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A Multilevel Approach to Firm Interrelationships Across European Regions

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A Multilevel Approach to Firm Interrelationships Across European Regions

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Abstract

Policymakers attempt to foster entrepreneurship within European regions yet firm interrelationships across European regions remain understudied. This paper analyses the extent to which past firm births and deaths influence future firm births and deaths across European NUTS 2 regions through the lens of competition, multiplier and Marshall effects. Using a novel multilevel mixed effects regression model, we find evidence for an immediate multiplier effect changing to a competition effect as time passes across European regions and countries. We also identify that significant variations in firm birth and death rates exist across European regions validating the importance of more decentralised regional entrepreneurial policies which has implications for policies like the European Regional Development Fund's (ERDF) Cohesion Plan and the Smart Specialisation Strategy.

Keywords: Firm Births, Firm Deaths, NUTS2 Regions, Multilevel Modelling

JEL: L1, C33, D22, R11

1. Introduction

This paper concerns itself with the investigation of interrelationships between firm births and deaths. These are instances where firm births/deaths influence future rates of firm births/deaths (Carree *et al.*, 2011; Gajewski and Kutan, 2018). The theoretical framework for this paper is set out in Johnson and Parker (1994) who conceptualise the different types of firm interrelationships which can occur between firm births and deaths. They refer to these effects as the multiplier and competition effects. The multiplier effect occurs in situations where firm births increase future births (and decrease future deaths) or where firm deaths increase future deaths (and decrease future births) (Lu *et al.*, 2008; Resende *et al.*, 2015). Contrastingly, the competition effect occurs when firm births increase future deaths (and decrease future births) or when firm deaths increase future births (and decrease future deaths) (Carree *et al.*, 2011; Pe'er and Vertinsky, 2008). Findings within this literature are mixed with some supporting the competition effect (Gajewski and Kutan, 2018; Nyström, 2007) and others supporting the multiplier effect (Lu *et al.*, 2008; Resende *et al.*, 2015). Many firm interrelationship studies analyse the determinants of either firm births or firm deaths in isolation. Meaning they examine how past firm births and deaths influence future firm births *or* future firm deaths but not both - see Arcuri *et al.* (2019) and Calá *et al.* (2016). While these studies provide detailed insights into how firm interrelationships influence firm births or firm deaths separately, they come at the expense of a fully comprehensive analysis of how firm interrelationships influence both firm births and deaths.

There has been a tendency in firm birth research to focus on certain types of analysis. Audretsch et al. (2019) highlights two distinct streams of study: (i) cross-country; and (ii) regional. This is apparent in firm death research as well (Muzi *et al.*, 2022; Ebert *et al.*, 2019). While cross-country analyses have value, their aggregate nature omits important nuanced factors which has seen Audretsch *et al.* (2019) ask for research concerned with entrepreneurial

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activities to consider "the hierarchical spatial structure of entrepreneurship determinants" (pg. 249). Theoretically, this is important because regional factors influence entrepreneurial activities. The influence of the triple helix system (university-industry-government) on regional entrepreneurship illustrates this (Kim *et al.*, 2012). Human capital, economic performance and employment share can all influence firm births (Alamá Sabater *et al.*, 2011; Felan *et al.*, 2021; Audretsch *et al.*, 2011) and firm deaths (Acs *et al.*, 2007; Manjón-Antolín and Arauzo-Carod, 2008; Renski, 2015). However, these factors would not be captured in aggregated national studies. Regional analyses will account for these factors but this comes at the expense of controlling for relevant country specific effects as regional studies do not typically examine multiple countries (Spigel, 2017; Spigel, 2016). Differences in fiscal paradigms, legislation and institutions/government policies can all influence firm births/deaths (Bartik, 1989; Harrison and Kanter, 1978; North, 1990; Yang *et al.*, 2018; Darooghe Arefi *et al.*, 2022). While we cannot analyse the effects of these specific factors due to data limitations, we can control for the influence of country in our estimation. Thus, we can contribute towards this methodological knowledge gap within the literature by conducting an analysis of firm birth and death interrelationships while controlling for regional factors and the influence of country. This will allow for cross-national comparisons of firm birth and death activity which Terjesen *et al.* (2016) and Reynolds (1991) advocate. Additionally, both Neumann (2021) and Fritsch and Noseleit (2013) have emphasised the importance of future research analysing the medium-term as well as short-term impact of entrepreneurship on future economic outcomes. This can be considered important given that the firm birth process can be a multi-stage one (Stayton and Mangematin, 2016) and competitive pressures from rival firms intensify over time (Dou *et al.*, 2021). This means firm births resulting from multiplier effects or firm deaths resulting from rivalry may take time to manifest. Despite this, many studies use exclusively one-year lag

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lengths to assess multiplier and competition effects – see Arcuri *et al.* (2019). We also contribute to this knowledge gap by using up to 3-year lag lengths of firm births and deaths.

The research question of this paper asks how firm births and deaths influence future firm births and deaths across European countries and regions. Analysing this question provides evidence on whether multiplier or competition effects are present across European regions and countries. Additionally, the paper also asks if certain types of firm interrelationships (multiplier or competition effects) manifest over time (1, 2 and 3 years). Utilising Eurostat and OECD data, we assemble an unbalanced panel data set concerned with firm births from 205 regions across 26 countries and firm deaths from 178 regions across 24 countries during the period 2008 to 2017. We then estimate a multilevel mixed effects regression to analyse the extent to which firm births and deaths influence future firm births and deaths. Control variables capturing macroeconomic performance, industrial employment and human capital are also accounted for. In doing this, we contribute to the relatively scarce literature on cross-country studies (Audretsch and Belitski, 2017; Hundt and Sternberg, 2016) while also explicitly considering regional factors and providing additional insights on the regional determinants of firm birth and death activity as called for by Arcuri *et al.* (2019). Furthermore, our use of up to 3-year lag lengths of firm births and deaths allows for a more complete picture of the interrelationships between firm births/deaths over time. Increased lag lengths allow us to see whether the competition effect dominates as is evident in other studies (Gajewski and Kutan, 2018) and/or whether this dominance changes over time.

The rest of this paper will be outlined as follows. Section 2 provides a review of relevant literature and develops our hypotheses. Section 3 presents the data and then Section 4 outlines our empirical methodology. The results are presented in Section 5. Section 6 provides a discussion of these results. Finally, Section 7 concludes and offers policy insights.

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2. Literature Review

Firm birth and death activity at a regional level can be dependent on a variety of factors including regional knowledge and infrastructure (Bishop, 2019; Colombelli and Quatraro, 2018; Duvivier *et al.*, 2021) as well as industrial factors and relatedness (Content *et al.*, 2019; Wixe and Andersson, 2017; Celbiş, 2021). Economic factors can also play a role in determining firm births and deaths (Koster and van Stel, 2014; Marin and Modica, 2021). Firm births and deaths have also been shown to influence future firm birth/death activity due to their ability to influence market room and competitive structures (Carree and Dejardin, 2020). We consider regional firm interrelationships through the lens of multiplier, competition and Marshall effects to explore the impact of past firm births and deaths on future firm births and deaths. These effects are discussed in the following subsections.

2.1. Multiplier Effects

The multiplier effect occurs when (i) firm births increase future firm births (and decrease future firm deaths) or when (ii) firm deaths increase future firm deaths (and decrease future firm births) (Lu *et al.*, 2008; Resende *et al.*, 2015). Organisations like the ERDF and Business Europe seek to increase firm births via investment and lobbying for greater investment in firms (BE, 2020; EC, 2020a). Within the literature some express concerns that public sector investment and incentive schemes may potentially crowd out regional entrepreneurship (Zikou *et al.*, 2017; Audretsch *et al.*, 2012). Others suggest that incentive programmes may actually reduce firm births (Tuszynski and Stansel, 2018).Theoretically, finding the multiplier effect should alleviate some of these concerns because it asserts that firm births should increase future firm births and decrease future firm deaths at a regional level (Kangasharju and Moisio, 1998). Conceptually, the multiplier effect can occur through an income or a demonstration effect (Dejardin, 2004; Johnson and Parker, 1994). Under the income effect, an initial increase in firm births can increase the level of income per person due to increased employment. As a result,

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more firm births occur to cope with increased consumer demand (Gajewski and Kutan, 2018; Sutaria and Hicks, 2004). Conversely, increases in firm deaths could decrease the level of income per person and induce further firm deaths because of reduced levels of consumption (Gajewski and Kutan, 2018). Regarding the demonstration effect, firm births induce further firm births when the creation of an enterprise signals the economic value of opening a business to other individuals who subsequently set up businesses of their own (Nyström, 2007; Dejardin, 2004). Similarly, firm deaths may signal a lack of economic value in certain firms which would incentivise individuals to exit the market rather than pursue entrepreneurship in a difficult environment (Bartoloni *et al.*, 2020).

Both the income and the demonstration effect can be seen to relate to the ecological view of the firm which emphasises the importance of changes to environmental conditions in which the firm operates as a key role in determining firm birth/death activity (Aldrich *et al.*, 2008; Aldrich and Wiedenmayer, 2019; Geroski *et al.*, 2010). Environmental factors, such as changes in the competitive environment including firm formation rates, population density and the characteristics of firms (e.g., their growth rates, size and age distributions) influence the rate of firm births and deaths across regions (Johnson, 2004; Colombelli and Quatraro, 2018; Lander and Heugens, 2017; Power *et al.*, 2019; Douma and Schreuder, 2013; Stinchcombe, 1965). Both Lu *et al.* (2008) and Resende *et al.* (2015) find support for the multiplier effect in the case of firm births in their analyses of Taiwan and Brazil respectively. Additionally, Carree *et al.* (2011) have also found evidence for the multiplier effect in the case of firm deaths in Italy. Similarly, Calá *et al.* (2016) provides empirical support for the presence of the multiplier effect for firm births in South America. Meanwhile, the findings of Pe'er and Vertinsky (2008) suggest that the multiplier effect is present in the case of both firm births and firm deaths in Canada. The following hypotheses examine the presence of a multiplier effect.

H1a: Firm births increase future firm births.

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H1b: Firm births decrease future firm deaths.

H1c: Firm deaths increase future firm deaths.

H1d: Firm deaths decrease future firm births.

