	(1) TFA – Probit	*(2) TFA – Hurdle*	*(3) R&D – Probit*	*(4) R&D – Hurdle*
Years Experience of Top Manager	–0.000 (0.001)	0.000 (0.006)	–0.001 (0.000)	–0.007 (0.005)
Operating Prof Margin	0.002 (0.015)	0.191 (0.183)	0.005 (0.013)	0.129 (0.132)
Per Cent of Sales: National Sales	0.000 (0.000)	–0.001 (0.003)	–0.002*** (0.000)	–0.020*** (0.002)
No Website	0.035* (0.020)	0.457* (0.236)	–0.096*** (0.017)	–1.013*** (0.179)
No Foreign Tech	–0.092*** (0.017)	–1.127*** (0.196)	–0.089*** (0.016)	–0.900*** (0.164)
Constrained	–0.044** (0.019)	–0.595*** (0.221)	0.024 (0.017)	0.265 (0.177)
Unconstrained	0.136*** (0.017)	1.690*** (0.199)	0.035** (0.015)	0.375** (0.157)
No. Credit Lines/Loans	0.014*** (0.003)	0.194*** (0.039)	0.001 (0.003)	0.022 (0.026)
DTI	–0.125** (0.050)	–1.007* (0.589)	0.016 (0.041)	0.404 (0.423)
Overdraft	–0.021 (0.014)	–0.308* (0.159)	0.005 (0.012)	–0.03 (0.126)
Term Loans	0.008 (0.018)	0.125 (0.210)	0.018 (0.016)	0.106 (0.163)
Observations	7,222	7,103	7,222	7.055

Source: Authors' calculations using WBES database.
Note: Standard errors in parenthesis; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

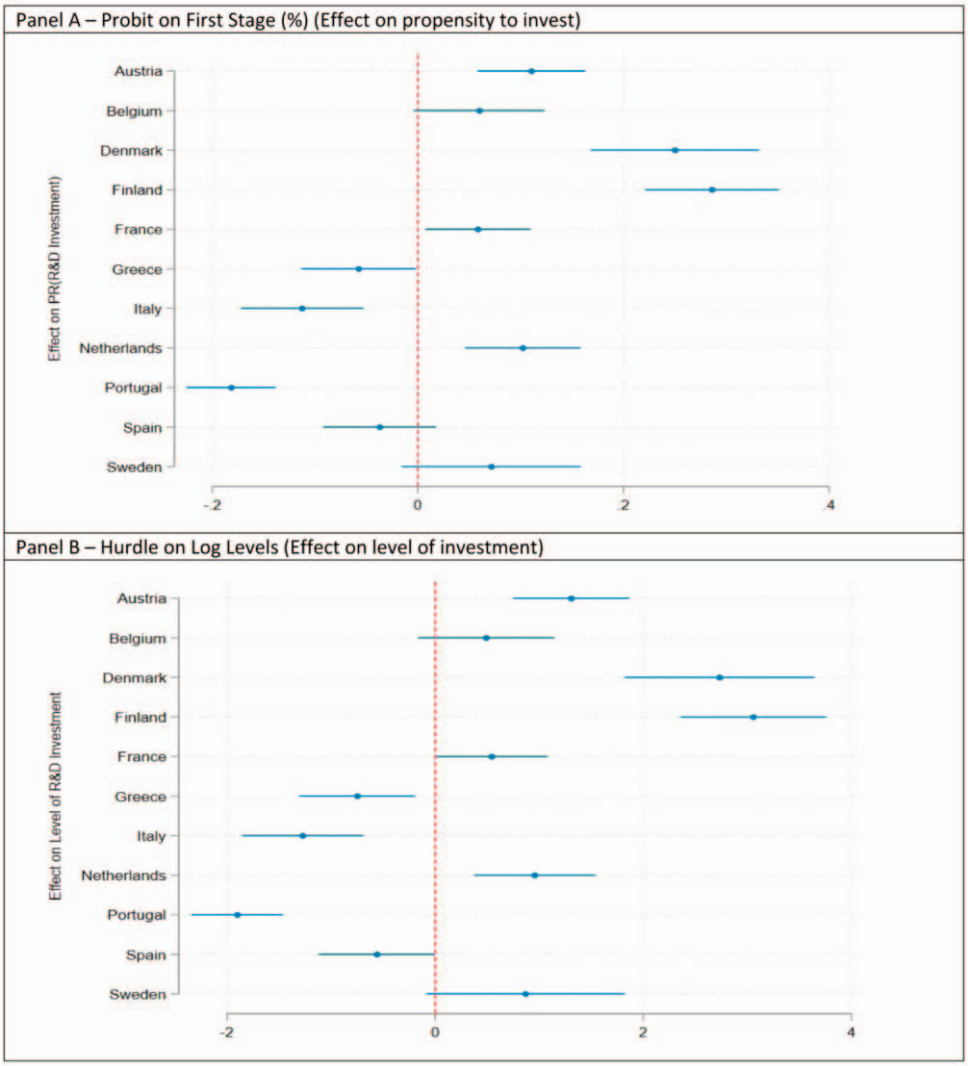
As in the previous section, we test whether the observed differences across countries could be explained at least partially by cross-country differences in these quality factors. Again, we extract the country-specific marginal effects from the regressions including the broad suite of quality indicators with the financial factors and other controls. The aim is to explore if the country differences change with the inclusion of these indicators. The effects for TFA are presented in Figure 13. While in the previous section, financial factors were found to explain some of the differences across countries, this is not the case with the additional quality factors as the previous relativities were maintained.