2.2. Competition Effects

The competition effect acts as a counterpoint to the multiplier effect. The competition effect exists when (i) firm births increase future firm deaths (and decrease future births) or when (ii) firm deaths increase future births (and decrease future deaths) (Carree *et al.*, 2011; Pe'er and Vertinsky, 2008). Findings relating to competition effects can be considered of great importance because they provide insight into how the stimulation of entrepreneurship will influence future rates of firm birth and deaths. The role of public policy in influencing firm births and deaths is a central question within entrepreneurial literature (Cumming and Li, 2013). Policy makers and industrial agencies seek to provide support for firms which could reduce firm deaths and maintain levels of competitiveness and growth within the economy (EC, 2020b; EI, 2021). Some within the literature express fears that public investment could crowd out or displace private investment (Cumming and Johan, 2019). Some evidence finds support for this concern (Cumming *et al.*, 2017). Theoretically, competition effects mean that firm births could be likely to occur following a period of firm deaths (Johnson and Parker, 1996). Public investment looking to increase regional firm births following a period of firm deaths could therefore conceptually be seen as inducing firm births which may have occurred anyway if a competition effect is present.

The competition effect can occur via a process of creative destruction whereby new firms destroy older firms (Brixy, 2014; Schumpeter, 1942). Firm births increase competition within the market leading to firm deaths (Dejardin, 2004). This process is referred to by Audretsch (1995) and Cefis *et al.* (2020) as a displacement effect. Another way which the

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competition effect can materialise is when firm deaths lead to future firm births through 'push-factor' or 'necessity-based' entrepreneurship where individuals pursue entrepreneurship to avoid unemployment (Baptista *et al.*, 2014; Block *et al.*, 2015). In this scenario, firm deaths lead to an increase in unemployment and some individuals start their own businesses to avoid being unemployed (O'Leary, 2022; Saridakis *et al.*, 2016). The manner in which firm births can induce further firm deaths is related to the industrial view of the firm where firms need to rely on their relative efficiency to be selected by the market to grow (Audretsch and Mahmood, 1994; Jovanovic, 1982). Those which cannot become victims of competition and die (Carreira and Teixeira, 2011; Schumpeter, 1942). Additionally, industrial literature would stipulate that firm deaths can also lead to firm births via the replacement and release of resources back into the economy after the death of firms (Brown *et al.*, 2013; Austin and Rosenbaum, 1990).

Evidence of the competition effect has been found by Arcuri *et al.* (2019) in French regions where firm births were found to increase future deaths. Carree *et al.* (2011) find a similar effect in Italian provinces, as does Albiol (2014) in South America. Similarly, the results of Resende *et al.* (2015), Nyström (2007) and Pe'er and Vertinsky (2008) find supporting evidence for the competition effect among both firm births and firm deaths. However, in these studies evidence for the multiplier effect was also found. The following hypotheses are considered to examine competition effects:

H2a: Firm births increase future firm deaths.

H2b: Firm births decrease future firm births.

H2c: Firm deaths increase future firm births.

H2d: Firm deaths decrease future firm deaths.

2.3. Marshall Effect

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Johnson and Parker (1994) do set forth a third effect called the Marshall effect. This occurs when firm deaths in one year are attributable to firm births the previous year. However, it is difficult to distinguish whether these firm deaths are attributable to the Marshall effect or the competition effect. This is because both effects share a similarity which makes differentiating between them difficult. They both state firm births should induce firm deaths and so a negative relation is expected in both cases (Johnson and Parker, 1994; Dejardin, 2004). However, a distinction can be drawn between the two conceptually. The Marshall effect is derived from the *trees of the forest* analogy set forth by Marshall (1890) where he reasons that few firms survive and that eventually time tells on them all. Therefore, this effect can be considered the natural passing and death of a certain number of firms from an initial pool of newly birthed businesses. By contrast, the competition effect states firm births should induce firm deaths due to competitive pressures (Gajewski and Kutan, 2018). The following hypothesis is considered to test for the Marshall effect:

H3: Firm births increase future firm deaths.

2.4. Intertemporal Effects

Most firm interrelationship studies will use lag lengths of one year – see Arcuri *et al.* (2019), Calá *et al.* (2016) and Carree *et al.* (2011) for examples. Meaning they examine how firm births/deaths in year t influence firm births/deaths in year $t+1$. This approach assumes that if multiplier, competition and/or Marshall effects are present, they are observable after just one year. This assumption could limit the understanding of how firm interrelationships operate. For example, the multiplier effect is present when firm births increase firm births (Johnson and Parker, 1994). However, the process involved in firms being born is a multi-stage one involving idea generation/identification and development (Bhave, 1994; Stayton and Mangematin, 2016). Therefore, firm births arising from multiplier effects may not manifest within just one year.

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Additionally, firm deaths may take a while to manifest given that competitive pressures intensify over time (Dou *et al.*, 2021). Thus, competition effects where firm births increase future deaths also may not manifest immediately. Therefore, both competition and multiplier effects may need to be analysed over time periods greater than one year. This paper adopts models with between 1-3 year lags. An overview of the hypotheses listed in this literature review will be provided in Appendix 1.

3. Data

This paper uses Eurostat and OECD data to analyse the interrelationship between past and future firm births and deaths. The definitions for firm birth and death activity in both the Eurostat and the OECD datasets are identical to one another and hence there is no issue which could arise from merging the two together (OECD, 2020). An unbalanced panel is assembled which covers most EU regions and the UK[i]. The data covers the period 2008 to 2017. Geographical detail and temporal coverage vary from country to country and are displayed in Appendix 2[ii]. Post-data cleaning the final estimation for the firm birth model pertains to 205 regions across 26 countries (n=1,004) while the firm death model pertains to 178 regions across 24 countries (n=828)[iii]. Additionally, we are also able to use data on regional GDP, education and industrial employment to control for regional specific characteristics which have been shown in the literature to impact firm births and deaths (Ayob, 2019; Bartoloni *et al.*, 2020; Bottasso *et al.*, 2017).

Table 1 provides the definitions of the variables used in our analysis. Firm births occur through the combination of at least two production factors. If a firm generates revenue and employs individuals, with the restriction that no other enterprises are involved in the event, this constitutes a firm birth. Firm deaths are similarly defined as the dissolution of a combination of at least two production factors with the restriction that no other enterprises are involved in the event (OECD, 2020). The stock of businesses is defined as the total number of firms

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engaging in activity from the 1st of January to 31st of December each year. Again, in this case creating turnover and/or employment in the period is 'activity'.

[Insert Table 1 around here]

The definition of the relevant variables in Table 1 are consistent with those of del Olmo-García *et al.* (2019), Power *et al.* (2019) and Doran *et al.* (2016). We follow the approach adopted by Carree *et al.* (2011) in defining firm birth and death rates as per equations (1) and (2) as follows:

$$Birth\ Rate_{rt} = \frac{Firm\ Births_{rt}}{Stock\ of\ Firms_{rt-1}} \quad (1)$$

$$Death\ Rate_{rt} = \frac{Firm\ Deaths_{rt}}{Stock\ of\ Firms_{rt-1}} \quad (2)$$

where $Firm\ Births_{rt}$ is the number of firms born in region *r* in time period *t*. $Firm\ Deaths_{rt}$ is the number firms which die in region *r* in time period *t*. $Stock\ of\ Firms_{rt-1}$ is the total number of active firms in region *r* in time period *t-1*, $Birth\ Rate_{rt}$ is the birth rate of firms in region *r* in time period *t*, and $Death\ Rate_{rt}$ is the death rate of firms in region *r* in time period *t*. These measures are included in our analysis as our dependent variables. A correlation matrix of these variables is available in Appendix 3.

4. Methodology

A significant advantage of our dataset is that it possesses a nested structure with data on NUTS 2 regions within European countries from 2008 to 2017. Multi-level modelling is an extension of random effects estimation with more than one level of dependence and which allows for random slopes and intercepts (Moffatt, 2015). The dependant variables in our models are the firm birth and death rates as defined previously in equations (1) and (2). As is consistent with existing firm interrelationship literature we use lagged firm birth/death activity as an

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explanatory variable (Arcuri *et al.*, 2019; Basile *et al.*, 2017; Carree and Dejardin, 2020). As the independent variables are lagged (i.e., are observed in *t-1*) and the dependent variables are not (i.e., are observed in *t*) we assume that the independent variables are predetermined. This should mitigate for what Abdallah *et al.* (2015) refers to as simultaneous endogeneity, whereby there are contemporaneous realizations between dependent variables and explanatory variables which affect each other. The explanatory variables which are relevant for our hypotheses are lagged versions of the firm birth and death rates which test for competition, multiplier and Marshal effects. Control variables which account for economic performance, industrial employment and human capital at regional levels are also included in the estimations. Equations (3) and (4) display the models to be estimated.

$$FB_{rt} = \beta_0 + \beta_1 FB_{rt-i} + \beta_2 FD_{rt-i} + \beta_3 X_{rt} + \beta_4 Year_t + \mu_c + \mu_r + \varepsilon_{rt} \quad (3)$$

$$FD_{rt} = \beta_0 + \beta_1 FB_{rt-i} + \beta_2 FD_{rt-i} + \beta_3 X_{rt} + \beta_4 Year_t + \mu_c + \mu_r + \varepsilon_{rt} \quad (4)$$

Here the dependent variable FB_{rt} is the firm birth rate in region *r* in period *t*. FD_{rt} is the firm death rate in region *r* in period *t*. β_0 is the constant term and β_1 through β_4 are the slope coefficients. FB_{rt-i} is the firm birth rate in region *r* in periods *t-1*, *t-2* and/or *t-3*. FD_{rt-i} is the firm death rate in region *r* in periods *t-1*, *t-2* and/or *t-3*. X_{rt} is a set of control variables[iv]. $Year_t$ is a series of dummy variables which control for year effects from 2008 to 2017. μ_c is the country specific random intercept and μ_r is the region-specific random intercept. The β values are the coefficients of the fixed effects of the model. They show the association between lagged firm birth and death rates (and the controls) on the dependent variable. Of specific interest to us are the coefficients β_1 and β_2 which will allow us to test our various hypotheses

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relating to the competition, multiplier and Marshal effects over time. We model the potential time effect by considering a series of lags in our model including *t-1*, *t-2* and *t-3*.

The country specific random effects (μ_c) allow for each country to possess a random intercept which accounts for different country specific factors which may impact on firm births and firm deaths within all regions of a country. The region-specific random effects (μ_r) allow for a random intercept which accounts for each region possessing different firm birth and death growth paths. In accounting for these random effects, we account for national as well as local contexts which may impact on firm birth and death rates. Our paper focuses on modelling firm births and deaths as a hierarchical structure addressing a general call by Audretsch *et al.* (2019) for this type of modelling approach. We estimate the births equation and death equation separately, and not as part of a system of equations. This is due to our focus on a multi-level modelling approach which precludes straightforward estimation of a multivariate model. Standard statistical diagnostics have been performed to test for the presence of multicollinearity and indicate that there is no evidence of multicollinearity within the model. See the correlation matrix of the variables included in the analysis presented in Appendix 3.

5. Results

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Table 2 presents the results of three estimations of our firm births equation (3) and the results of three estimations of our firm deaths equation (4) to view the findings corresponding to *t-1* to *t-3* lags of firm births and firm deaths Columns I and IV include only one lag of firm birth and death rates. In Columns II and V, we extend this to two lags, and finally to three lags in Columns III and VI[v]. Columns I, II and III display the results for firm births while columns IV, V and VI display results for firm deaths. The chi-squared statistics are significant for all models (p-value<0.0001) indicating that the mixed effects multilevel model estimation is more appropriate than a standard linear regression model. This highlights the importance of the mixed effects multilevel approach as is suggested by Audretsch *et al.* (2019).

5.1 Firm Interrelationship Results

[Insert Table 2 around here]

Beginning with the results of equation (3) explaining firm birth rates (Columns I-III), we observe positive and significant coefficients of lagged firm birth rates on future firm birth rates. Regardless of the number of lags considered, the impact of past firm births on future births is positive signifying a multiplier effect and support for *H1a* which states that firm births increase future firm births. This result is similar to the results of Calá *et al.* (2016) and Pe'er and Vertinsky (2008) who both find evidence of the multiplier effect in the case of firm births. This evidence is also supported when considering the impact of lagged firm deaths on firm births in Column I though less so when further lags are added. In Column I, the coefficient on lagged death rates is negative and significant indicating the past firm deaths reduce future birth rates providing evidence of a multiplier effect supporting *H1d.* Calá *et al.* (2016) also find that firm deaths reduce future firm births. However, in Columns II and III additional lags result in firm deaths in *t-2* and *t-3* increasing future firm births providing evidence of a competition effect

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which supports hypothesis *H2c*. Similar results have been found in the literature by Lu *et al.* (2008) who observe that firm deaths increase future firm births.

Progressing to firm death rates in Columns IV to VI, Table 2. In all models the coefficients on lagged firm death rates are positive and statistically significant (save for t-3) which also finds support for a multiplier effect and hypothesis *H1c* where firm deaths increase future firm deaths. This evidence supports the findings of Resende *et al.* (2015). When considering the coefficient of lagged firm births rates (t-1) on firm deaths in Column IV, we find that it is negative and significant supporting hypothesis *H1b* and providing evidence of a multiplier effect where increases in birth rates reduce future firm death rates. However, in Columns V and VI when further lags of births are added their coefficients are positive and significant suggesting a competition effect emerges with time supporting *H2a*. The emergence of the competition effect could indicate the presence of a Schumpeterian style creative destruction effect where firms die as a result of succumbing to competitive pressures (Carreira and Teixeira, 2011). A similar pattern is also observed by Nyström (2007).

Support is also found for the Marshall effect or hypothesis *H3* which states that firm births rates increase future firm deaths as the results in Column IV indicate lagged firm births increase future firm deaths. However, as noted earlier it is difficult to infer whether this is occurring due to Marshall effects (natural passing of firms) or competition effects (Johnson and Parker, 1994). Firm births increasing firm deaths could be a result of competitive pressures (Cefis *et al.*, 2020) or a natural passing of recently birthed firms as per the Marshall effect (Marshall, 1890). A summary of the decisions regarding the hypotheses proposed in Section 2 can be seen below in Appendix 6.

5.2. National Results

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To capture country-specific effects mean predicted random intercepts are calculated in a manner consistent with Hamilton (2013) for each country within the dataset. These estimates provide an indication of the degree to which firm birth or death rates are impacted by country specific effects. We illustrate these simply in Figures 1 and 2. The results indicate a collection of countries including Lithuania, Latvia, and other eastern European nations, have relatively high values associated with firm births. The highest mean predicted random intercept values associated with firm births are Lithuania (0.55), Latvia (0.23), and Poland (0.14). The three countries with the lowest values are Ireland (-0.29), Cyprus (-0.26), and Sweden (-0.19). The remaining values for countries tend to hover closely over or under 0. Additionally, we see a collection of some higher performing western European countries like Ireland, Cyprus, and Sweden with negative values associated with firm births. The highest mean predicted random intercept values associated with firm deaths include Lithuania (1.74) and Latvia (0.39) again followed by Portugal (0.20). Ireland, Cyprus, and Sweden occupy the three lowest spots with values of -0.83, -0.60, and -0.47 respectively.

[Insert Figure 1 around here]

[Insert Figure 2 around here]

This may seem a counter-intuitive observation initially, but if we look at the values associated with firm deaths, we see that the majority of these higher performing western countries also have lower values associated with firm deaths potentially indicating that higher performing countries have less 'market room' available within their economies, see Carree and Dejardin (2020). As a result, their lower firm death rates lead to less opportunities for new firm births. Furthermore, the lower levels of economic performance in some of the eastern European economies may contribute to greater levels of 'turbulence' or 'flux' which is firm births plus deaths, see Beesley and Hamilton (1984) for further discussion of this. In this case, firm births

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and deaths occur regularly due to the cyclical perpetuating nature of firm deaths taking place. This can arise from economic pressures inducing new firm births in order to combat those same economic pressures. For example, push-factor entrepreneurship whereby unemployment may lead to self-employment to help people avoid unemployment, Cheratian *et al.* (2019). Additionally, the results of an interclass correlation (ICC) estimation performed post-estimation and random effects parameters from the mixed effects estimation both indicate that there is a significant correlation between firm birth and death activity at national and regional levels. These estimates are available in Appendices 5 and 6 respectively.

5.3. Implications for Policy

The ERDF and the Cohesion Fund seek to enhance rates of sustainable growth and job creation by investing into start-ups firms and SMEs (EU, 2021). Other industrial agencies like Business Europe look to achieve similar goals via lobbying for investment (BE, 2020). Our findings have three implications for them. Firstly, evidence for both the multiplier and competition effects are found across all models. This means that firm births appear to increase future firm births, but evidence is also found that over longer time periods firm births can also increase future deaths. Investment into start-ups can therefore be viewed as a positive vehicle for inducing entrepreneurial growth in the immediate future, but it should be noted that over longer periods more negative crowding out-type effects discussed by Zikou *et al.* (2017) are also observable. Secondly, greater rates of 3rd level education appear to increase firm births. This emphasises the potential role human capital can have in regional idea generation and entrepreneurship. It also shows that the ERDF's goal of improving equal access to quality education services does not only promote social inclusivity, but also firm births. This is in line with other empirical findings from Breznitz and Zhang (2022) and Qian *et al.* (2013). Thirdly, higher levels of employment in the industrial sector appear to negatively influence both firm births and deaths within regions. This suggests that having a large amount of a regions'

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employment share in industrial sectors reduces firm deaths and firm births. Conceptually, this could be because the industrial employment variable captures the degree of specialisation in a region. Collections of firms which all operate in similar industries could produce localisation externalities which may reduce future firm deaths (Basile *et al.*, 2017). The reduction in firm births could be explained by a lack of diversity which impedes the transfer of different types of knowledge and reduces idea generation due to cognitive lock-ins (Crowley *et al.*, 2021). More diversified regions may better facilitate new knowledge transfer and increase firm births as per Bishop (2012). This finding is of relevance to European Smart Specialisation strategy (S3) which focuses investment into a region's 'relative strengths' to improve economic growth (EC, 2014). Focusing on a regions' relative strengths may make regions more specialised with larger shares of their employment in a certain industry. Our findings suggest this could help reduce firm deaths but also reduce firm births. Decentralised policies, like the S3 strategy (Laranja, 2022), would allow policymakers to harness the benefits of specialised investment into certain prominent sectors within regions. Meaning, as Hausmann and Rodrik (2006) said, policy makers could be 'doomed to choose' between reducing firm deaths and increasing firm births.

6. Conclusion

This paper examines the extent to which firm births and deaths influence future firm births and deaths across European regions through competition, multiplier and Marshall effects. The results indicate that the multiplier effect is the dominant effect. Meaning that across all models, the coefficients indicating the presence of the multiplier effect are more prevalent or greater in size than the coefficients indicating the presence of the competition effect. Evidence for the multiplier effect was found through firm births increasing future births. However, evidence for the competition effect can also be found when two- and three-year lag lengths are added to the model. Indicating that both effects can be observed but that the multiplier effect can be

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observed more immediately than the competition effect. This provides important insights for public policy initiatives looking to increase firm births. Some express concerns that government investment ends up 'crowding out' or reducing entrepreneurship (Zikou *et al.*, 2017; Cumming and Li, 2013). Others find support for policy initiatives looking to increase firm births (Tuszynski and Stansel, 2018; Bruce and Deskins, 2012). These mixed findings are why it has been suggested that bespoke interventions are required to positively influence entrepreneurial conditions (Brown and Mason, 2017). Our findings suggest that inducing firm births is not straightforward. Multiplier effects are observed over one year but as time lapses we begin to see evidence of competition effects whereby firm births can increase firm deaths. Therefore, industrial support agencies must be mindful of both the positive effects and more negative 'crowding out' effects discussed by Zikou *et al.* (2017).

This paper answers the call of Audretsch *et al.* (2019) to use multilevel modelling to account for national and sub-national effects when analysing entrepreneurial activity. Results indicate there are significant differences in the effect which country has on firm birth and death activity as western European countries appear to have lower firm birth rates, but also have lower rates of firm deaths compared to eastern European countries which have larger levels of both firm births and deaths. The higher levels of turbulence or flux in eastern European countries could be because of national factors. For example, Bosma *et al.* (2018) find that productive entrepreneurship is influenced by institutional quality and financial stability which may be more prevalent in western European countries (Charron *et al.*, 2021). Another key contribution of the paper is the cross-country estimation of firm interrelationships which up to this point have predominantly been examined in single countries (Arcuri *et al.*, 2019; Basile *et al.*, 2017; Tian, 2018).

Other implications from this analysis include the positive association which third level education has on firm birth rates. This could be attributable to university education positively

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influencing a regions' entrepreneurial ecosystem and fostering greater rates of firm births (Breznitz and Zhang, 2022; Wright *et al.*, 2017). Additionally, the results show that regions with larger shares of employment in industrial sectors have reduced firm birth and death rates. Conceptually, this could be explained by the industrial employment variable capturing the degree to which a region is specialised. Collections of similar firms which operate in a certain industry could produce positive localisation externalities reducing firm deaths (Basile *et al.*, 2017). However, the lack of diversity within a specialised region may impede on the transfer of different knowledge and fail to lead to the generation of new ideas due to cognitive lock-in issues (Crowley *et al.*, 2021). Diversification of a region may better facilitate new knowledge transfer and increase firm births as per the findings of Bishop (2012). This finding is of key relevance to the European Smart Specialisation strategy which focuses investment into a region's 'relative strengths' to improve economic growth (EC, 2014). Focusing on the relative strengths of a region may reduce firm deaths but come at the expense of also reducing firm births.