Figure 13: Marginal Effects – Tangible Fixed Assets With Quality and Finance Factors



Again as before, we undertake a similar exercise for the country differences in R&D investment. The effects are presented in Figure 14. While financial factors were not found to be major barriers to R&D, these variables do appear to explain some of the observed differences. While a broader group of countries were identified as having higher R&D investment than Ireland, some of these differences are not evident following the inclusion of these factors. For example, the differences between Sweden and Belgium relative to Ireland are now no longer statistically significant. These findings indicate the importance of internationalisation and digitalisation for research and development expenditure patterns across countries.

Figure 14: Marginal Effects – Tangible Fixed Assets With Quality and Finance Factors



Source: Authors' calculations using WBES database.

VI A COUNTERFACTUAL LEVEL OF IRISH FIRM INVESTMENT

Having explored the differences between firms in Ireland and other countries, and tested the difference in sensitivities, an interesting exercise is to produce a counterfactual estimate of investment for Irish firms if they were to invest in line with other countries' sensitivities and their own characteristics. To undertake this

counterfactual, we estimate the regressions on the sample of countries with Ireland excluded. We also exclude the country dummies to allow the sensitivities pick up only variation in the firm-level variables included in each regression. We then produce the following model-based prediction to show an estimate of what a counterfactual Irish investment level would be if Irish firms behaved as the firms in other countries do, given their own characteristics:

$$\widehat{lnI^{*}_{it}} = f(X_{i,IE}\beta_{nonIE})$$

In this analysis, we take the NE group as a benchmark, as these countries are likely to be similar to Ireland in terms of economic structures and patterns of economic development. We also find that this group posts higher investment activity across some of the assessments above, therefore it is useful to draw on these countries in this exercise. We present two sets of counterfactual predictions; one based on the simple accelerator model and the second based on the saturated model with both the financial factors and the quality indicators. In all of our counterfactual specifications, we present the data for the overall sample, but we also explore the differences across some key firm groups to understand whether heterogeneous effects are present. We present the differences for firm sector, size groups, age categories and firm ownership (foreign-owned versus domestic firms).

The findings for tangible fixed assets are presented in Table 10 for the binary probit predictions. There is no major difference overall between the actual data and

Table 10: Predicted Versus Actual – Tangible Fixed Assets – Share of Investing Firms

	Actual %	*CF 1: Accelerator %*	*CF 2: A+FF+Q %*
Overall	57	61	59
Industry	64	67	66
Construction & Real Estate	79	74	69
Wholesale and Retail	48	56	54
Hotels and Restaurants	48	56	54
Other services	59	59	61
Young	52	58	56
Mature	55	58	57
Old	62	66	64
Small	50	56	55
Medium	69	68	67
Large	76	77	81
Domestic	56	61	59
Foreign	65	64	70

Source: Authors' calculations using WBES database.
Note: CF – Counterfactual, A+FF+Q – Accelerator with financial factors and quality indicators.

the predicted levels; the accelerator model suggests a slightly higher probability of investment, but this finding drops away as variables for financing and quality are included. However, we do find some interesting patterns across the different groups of enterprises. On the one hand, we find that Irish construction firms are actually more likely to invest than they would be predicted to under both counterfactuals: the second counterfactual is nearly 10 percentage points lower than the actual data. On the other hand, we find that Irish wholesale and retail, as well as hotels and restaurants sectors, are underinvesting relative to what would be predicted. Irish young firms are investing less than predicted; i.e. the counterfactual investment propensities are higher than the actual Irish data. Small Irish firms are also underinvesting relative to the comparison groups. Focusing on the difference between foreign and domestic firms, both groups have higher investment propensities in the counterfactuals than the actual when compared to all countries.