Despite these contributions, our paper is not without its' own limitations. While the multilevel analysis helps to account for both national and regional effects, it does mean we are restricted to using control variables which are available at the NUTS 2 regional level. Fortunately, we can use control variables which account for human capital, industrial employment share and economic performance which have been used in similar studies e.g., Bartoloni *et al.* (2020), Ayob (2019) and Bottasso *et al.* (2017). However, future studies may look to use of more detailed data on firm sector or size. This could show how competition and multiplier effects are influenced by the births/deaths of small/large firms or firms in specific industries.

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Endnotes

[i] Data on the United Kingdom is included because the period for the study is 2008 to 2017 and the United Kingdom was a member of the European Union for this entire period.

[ii] The OECD (2017) also highlights this inconsistency in the availability of firm birth and death data across European countries. The unbalanced nature of the data is accounted for in our empirical modelling as detailed in Section 4.

[iii] Data cleaning measures include extracting business demography data from the Eurostat and OECD websites, merging the data together while creating regional codes and spatial scale codes to identify the areas to which the data pertains too.

[iv] These control variables include the natural log of GDP per inhabitant in region, a human capital variable and the percentage of industrial employment in region *r*, in country *c*, in period *t*.

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Table 1 Variable Definitions

Variable:	Definition:	Source:
Firm Births	A firm birth amounts to the creation of a combination of production factors with the restriction that no other enterprises are involved in the event.	(OECD, 2020)
Firm Deaths	A death amounts to the dissolution of a combination of production factors with the restriction that no other enterprises are involved in the event.	(OECD, 2020)
Stock of Firms	The stock of firms is the total number of firms considered to be engaging in activity which is defined as any turnover and/or employment in the period from 1st January to 31st December in a given year.	(OECD, 2020)
Log of GDP	The natural log of Gross domestic product (GDP) at current market prices by NUTS 2 regions measured by Euro per inhabitant.	(Eurostat, 2019)
Education	Percentage of the active population (i.e. those in employment) which have a 3rd level International Standard Classification of Education (ISCE) qualification.	(Eurostat, 2019)
Industrial Employment	The percentage of employed persons who are working in the Industrial (except construction) NACE sector of the economy (B-E in NACE Rev. 2).	(Eurostat, 2019)

Source: (OECD, 2020; Eurostat, 2019) Note 1: Firm birhts and deaths are defined as per the Eurostat-OECD Manual on Business Demography Statistics.

Table 2 Mixed Effects Regression Results for Lagged Firm Birth and Death Rates

Variables	Births			Deaths		
	I	II	III	IV	V	VI

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Birth Rate$_{t-1}$,	0.34*** (-0.27)	0.44*** (-0.04)	0.22*** (-0.04)	-0.22** (-0.10)	0.13*** (-0.04)	0.02 (-0.04)
Birth Rate $_{t-2}$,		0.14*** (-0.04)	0.16*** (-0.04)		0.06* (-0.04)	0.02* (-0.04)
Birth Rate$_{t-3}$			0.20*** (-0.04)			0.13*** (-0.04)
Death Rate $_{t-1}$,	-0.05** (-0.01)	-0.04 (-0.05)	0.01 (-0.07)	0.78*** (-0.19)	0.15*** (-0.06)	0.25*** (-0.08)
Death Rate $_{t-2}$,		0.39*** (-0.04)	0.31*** (-0.06)		0.30*** (-0.04)	0.27*** (-0.07)
Death Rate$_{t-3}$			-0.03 (-0.04)			0.02 (-0.05)
Log of GDP per inhabitant	-4.59E-03	-2.31e-03	5.28e-04	7.49e-04	-3.04e-03	1.00e-03
	(-3.61e-03)	(-2.55e-03)	(-3.18e-03)	(-0.01)	(-2.87e-03)	(-3.44e-03)
Education	4.63e-04**	3.58e-04**	1.72e-04	1.97e-04	1.67e-04	1.05e-04
	(-1.82e-04)	(-1.45e-04)	(1.68e-04)	(-1.99e-04)	(-1.56e-04)	(-1.90e-04)
Industrial Employment	-7.06e-04***	-2.51e-04*	-2.87e-04**	-3.64e-04***	-1.11e-04	1.53e-05
	(-1.48e-04)	(-1.32e-04)	(1.36e-04)	(-1.27e-04)	(1.38e-04)	(-1.68e-04)
Model P Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Model chi2 Statistic	189.58	35.44	120.77	41.52	54.00	78.92
Model P Value chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

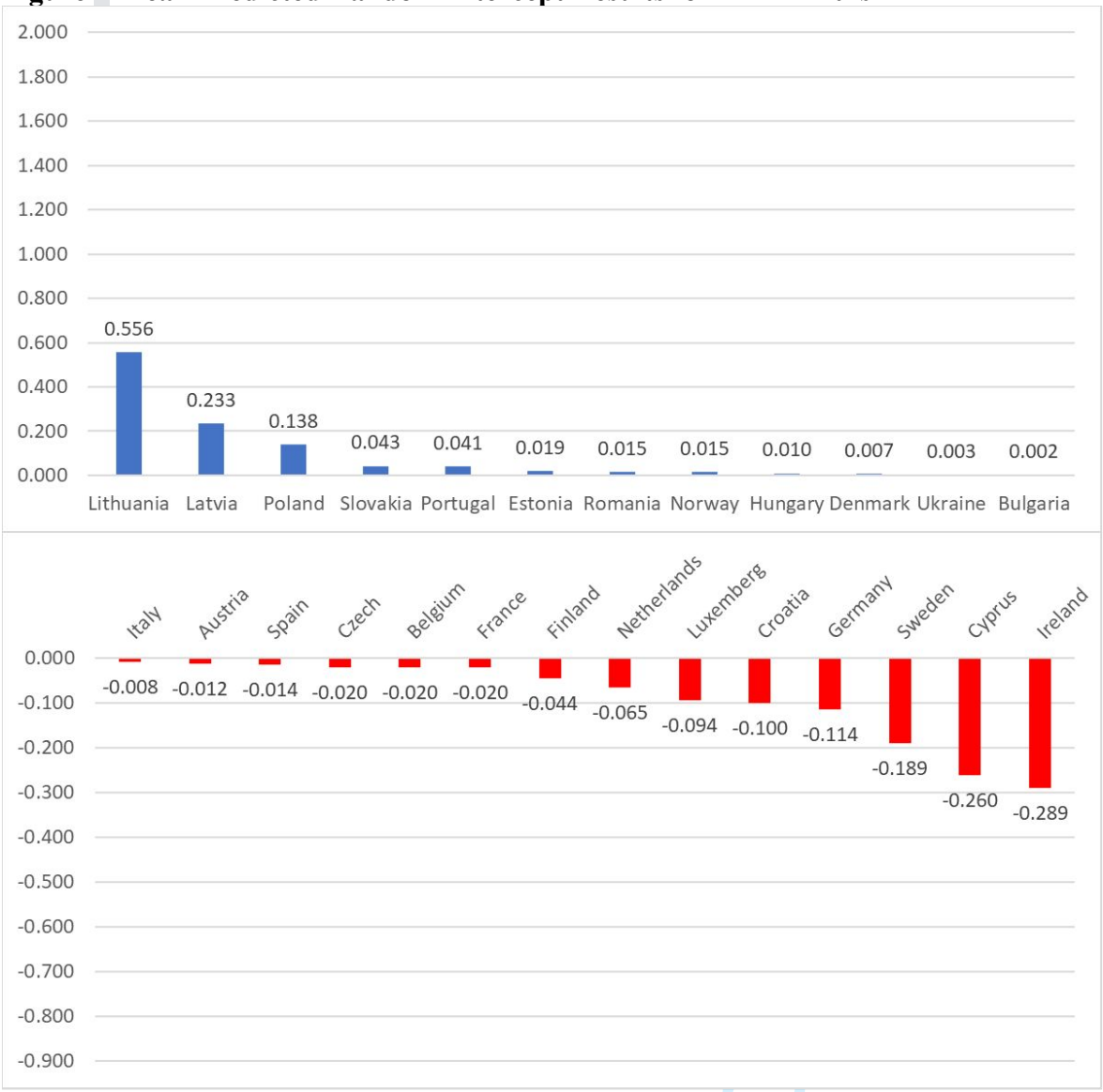
Random-effects Parameters for Birth Rate	*Estimate*	*Std. Err.*	*[95% Confidence Interval]*	
Country	0.01**	2.15e-03	0.01	0.02
Region	5.71e-10**	1.11e-09	1.27e-11	2.56e-08

Random-effects Parameters for Death Rate	*Estimate*	*Std. Err.*	*[95% Confidence Interval]*	
Country	0.01**	2.2e-03	0.01	0.02
Region	8.06e-12**	1.45e-11	2.35e-13	2.76e-10

*** p<0.01, ** p<0.05, * p<0.1 Standard errors are reported in parentheses. Year fixed effects are included in this estimation (see Appendix 4)

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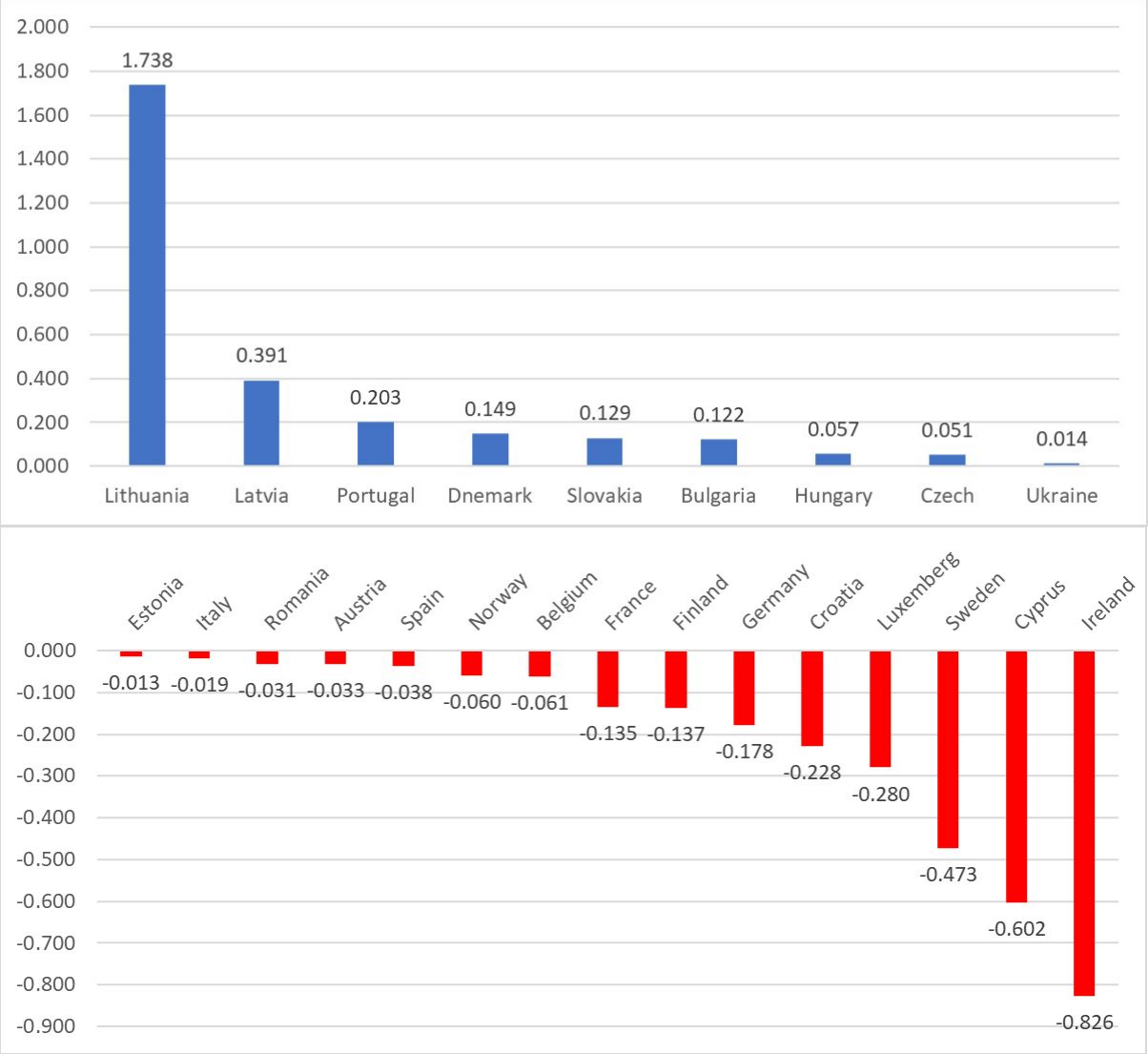
Figure 1 Mean Predicted Random Intercept Results for Firm Births



Note: All values are rounded to three decimal places.

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Figure 2 Mean Predicted Random Intercept Results for Firm Deaths



Note: All values are rounded to three decimal places.

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Supplementary Material

Appendix 1 Overview of the Hypotheses

By way of summary, the Table below illustrates the expected association between firm births (FB) and firms deaths (FD) and past firm births and firms deaths for the competition, multiplier, and Marshall effects. For the multiplier effect to be present, we would expect a positive relationship between future firm births and previous firm births ($\Delta FB_t/\delta FB_{t-1}>0$) meaning that firm births would positively influence future firm births where Δ and δ represent change in firm births and firm deaths and t denotes a given year. In contrast, for the competition effect we would expect a negative relationship between future firm births and previous firm births ($\Delta FB_t/\delta FB_{t-1}<0$) meaning that firm births negatively influence future firm births. Analogously, we would expect $\frac{\Delta FD_t}{\delta FD_{t-1}} > 0$ when there is a multiplier effect with past deaths positively influencing future deaths. Under the competition effect the opposite effect is observed $\frac{\Delta FD_t}{\delta FD_{t-1}} < 0$ with higher previous firm deaths positively influencing less future firm deaths. The effects of firm deaths on future firm births $\Delta FB_t/\delta FD_{t-1}$ or firm births on future firm deaths $\Delta FD_t/\delta FB_{t-1}$ differs for the multiplier ($\Delta FB_t/\delta FD_{t-1}$ <0) and competition effect ($\Delta FB_t/\delta FD_{t-1}$ >0) but as explained above the effect of firm births on future deaths is similar for the competition and Marshall effects ($\Delta FB_t/\delta FD_{t-1}$ <0).

Firm Activity	Multiplier	Competition	Marshall
$\Delta FB_t/\delta FB_{t-1}$	+	-	NA
$\Delta FD_t/\delta FD_{t-1}$	+	-	NA
$\Delta FB_t/\delta FD_{t-1}$	-	+	NA
$\Delta FD_t/\delta FB_{t-1}$	-	+	+

Where Δ and δ represent change in firm births (FB) and firm deaths (FD) and t is a given time period (a year) and NA is not applicable. Source: Adapted from Johnson and Parker (1994).

Appendix 2 Regional Data by Country for Firm Births and Deaths

Country	Spatial Scale	Years	Source

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Austria	NUTS 2	2009-2016	Eurostat
Belgium	NUTS 2	2009-2015	Eurostat
Bulgaria	NUTS 2	2009-2016	Eurostat
Cyprus	NUTS 2	2009-2015	Eurostat
Czech Rep	NUTS 2	2014-2016	Eurostat
Germany	NUTS 0	2009-2017	OECD
Denmark	NUTS 2	2009-2013	Eurostat
Estonia	NUTS 2	2009-2017	Eurostat
Spain	NUTS 2	2009; 2011-2013	Eurostat
Finland	NUTS 2	2009-2017	Eurostat
France	NUTS 2	2015-2017	Eurostat
Croatia	NUTS 2	2012-2016	Eurostat
Hungary	NUTS 2	2009; 2011-2016	Eurostat
Ireland	NUTS 0	2009-2017	OECD
Iceland	NUTS 0	2010-2017	Eurostat
Italy	NUTS 2	2009; 2011-2016	Eurostat
Lithuania	NUTS 2	2009-2017	Eurostat
Luxemburg	NUTS 2	2009-2017	Eurostat
Latvia	NUTS 2	2009-2017	Eurostat
Netherlands	NUTS 2	2009[1]	OECD
Norway	NUTS 2	2009-2016	Eurostat
Poland	NUTS 2	2009[1]	Eurostat
Portugal	NUTS 2	2009; 2011-2016	Eurostat
Romania	NUTS 2	2009; 2011-2016	Eurostat
Sweden	NUTS 0	2009-2017	Eurostat
Slovakia	NUTS 2	2009-2016	Eurostat
UK	NUTS 2	2010-2016	OECD

Appendix 3. Correlation Matrix

	Birth Rate	Death Rate	Log of GDP per inhabitant	Education	Industrial Employment	Year
Birth Rate	1					
Death Rate	0.4231***	1				
Log of GDP per inhabitant	-0.1454***	-0.1760***	1			
Education	0.2747***	0.0322	0.6037	1		
Industrial Employment	-0.1730***	-0.0532	-0.5509***	-0.5572***	1	
Year	0.0461	-0.1075***	0.0708***	0.2750***	-0.0546**	1

*** p<0.01, ** p<0.05, * p<0.1

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Appendix 4 Year Results

Variables	Firm Birth Rate Models			Firm Death Rate Models		
	I	II	III	IV	V	VI
Birth Rate$_{t-1}$	0.34***	0.44***	0.22***	-0.22**	0.13***	0.02
	(-0.27)	(-0.04)	(-0.04)	(-0.10)	(-0.04)	(-0.04)
Birth Rate$_{t-2}$		0.14***	0.16***		0.06*	0.02*
		(-0.04)	(-0.04)		(-0.04)	(-0.04)
Birth Rate$_{t-3}$			0.20***			0.13***
			(-0.04)			(-0.04)
Death Rate$_{t-1}$	-0.05**	-0.04	0.01	0.78***	0.15***	0.25***
	(-0.01)	(-0.05)	(-0.07)	(-0.19)	(-0.06)	(-0.08)
Death Rate$_{t-2}$		0.39***	0.31***		0.30***	0.27***
		(-0.04)	(-0.06)		(-0.04)	(-0.07)
Death Rate$_{t-3}$			-0.03			0.02
			(-0.04)			(-0.05)
Log of GDP per inhabitant	-4.59E-03	-2.31e-03	5.28e-04	7.49e-04	-3.04e-03	1.00e-03
	(-3.61e-03)	(-2.55e-03)	(-3.18e-03)	(-0.01)	(-2.87e-03)	(-3.44e-03)
Education	4.63e-04**	3.58e-04**	1.72e-04	1.97e-04	1.67e-04	1.05e-04
	(-1.82e-04)	(-1.45e-04)	(1.68e-04)	(-1.99e-04)	(-1.56e-04)	(-1.90e-04)
Industrial Employment	-7.06e-04***	-2.51e-04*	-2.87e-04**	-3.64e-04***	-1.11e-04	1.53e-05
	(-1.48e-04)	(-1.32e-04)	(1.36e-04)	(-1.27e-04)	(1.38e-04)	(-1.68e-04)
Years						
2011	-1.15E-03	NA	NA	-4.96E-03	NA	NA
	(3.05E-03)			(0.01)		
2012	-1.74E-04	-0.01***	NA	-0.01	-0.01	NA
	(2.46E-03)	(3.76E-03)		(0.01)	(3.41E-03)	
2013	0.01***	3.26E-03	-2.64E-04	0.01	-0.01**	-0.01***
	(2.46E-03)	(3.49E-03)	(3.29E-03)	(0.01)	(3.21E-03)	(3.50E-03)
2014	0.01***	6.86E-04	5.68E-04	-1.54E-03	-0.01***	-0.01***
	(2.54E-03)	(3.57E-03)	(3.24E-03)	(0.01)	(3.33E-03)	(3.49E-03)
2015	0.01**	-3.29E-03	-2.86E-03	3.93E-03	-0.01***	-0.01***

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	(2.62E-03)	(3.68E-03)	(3.32E-03)	(0.01)	(3.40E-03)	(3.58E-03)
2016	0.01***	2.33E-03	-9.01E-04	0.01	-0.01***	-0.01**
	(2.59E-03)	(3.72E-03)	(3.45E-03)	(0.01)	(3.46E-03)	(3.74E-03)
2017	0.01***	0.01**	0.01	0.01	-0.01**	-3.74E-03
	(2.84E-03)	(3.87E-03)	3.64E-03	(0.01)	(0.01)	(0.01)

*** p<0.01, ** p<0.05, * p<0.1 Standard errors are reported in parentheses.

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Appendix 5 Interclass Correlation Estimates for Firm Birth and Death Rates Between Regional and National Level

Variable	Estimate	Std. Err.	Confidence Interval 99%	
Firm Birth Rate	0.33	0.09	0.15	0.58
Firm Death Rate	0.29	0.09	0.12	0.56

Appendix 6 Hypotheses Decisions

Hypothesis	**Definition**	**Decision**	**Effect**
H1a	*Firm births increase future firm births.*	Supported	Multiplier
H1b	*Firm births decrease future firm deaths.*	Supported	Multiplier
H1c	*Firm deaths increase future firm deaths.*	Supported	Multiplier
H1d	*Firm deaths decrease future firm births.*	Supported	Multiplier
H2a	*Firm births increase future firm deaths.*	Supported	Competition
H2b	*Firm births decrease future firm births.*	Not Supported	Competition
H2c	*Firm deaths increase future firm births.*	Supported	Competition
H2d	*Firm deaths decrease future firm deaths.*	Supported	Competition
H3	*Firm births increase future firm deaths.*	Supported	Marshall

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Appendix 7 Random Effects Parameters from Mixed Effects Estimation

The random effects parameter displayed above in Table 3 indicates that country effects play a statistically significant part in influencing the rate of firm births. The estimate value of 0.01 indicates that the firm birth rate varies from the grand mean firm birth rate by roughly 1%. Given that the confidence interval is not overlapping with '0', this indicates statistical significance at the 0.05 level of significance. Results for NUTS 2 regions indicate that region also plays a statistically significant role in influencing firm birth rates. The very low estimate value of 5.71e-10 indicates that the firm birth rate varies by less than 1% from the grand mean firm birth rate. However, given the confidence interval is not overlapping with '0' again indicates statistical significance at the 0.05 level of significance.