The results for the predictions using the hurdle model on the level of investment in tangible fixed assets are presented in Table 11. It must be noted that the level of investment predictions is calculated for those firms who reported actual investment i.e. firms with no capital expenditure were excluded from the calculations. Therefore they must be considered in the context of the above patterns (smaller, younger firms being less likely to invest in general). The median level of the actual investment and the median level of the counterfactuals are presented. Across both of the counterfactuals, we find a notable investment gap i.e. the Irish firm

Table 11: Predicted Versus Actual – Tangible Fixed Assets – Level of Investment

	Actual	*CF 1: Accelerator*	*CF 2: A+FF+Q*
Overall	44,000	66,018.02	61,450.17
Industry	56,000	14,9075.60	122,852.10
Construction & Real Estate	35,000	50,928.39	47,901.50
Wholesale and Retail	35,000	48,179.28	45,730.96
Hotels and Restaurants	25,000	47,789.94	43,580.02
Other services	70,000	74,683.33	74,497.09
Young	25,000	43,191.13	37,689.69
Mature	50,000	68,157.19	65,661.25
Old	50,000	75,044.59	74,859.59
Small	30,000	46,004.39	43,580.02
Medium	75,000	124,563.70	124,869.60
Large	300,000	533,579.10	626,380.00
Domestic	42,000	62,225.07	60,175.70
Foreign	150,000	248,201.50	223,500.60

Source: Authors' calculations using WBES database.
Note: CF – Counterfactual, A+FF+Q – Accelerator with financial factors and quality indicators.

investment under the counterfactual was much higher than the actual data. The median investment level is approximately 44,000 whereas the predicted investment is over 60,000 in both scenarios. There are notable differences across groups of firms. In terms of the predicted versus actual investment, the industrial sectors had the highest gap along with the hotels and restaurants sector. Firms in the other services sector are the closest in terms of the gap between actual and predicted. Foreign firms posted a larger gap than domestic firms in terms of the level of investment which is notable as the FDI sector in Ireland is traditionally a high-investment sector, dominated by extremely large firms. However, as these are median predictions it might be the case that the largest FDI firms are still investing extremely large amounts, but the smaller FDI firms are not investing as would be expected given their characteristics.

Having reviewed the figures in relation to tangible fixed assets (TFA), the data for research and development are presented below. As was the case with TFA, the probability of investment counterfactuals is presented in Table 12 while the predictions for the level of investment are presented in Table 13. Beginning with the counterfactuals for the propensity to invest, the baseline predicted counterfactual indicates that investment is approximately considerably lower in actual terms than the counterfactual; 15 per cent of Irish firms actually invested in R&D whereas the counterfactual predictions were 21 per cent and 22 per cent respectively. Considerable variation exists across sectors with the biggest investment gap (where the prediction is higher than the actual) being in the other services sector and industrial sectors. Indeed, the R&D propensity for hotels and restaurants was lower in the counterfactual than the actual data. Construction and wholesale and retail service firms are also identified as having a small gap. The gap is smaller for young firms as compared with older firms. This is not unexpected as younger firms are often dynamic and more welcoming of risky investments in the early part of their lifecycle. Large firms have a larger gap than smaller firms. Indeed, what is quite noticeable is that foreign firms have a larger expected propensity than domestic firms but the gap between the actual and predicted is larger for foreign-owned enterprises.

Finally, we present the counterfactual investment predictions for the level of R&D investment, for those companies which actually invested in R&D. While again we identify large investment gaps where the predicted investment is well below the actual level, some notable differences emerge in terms of the firm groups. We find the largest gaps for domestic firms and small- and medium-sized firms. Indeed, foreign firms and firms in the other services sector (which includes IT firms) are invested considerably more than would be predicted by the model, as are large firms. This is likely to reflect the high productivity, dynamic firms that Ireland has in some of the computer services and other IT sectors which are extremely small in terms of the number of firms, but they make very large investments when deploying R&D capital. Industrial firms and hotels and restaurants have large gaps, whereas

construction and wholesale and retail firms are investing more than in the counterfactual.