In the case of firm death rates, both country and NUTS 2 regions appear to play a statistically significant role in influencing firm death rates. The estimate value of 0.01 indicates that the firm death rate varies from the grand mean firm birth rate by roughly 1% and the confidence interval is not overlapping with '0' indicating statistical significance at the 0.05 level of significance. The very low estimate value of 8.06e-12 indicates that the firm death rate varies by less than 1% from the grand mean firm death rate. However again, the confidence interval is not overlapping with '0' indicating statistical significance at the 0.05 level of significance.

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Table 1 Variable Definitions

Variable:	Definition:	Source:
Firm Births	A firm birth amounts to the creation of a combination of production factors with the restriction that no other enterprises are involved in the event.	(OECD, 2020)
Firm Deaths	A death amounts to the dissolution of a combination of production factors with the restriction that no other enterprises are involved in the event.	(OECD, 2020)
Stock of Firms	The stock of firms is the total number of firms considered to be engaging in activity which is defined as any turnover and/or employment in the period from 1st January to 31st December in a given year.	(OECD, 2020)
Log of GDP	The natural log of Gross domestic product (GDP) at current market prices by NUTS 2 regions measured by Euro per inhabitant.	(Eurostat, 2019)
Education	Percentage of the active population (i.e. those in employment) which have a 3rd level International Standard Classification of Education (ISCE) qualification.	(Eurostat, 2019)
Industrial Employment	The percentage of employed persons who are working in the Industrial (except construction) NACE sector of the economy (B-E in NACE Rev. 2).	(Eurostat, 2019)

Source: (OECD, 2020; Eurostat, 2019) Note 1: Firm birhts and deaths are defined as per the Eurostat-OECD Manual on Business Demography Statistics.

Table 2 Mixed Effects Regression Results for Lagged Firm Birth and Death Rates

Variables	Births			Deaths		
	I	II	III	IV	V	VI

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Birth Rate$_{t-1}$,	0.34*** (-0.27)	0.44*** (-0.04)	0.22*** (-0.04)	-0.22** (-0.10)	0.13*** (-0.04)	0.02 (-0.04)
Birth Rate $_{t-2}$,		0.14*** (-0.04)	0.16*** (-0.04)		0.06* (-0.04)	0.02* (-0.04)
Birth Rate$_{t-3}$			0.20*** (-0.04)			0.13*** (-0.04)
Death Rate $_{t-1}$,	-0.05** (-0.01)	-0.04 (-0.05)	0.01 (-0.07)	0.78*** (-0.19)	0.15*** (-0.06)	0.25*** (-0.08)
Death Rate $_{t-2}$,		0.39*** (-0.04)	0.31*** (-0.06)		0.30*** (-0.04)	0.27*** (-0.07)
Death Rate$_{t-3}$			-0.03 (-0.04)			0.02 (-0.05)
Log of GDP per inhabitant	-4.59E-03	-2.31e-03	5.28e-04	7.49e-04	-3.04e-03	1.00e-03
	(-3.61e-03)	(-2.55e-03)	(-3.18e-03)	(-0.01)	(-2.87e-03)	(-3.44e-03)
Education	4.63e-04**	3.58e-04**	1.72e-04	1.97e-04	1.67e-04	1.05e-04
	(-1.82e-04)	(-1.45e-04)	(1.68e-04)	(-1.99e-04)	(-1.56e-04)	(-1.90e-04)
Industrial Employment	-7.06e-04***	-2.51e-04*	-2.87e-04**	-3.64e-04***	-1.11e-04	1.53e-05
	(-1.48e-04)	(-1.32e-04)	(1.36e-04)	(-1.27e-04)	(1.38e-04)	(-1.68e-04)
Model P Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Model chi2 Statistic	189.58	35.44	120.77	41.52	54.00	78.92
Model P Value chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

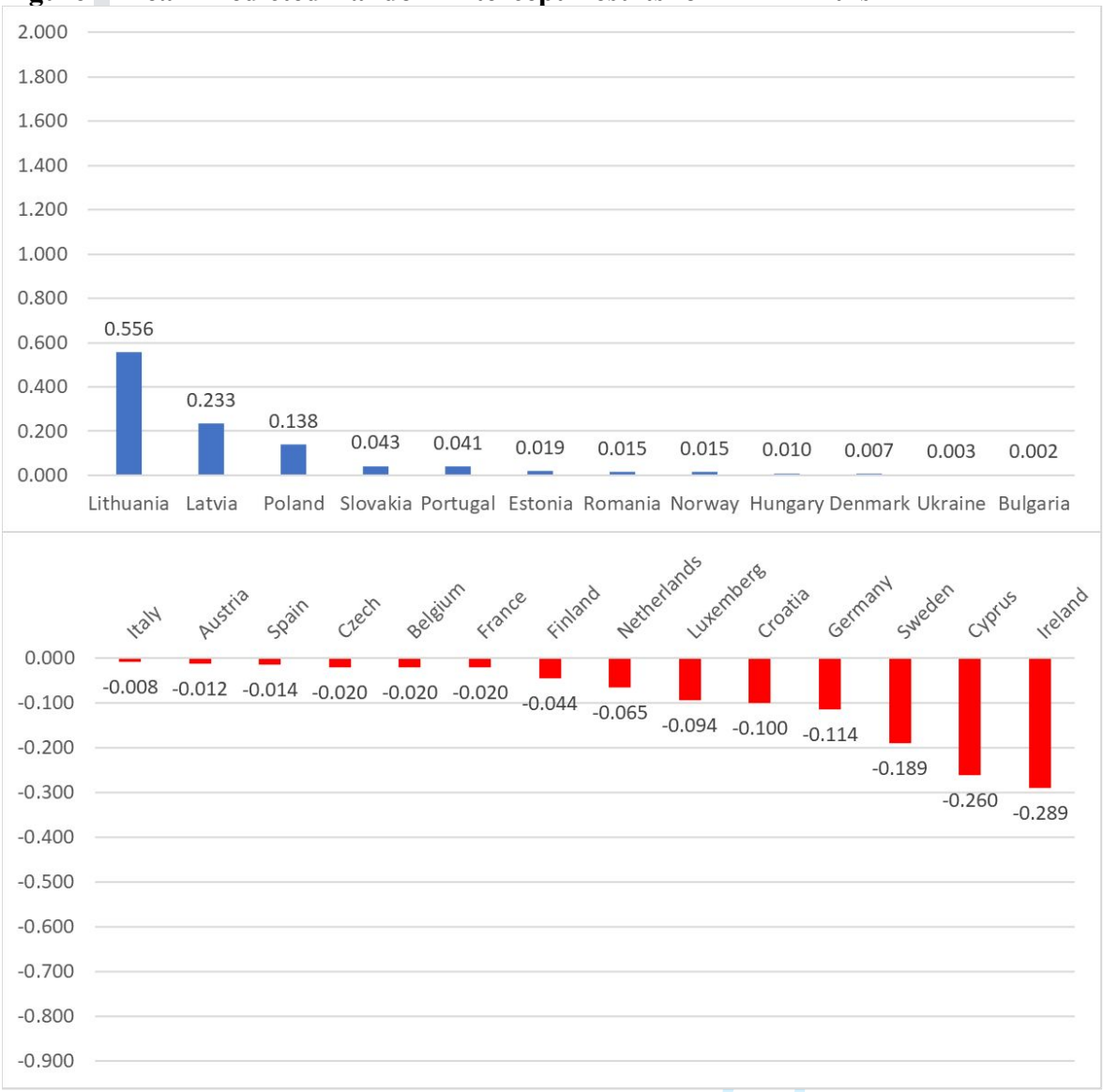
Random-effects Parameters for Birth Rate	*Estimate*	*Std. Err.*	*[95% Confidence Interval]*	
Country	0.01**	2.15e-03	0.01	0.02
Region	5.71e-10**	1.11e-09	1.27e-11	2.56e-08

Random-effects Parameters for Death Rate	*Estimate*	*Std. Err.*	*[95% Confidence Interval]*	
Country	0.01**	2.2e-03	0.01	0.02
Region	8.06e-12**	1.45e-11	2.35e-13	2.76e-10

*** p<0.01, ** p<0.05, * p<0.1 Standard errors are reported in parentheses. Year fixed effects are included in this estimation (see Appendix 4)