Table 12: Predicted Versus Actual – Research and Development – Percentage of Investors

	Actual %	*CF 1: Accelerator %*	*CF 2: A+FF+Q %*
Overall	15	21	22
Industry	33	43	41
Construction & Real Estate	9	13	13
Wholesale and Retail	11	14	14
Hotels and Restaurants	12	10	10
Other services	18	34	35
Young	13	16	17
Mature	18	24	24
Old	14	21	21
Small	11	17	16
Medium	22	27	28
Large	27	46	49
Domestic	15	20	21
Foreign	31	42	44

Source: Authors' calculations using WBES database.
Note: CF – Counterfactual, A+FF+Q – Accelerator with financial factors and quality indicators.

Table 13: Predicted Versus Actual – Research and Development – Level of Investment

	*Actual**	*CF 1: Accelerator*	*CF 2: A+FF+Q*
Overall	25,000	40,083	35,158
Industry	30,000	40,083	35,158
Construction & Real Estate	40,000	17,791	16,682
Wholesale and Retail	20,000	11,024	11,876
Hotels and Restaurants	5,000	90,519	87,397
Other services	150,000	74,683	74,497
Young	25,000	27,710	19,790
Mature	22,000	40,083	35,158
Old	50,000	65,091	67,468
Small	10,500	24,561	17,728
Medium	32,000	90,519	67,468
Large	300,000	295,402	291,377
Domestic	22,000	40,083	35,158
Foreign	300,000	139,767	197,965

Source: Authors' calculations using WBES database.
Note: CF – Counterfactual, A+FF+Q – Accelerator with financial factors and quality indicators. *Rounded to the nearest euro.

A number of findings emerge from this section. Based on conducting counterfactual scenarios using other countries' coefficients and Irish enterprises' data, we find the share of Irish enterprises investing in tangible fixed assets is close to what would be expected under the scenarios, with some slight investment gaps for young, small firms, especially those in wholesale, retail and hospitality. However, we find that the level of investment is lower than we see in the counterfactual, with effects across most sectors and firm groups. Focusing on the gaps for research and development, we find generally in terms of the propensity to invest, there is a general investment gap but it is larger for industrial enterprises. For those firms who do invest, in level terms, we find the largest gaps for domestic firms and small- and medium-sized firms. Indeed, foreign firms, and firms in the other services sector (which includes IT firms), are investing considerably more than would be predicted by the model as are large firms.

VII IS R&D REALLY LOW? A DISCUSSION OF THE ECONOMIC AND POLICY IMPLICATIONS

In the preceding analysis, we have identified a lower level of R&D investment for Irish firms relative to other countries. We have found that this effect occurs for domestic enterprises relative to foreign firms, with foreign firms in Ireland investing more than would be predicted by the model. These findings raise a number of pertinent questions that relate to the broader debate on the performance of indigenous firms and the particular structure of the Irish economy which is dominated (in output terms) by a small number of very large multinational enterprises. In particular, the findings pose the question as to whether the low R&D investment is due to a low investment appetite, low productivity or a related issue such as a crowding-out effect whereby the multinationals squeeze out domestic enterprises and this lowers their R&D (and likely productivity, performance and survival)? This also poses questions as to what the optimal level of R&D is in a small open economy like Ireland and what should the design of the policy response be. While any causal determination of the impact of MNEs on domestic firms is outside the scope of this paper, this section attempts to contextualise our research within the broader debate regarding Irish firm research and development expenditure, the economic impact of the R&D underspend, as well as providing some insight for policy.