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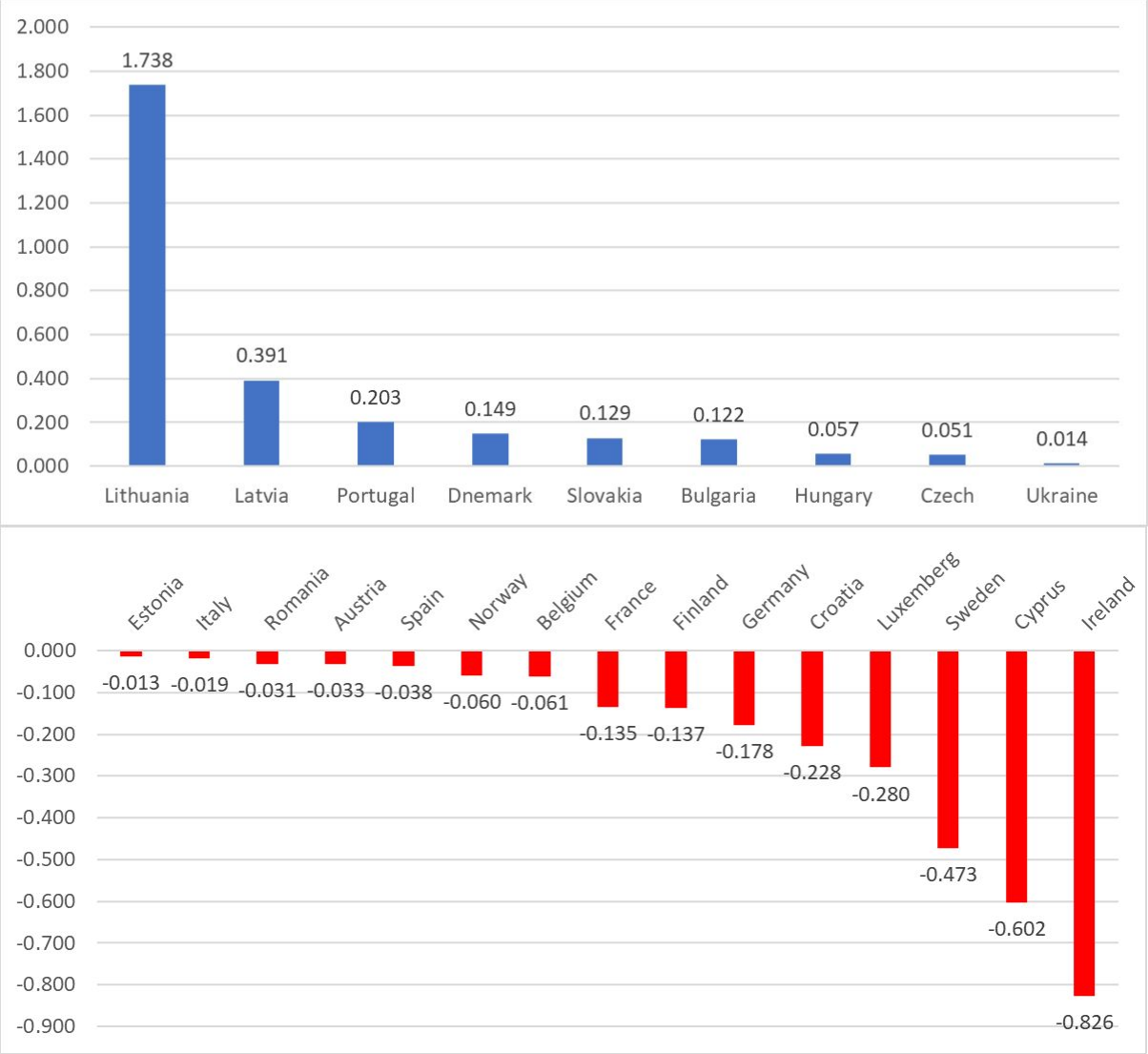
Figure 1 Mean Predicted Random Intercept Results for Firm Births



Note: All values are rounded to three decimal places.

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Figure 2 Mean Predicted Random Intercept Results for Firm Deaths



Note: All values are rounded to three decimal places.

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Responses to the comments to the authors

Referee 1

Comment R1.1.

Comments to the Author
Thanks for inviting me to read and assess this paper. While the paper has some interesting aspects, the core idea and insights from this paper does not seem to be totally clear. Below I have noted some of the main issues and questions that arose from reading your paper.

Response R1.1.
We would like to thank you for taking the time to read our paper and for providing detailed comments on it. We are glad that you found it interesting in parts and we hope that our responses and changes to the manuscript now make the core ideas/insights of the paper clearer. This paper provides two core insights to the literature.

This paper investigates the nature of firm interrelationships across European Regions from a multilevel perspective (country and regional) and addresses the following research questions:

(1) How do firm births and deaths influence future firm births and deaths across European countries and regions?
(2) Are certain types of firm interrelationships (multiplier or competition effects) manifest over certain time periods (1, 2 and 3 years)?

In addressing these two research questions, the paper adds to the literature in two ways.

(1) The paper provides insight into firm interrelationships while analysing regional factors and controlling for the influence of country on both firm births and deaths. Conceptually, regional factors can influence firm birth/death activity. The triple helix system emphasises the importance of regional university, industry and government factors in influencing regional entrepreneurship (Kim *et al.*, 2012). Multiple regional studies also show regional human capital, economic performance and employment share influence firm births (Alamá Sabater *et al.*, 2011; Felan *et al.*, 2021; Audretsch *et al.*, 2011) and firm deaths (Acs *et al.*, 2007; Manjón-Antolín and Arauzo-Carod, 2008; Renski, 2015). While many regional studies do account for these factors, they don't control for the influence of country because they typically examine in a single-country context – see Arcuri *et al.* (2019) and Bishop (2019) for examples. Controlling for the role which country plays in determining firm births and deaths is important because national factors can influence this as well. Country-level factors like laws & taxes, business loan subsidies and public financing can influence firm births/deaths (Harrison and Kanter, 1978; Yang *et al.*, 2018). Additionally, laws and fiscal policies can also play a part in determining firm birth/death activity (Fox and Murray, 2019; Kieschnick, 1981; Darooghe Arefi *et al.*, 2022). By conducting a regional analysis which also controls for the role of country in firm births/deaths, this paper helps provides greater insight into the firm interrelationships literature.

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(2) The paper also provides insight into the nature of firm interrelationships over time. Frequently firm interrelationships look to analyse competition and multiplier effects over a one-year period of time – see Arcuri *et al.* (2019) for example. This method assumes that if multiplier and competition effects occur, they are observable within a year. Meaning that firm births induced by multiplier or competition effects and/or firm deaths induced by multiplier or competition effects both take place within a year. Conceptually, this may not be the case as the firm birth process is a multi-stage process which takes time to occur (Stayton and Mangematin, 2016; De Koning and Muzyka, 1996). Additionally, competitive pressures intensify over time (Dou *et al.*, 2021) and as a result firm deaths resulting from rivalry may take time to manifest. By using lag lengths of 1, 2 and 3 years this paper allows us to observe competition and multiplier effects over time and account for this intertemporal aspect.

Through addressing these gaps in the literature it provides the following insights. Firstly, the paper provides insight into the nature of firm interrelationships over time. Firm births are found to induce future firm births across European regions via multiplier effects. However, when interrelationships are analysed over 2- and 3-year periods of time, evidence of competition effects are also found. These include firm births increasing firm deaths and firm deaths increasing firm births over 2-year periods. The observed multiplier effects suggest that stimulating firm births would induce more firm births in the future which can be seen as a positive for policy strategies which seek to utilise entrepreneurship to achieve economic growth like the Smart Specialisation Strategy (S3) (Laranja, 2022). However, the observed competition effects suggest that over time the stimulation of firm births may induce more negative or 'crowding-out' effects and increase firm deaths. These results emphasise that increased attention should be paid to the period of time which firm interrelationships are examined over as multiplier effects appear to be more immediately observable than competition effects.

Secondly, the paper also provides insights into how both firm birth and death activity can be influenced by both country and region. Results indicate there is significant variations in firm birth/death activity across European regions and countries. Lower performing Eastern European economies exhibit greater levels of 'turbulence' or 'flux' and have relatively high rates of both firm births and deaths. Some higher performing Western European Economies appear to have lower firm birth rates, but also have relatively low rates of firm death. Potentially indicating Western European economies may have lower amounts of market room as a result of lower death rates which may reduce firm births (Carree and Dejardin, 2020). Regional strengths also appear to influence firm birth/death activity. Education rates are found to significantly influence firm births at a regional level. This potentially provides evidence to support findings that knowledge or human capital stock within regions positively influences regional firm births as per Ayob (2019). Additionally, higher rates of employment in industrial sectors are found to reduce both firm births and deaths. This suggests there maybe specialisation-induced externalities which influence regional firm births and deaths through the colocation of similar firms which operate in the same sector. Positive localisation externalities may reduce firm deaths (Basile et al., 2017). Over time through, the lack of diversity within the region may then impede the transfer of different knowledge and fail to lead to the generation of new ideas due to cognitive lock-in issues (Crowley et al., 2021). Diversification of a region is thought to better

facilitate new knowledge transfer and positively influence firm births as per the findings of Bishop (2012).

Comment R1.2.

Introduction and positioning:
The introduction is written a bit odd. Section 2 and 3 blends what this paper does (in great lengths) with the gaps in the literature. This makes it quite hard to follow. The editorial by Barney (2018) may help you in being clearer; presenting the gaps, before presenting how you would contribute to resolving/answering these gaps.

Response R1.2.
Thank you for this comment.

We have reviewed Barney (2018) thoroughly and have amended the introduction to follow the style suggested. Please see a step-by-step breakdown of how we have done this with reference to the instructions of Barney (2018). For clarity, we provide quotes from Barney (2018) below in italics followed by our reworking of the introduction.

We would like to thank the reviewer for this helpful guidance and now feel that the introduction is much improved. We hope that you consider it to be better structured, carefully describing the core ideas and insights of the paper much more clearly.

Barney (2018) comments on the first sentence of the first paragraph as follows:
"an author must make it clear to the reader what conversation their paper proposes to join; thus, the first sentence of the paper must make this clear to the reader. In the case of this essay, the conversation focuses on "how to write and publish theory papers in top management journals… However, it can be appropriate to start an empirical paper with a brief description of the phenomenon that is being studied" (Barney 2018, pg. 345)

In following this style, we have altered the first sentence of our paper so that the core focus of the paper is clear. This is reproduced for your convenience directly below.

> 'This paper concerns itself with the investigation of interrelationships between firm births and deaths. These are instances where firm births/deaths influence future rates of firm births/deaths (Carree *et al.*, 2011; Gajewski and Kutan, 2018). The theoretical framework for this paper is set out in Johnson and Parker (1994) who conceptualise the different types of firm interrelationships which can occur between firm births and deaths. They refer to these effects as the multiplier and competition effects. The multiplier effect occurs in situations where firm births increase future births (and decrease future deaths) or where firm deaths increase future deaths (and decrease future births) (Lu *et al.*, 2008; Resende *et al.*, 2015). Contrastingly, the competition effect occurs when firm births increase future deaths (and decrease future births) or when firm deaths increase future births (and decrease future deaths) (Carree *et al.*, 2011; Pe'er and Vertinsky, 2008).' - [Page 2, paragraph 1, line 27-37]

Barney (2018) recommends that the rest of the first paragraph considers the following:

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"After making it clear what conversation their paper proposes to join, the author must convince the reader—especially a reader with expertise in this conversation— that they have been paying attention to this conversation's main find- ings and conclusions. This does not require a literature review. Rather, it requires two or three sentences that summarize a conversa- tion's main research traditions, along with the most important results associated with those traditions." (Barney 2018, pg. 346)

In following this second guideline, we include the following three sentences at the end of paragraph 1.