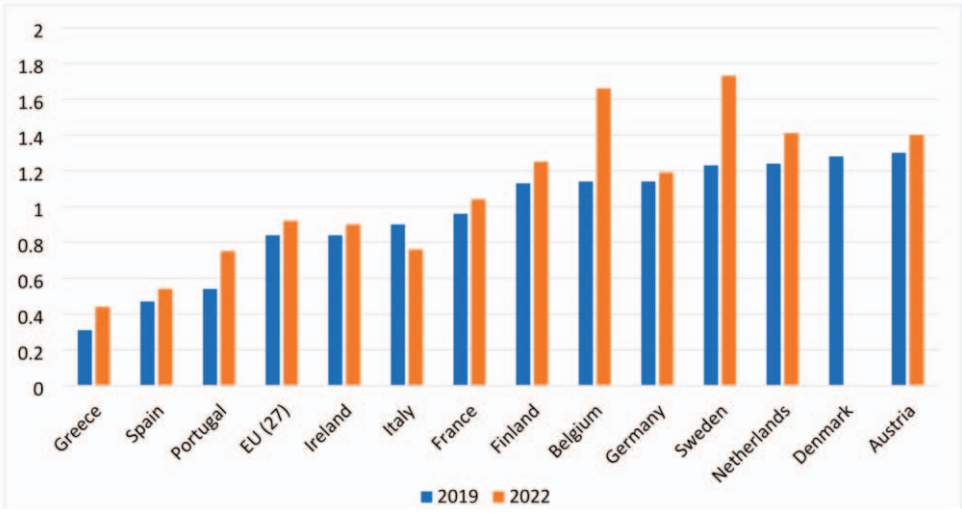
To begin this section, we first attempt to triangulate our findings with additional data at the aggregate level. This is important to explore whether the underinvestment is economy wide, pointing to a broader macroeconomic challenge or whether it is purely a distributional issue across firms. If the underinvestment is not an aggregate issue, then the economic impacts are likely to be lessened and the risks are more to

do with whether R&D is concentrated with multinationals and thus exacerbate any economic risks from a downturn in MNC investment.[4]

To capture the aggregate level of R&D activity, including both multinational and other firms, we draw on Eurostat data on the proportion of the labour force in research and development roles. While the labour share in R&D differs from our investment variable in the previous section, given the potential distortionary effects from using value measures scaled by GDP, we feel the employment measures are a better indicator of actual R&D. The National Competitiveness and Productivity Council (NCPC) notes Ireland has a low level of R&D expenditure relative to both GNI and GDP as compared to the European average and the OECD average, so exploring the employment effects can back this up.

In Figure 15, it can be seen that for both 2019 and 2022 (pre and post the pandemic), Ireland has a low employment share in R&D roles relative to the other countries. This finding is in line with our own research. As this indicator below captures both multinationals and indigenous firms, this does provide some supportive evidence of an underinvestment.

Figure 15: Proportion of the Labour Force in R&D Employment



Source: Eurostat.

Given these data, our own research, and the findings of the NCPC (2023) questions arise as to what the economic cost of lower R&D is and what the optimal level of R&D should be in the Irish economy. In terms of the first aspect, there is an extensive literature which considers the direct benefit of R&D spend on innovation and productivity growth. In terms of explaining the link between

[4] We thank an anonymous referee for suggesting a discussion of these channels.

productivity and innovation at the firm level, a very large literature has developed which explicitly tries to link innovation expenditures through innovation outputs to productivity. This work has mainly been built on the seminal paper of Crepon *et al*. (1998) (the CDM model). A number of findings emerge from their research. First, the probability of engaging in R&D activity increases with firm size, market size and market diversification as well as with demand-pull and technology factors. The innovation outputs increase with innovation effort as well as with the absorptive capacity of the firm. Firm productivity rises with innovation output but controlling for labour quality and capital inputs.

Building on this seminal study a large number of research papers have tested variants of this model using both cross-sectional and panel data across different countries and with different specifications for innovation inputs, outputs and productivity measures. Extension papers have explored the following aspects of innovation: financing innovation, or innovation and employment, or innovation and trade, or competition, or intellectual property; some adopt a managerial perspective, or the broader innovation system. A full review of the literature using the CDM approach can be found in Loeoef *et al*. (2017). The key aspect in relation to our research, and the intersection with this literature, is that Irish firms are likely to be experiencing lower productivity levels due to the low level of investment in R&D. Thus a clear economic cost of the underinvestment will be lower economic growth through the productivity channel. Therefore dealing with the underinvestment would clearly boost growth.

The question then arises as to what is the optimal level of R&D. The equilibrium level of investment in R&D is the level which would be chosen by firms to maximise profits in an unconstrained environment with no uncertainty. Naturally, there are constraints acting to dampen Irish R&D and these could be on the demand side (holding back the firm) or the supply side (constraints such as infrastructure, access to finance etc). While future research should be targeted to identify the relative impact of these constraints, the counterfactual analysis in our paper indicates that if Irish firms were to invest in line with how peer firms in other countries were investing, the share of firms investing in R&D should increase to 22 per cent from 15 per cent and the level of investment per firm increase from €25,000 to €40,000. While this does not necessarily represent the optimal level of investment, it does give some insight into the scale of the underinvestment.

From a policy perspective, addressing the R&D underinvestment in an Irish context is likely to lead to a number of benefits. First, it would likely lead to a first order impact on growth if innovation were to rise and productivity then would subsequently increase. Secondly, if indigenous firms' productivity rises and their contribution to the domestic economy increases, this can diversify the economic base and lower the risks around multinational concentration.

From a policy perspective, a range of measures has been suggested that could help to increase investment from an R&D perspective. First, the NCPC (2023) has

suggested that tax reliefs for SME R&D investment be extended and ensure that they are easy to access. This would likely help to facilitate the investment activity. Additionally, funding schemes which deal with the long-term challenge of collateralising R&D investments (such as credit guarantee arrangements) should be explored in more detail. Over and above these effects, to build a comprehensive knowledge base, it would be extremely useful if a survey were conducted to explore the barriers to R&D investment for domestic enterprises and this could help inform policymakers.

VIII CONCLUSIONS

A number of findings emerge from our analysis. First, considering investment in tangible fixed capital investment, we do not find a systematically lower investment level for Irish firms relative to all other countries; however, on balance it appears investment is lower than other small Northern European economies. Firms in Sweden and Denmark have a notably higher probability of investing in tangible fixed assets, controlling for firm-level factors and firm fundamentals. For the level of investment, Ireland has a lower level than that of Denmark, Sweden and Austria but it is higher than that of France, Greece, Italy, Portugal and Spain.

Turning to expenditures on research and development, Irish firms are statistically less likely to invest in research and development compared to firms in Austria, Belgium, Denmark, the Netherlands and Sweden. If they do invest, they also invest in smaller amounts than similar firms in these countries. The opposite is the case for firms in Italy, Portugal, Spain and Greece as compared to Irish firms. This suggests a clear underinvestment in research and development is evident for Irish enterprises when compared with a broad group of similar Northern European economies. This finding is likely to have an impact on the relative productivity of Irish domestic firms as compared to comparator firms in these countries.

The analysis in this section has clearly indicated that Irish enterprises have similar sensitivities to output growth for tangible fixed assets relative to other countries i.e. if changes in output growth illicit similar reactions in terms of capital spending for Irish and other country enterprises. However differences exist for research and development expenditure: first, we do not find any statistical link for Irish firms between output growth and R&D investment propensity. This is likely an explanatory factor for the lower investment propensities seen in the section above; second, we find that the sensitivity is somewhat higher for Irish firms in terms of the level of investment i.e. when Irish firms do invest, the relationship between their growth and the level of spending on R&D is higher for Ireland than other countries.

We explore whether country differences could be explained by either financial factors or indicators of the quality of the firm that are unexplained by the simple

output accelerator. In general, we find financially constrained firms, and those with high indebtedness relative to income, have notably lower investment in fixed assets. While we do find that financially unconstrained firms have the highest level of investment in R&D, financial factors do not appear to be as major a barrier for investment in R&D.

The variables relating to internationalisation (domestic share of sales), having a website and using foreign technology are all negative and significant in the research and development regressions. These findings suggest that domestic focused firms, those without basic digital offerings and those not relying on foreign technology are much less likely to invest in research and development. Also, if they do invest, the level of investment will be lower. This is a notable finding and indicates support for digitalisation and internationalisation.

In summary, these findings suggest considerable complexities in determining the extent to which Irish firms are underinvesting. Part of this complexity is driven by the notable heterogeneous effects that we have determined which highlight the variation across size, sector, age groups and foreign ownership. The evidence suggests that groups of Irish enterprises are likely have scope to expand investment, and this is particularly the case for R&D expenditure. The differences in this asset class remained unexplained to a greater extent than the tangible fixed assets for which financing factors played a key role. Understanding and monitoring investment requirements over time is going to require extensive data on asset types across firms to ensure that policies can be flexibly deployed across the extremely heterogeneous enterprise population.

A number of important limitations to our research are evident. First, as we do not observe firms for the same country over time, it is not possible to determine the extent to which these patterns are purely cross-sectional. This also applies to any attempt to understand any country-specific time-varying macroeconomic factors or financial conditions which we cannot identify in a cross-sectional study. Finally, a further caveat to these findings is that, while the survey data relate to 2018 and 2019 in a majority of cases, some surveys were undertaken during the period of the COVID-19 crisis. As the pandemic would have caused major disruption to investment planning and economic performance, the patterns in those surveys may not be expected to continue or be a good guide for future or past behaviour given the unique nature of the shock.

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