> 'Findings within this literature are mixed with some supporting the competition effect (Gajewski and Kutan, 2018; Nyström, 2007) and others supporting the multiplier effect (Lu *et al.*, 2008; Resende *et al.*, 2015). Many firm interrelationship studies analyse the determinants of either firm births or firm deaths in isolation. Meaning they examine how past firm births and deaths influence future firm births *or* future firm deaths but not both - see Arcuri *et al.* (2019) and Calá *et al.* (2016). While these studies provide detailed insights into how firm interrelationships influence firm births or firm deaths separately, they come at the expense of a fully comprehensive analysis of how firm interrelationships influence both firm births and deaths.' - [Page 2, paragraph 1, line 37-45]

Barney (2018) recommends that second paragraph details *"an unresolved theoretical issue in the received literature and then to demonstrate why this unresolved issue is important… While not denying the importance of the work cited in the first paragraph, the second paragraph must establish a legitimate reason for writing a new theory paper. Usually, that reason is to re- solve a theoretical issue that has not been re- solved in the received literature. Thus, the rest of the second paragraph must first identify this issue and then explain why it is important."* (Barney 2018, pg. 346)

In following this third guideline, our second paragraph now details the unresolved theoretical issues and why it is important to address these. The theoretical issues in this case pertain to:

(1) the theoretical disregard for the influence of both country and region in influencing firm interrelationships. National factors like laws and taxes, business loan subsidies and public financing can influence firm births/deaths (Harrison and Kanter, 1978; Yang *et al.*, 2018). Other authors point to the influence of legislative and fiscal paradigms (Fox and Murray, 2019; Kieschnick, 1981; Darooghe Arefi *et al.*, 2022). Additionally, many in the literature stress the importance of institutions (Baumol, 1996; North, 1990). The above means that the country firms operate in can influence their birth and death. Likewise, regional factors can also influence entrepreneurial activities. The triple helix system (university-industry-government) influences regional entrepreneurship (Kim *et al.*, 2012). Multiple regional studies have found that regional factors like human capital, economic performance and employment share influence firm births (Alamá Sabater *et al.*, 2011; Felan *et al.*, 2021; Audretsch *et al.*, 2011) and firm deaths (Acs *et al.*, 2007; Manjón-Antolín and Arauzo-Carod, 2008; Renski, 2015). Therefore, conceptually both regional and national influences should be controlled for when examining firm interrelationships. However, this is rarely done. As Audretsch et al. (2019) points

out, the approach of most research in this area is either cross-country or regional analysis. This means the literature has many studies which examine the influence of region or the influence of country, but few which examine both. We uniquely examine how firm interrelationships are influenced by regional factors while controlling for the effect of country.

(2) the theoretical assumption of most firm interrelationship studies is that multiplier and competition effects manifest and can be observed within one year. Theory suggests multiplier and competition effects may take longer than this to occur (Nyström, 2007). For example, multiplier effects whereby firm births induce more firm births via signalling/demonstration effects as per Dejardin (2004) involves firm births signalling the economic value associated with starting a firm to others. Thus, firms being born signals to others that starting a firm is a good idea. However, the firm birth process is a multi-stage iterative process which begins with idea generation/identification and progresses gradually towards the birth of a firm (Bhave, 1994; De Koning and Muzyka, 1996; Stayton and Mangematin, 2016). Therefore, multiplier effects may take longer than one year to manifest and thus cannot be observed by only looking at one year. Additionally, competition effects where firm births induce firm deaths via competitive pressures may also not manifest immediately as rivalry between firms intensifies over time (Dou *et al.*, 2021). Thus, competition effects may take longer than a single year to manifest.

Now that these theoretical issues have been properly identified we state them, explain them and discuss why it is important to address them in our introduction which we provide for your convenience below.

> 'There has been a tendency in firm birth research to focus on certain types of analysis. Audretsch et al. (2019) highlights two distinct streams of study: (i) cross-country; and (ii) regional. This is apparent in firm death research as well (Muzi *et al.*, 2022; Ebert *et al.*, 2019). While cross-country analyses have value, their aggregate nature omits important nuanced factors which has seen Audretsch *et al.* (2019) ask for research concerned with entrepreneurial activities to consider "the hierarchical spatial structure of entrepreneurship determinants" (pg. 249). Theoretically, this is important because regional factors influence entrepreneurial activities. The influence of the triple helix system (university-industry-government) on regional entrepreneurship illustrates this (Kim *et al.*, 2012). Human capital, economic performance and employment share can all influence firm births (Alamá Sabater *et al.*, 2011; Felan *et al.*, 2021; Audretsch *et al.*, 2011) and firm deaths (Acs *et al.*, 2007; Manjón-Antolín and Arauzo-Carod, 2008; Renski, 2015). However, these factors would not be captured in aggregated national studies. Regional analyses will account for these factors but this comes at the expense of controlling for relevant country specific effects as regional studies do not typically examine multiple countries (Spigel, 2017; Spigel, 2016). Differences in fiscal paradigms, legislation and institutions/government policies can all influence firm births/deaths (Bartik, 1989; Harrison and Kanter, 1978; North, 1990; Yang *et al.*, 2018; Darooghe Arefi *et al.*, 2022). While we cannot analyse the effects of these specific factors due to data limitations, we can control for the influence of country in our estimation. Thus, we can contribute towards this methodological knowledge gap within the literature by conducting an analysis of firm birth and

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death interrelationships while controlling for regional factors and the influence of country. This will allow for cross-national comparisons of firm birth and death activity which Terjesen *et al.* (2016) and Reynolds (1991) advocate. Additionally, both Neumann (2021) and Fritsch and Noseleit (2013) have emphasised the importance of future research analysing the medium-term as well as short-term impact of entrepreneurship on future economic outcomes. This can be considered important given that the firm birth process can be a multi-stage one (Stayton and Mangematin, 2016) and competitive pressures from rival firms intensify over time (Dou *et al.*, 2021). This means firm births resulting from multiplier effects or firm deaths resulting from rivalry may take time to manifest. Despite this, many studies use exclusively one-year lag lengths to assess multiplier and competition effects – see Arcuri *et al.* (2019). We also contribute to this knowledge gap by using up to 3-year lag lengths of firm births and deaths.' - [Page 2, paragraph 2, line 46-76]

Barney (2018) recommends that the third paragraph initially details the purpose of the paper. He wrote *"*[the third paragraph] *is where the author presents the central research question their paper seeks to answer. This is done without subtlety, using a simple, short, de- clarative sentence that tells the reader what question the paper is going to answer. Of course, the answer to this question—to be developed in the paper—must resolve the theoretical issue identified in the second paragraph."* (Barney 2018, pg. 346)

In following this fourth guideline, our third paragraph now starts with the following declarative statements regarding the specific research questions of this paper:

'The research question of this paper asks how firm births and deaths influence future firm births and deaths across European countries and regions. Analysing this question provides evidence on whether multiplier or competition effects are present across European regions and countries. Additionally, the paper also asks if certain types of firm interrelationships (multiplier or competition effects) manifest over time (1, 2 and 3 years).' - [Page 4, paragraph 2, line 77- 81]

Barney (2018) recommends that the rest of the third paragraph provides *"a pre- view of how the paper answers its research question and some of the critical implications of this answer."* (Barney 2018, pg. 347). This extract addresses this point.

'Utilising Eurostat and OECD data, we assemble an unbalanced panel data set concerned with firm births from 205 regions across 26 countries and firm deaths from 178 regions across 24 countries during the period 2008 to 2017. We then estimate a multilevel mixed effects regression to analyse the extent to which firm births and deaths influence future firm births and deaths. Control variables capturing macroeconomic performance, industrial employment and human capital are also accounted for. In doing this, we contribute to the relatively scarce literature on cross-country studies (Audretsch and Belitski, 2017; Hundt and Sternberg, 2016) while also explicitly considering regional factors and providing additional insights on the regional determinants of firm birth and death activity as called for by Arcuri *et al.* (2019). Furthermore, our use of up to 3-year lag lengths of firm births and deaths allows for a more complete

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picture of the interrelationships between firm births/deaths over time. Increased lag lengths allow us to see whether the competition effect dominates as is evident in other studies (Gajewski and Kutan, 2018) and/or whether this dominance changes over time.' - [Page 4, paragraph 2, line 81-94]

Comment R1.3.

The theory section has limited linkage to the wider debate on entrepreneurial policies etc, which you seem to try to link to in the contributions/implications. This could aid in getting the discussion more linked to what you are exploring. And what you are pursuing in this paper is not clear. Presenting a clear research question in the introduction can help you with that as well.

Response R1.3.

Regarding the use of a clear research question in the introduction, we have now included the below and feel it has improved the clarity of the manuscript. The paper looks to provide key insights into the firm interrelationship's literature. It does this in two main ways. Firstly, it adopts a method of assessment which allows for analysing firm births and deaths while also controlling for regional-level factors and the context of country. This is important considering that both national and regional factors can play a role in influencing firm births and deaths (Arcuri *et al.*, 2019; Bishop and Shilcof, 2017; Audretsch *et al.*, 2019), but entrepreneurial literature appears to have a clear divide of regional studies within a single country (Carree and Dejardin, 2020; Basile *et al.*, 2017) or cross-country national studies which can't account for regional factors (Fernández-Serrano *et al.*, 2018). Secondly, the paper provides insights relating to the temporal aspects of multiplier and competition effects. The firm births process is a multi-step process which may not be instantaneous (Stayton and Mangematin, 2016). Additionally, competitive pressures intensify over time (Dou *et al.*, 2021). This means that firm births which emerge as a result of multiplier effects or the firm deaths which occur as a result of competition effects may take longer than one year to manifest. We want to account for this in our analysis of competition and multiplier effects. We feel our research question now reflects this and provides a clear outline of what the paper hopes to achieve.

'The research question of this paper asks how firm births and deaths influence future firm births and deaths across European countries and regions. Analysing this question provides evidence on whether multiplier or competition effects are present across European regions and countries. Additionally, the paper also asks if certain types of firm interrelationships (multiplier or competition effects) manifest over time (1, 2 and 3 years).' - [Page 4, paragraph 2, line 77- 81]

Thank you for this comment. We have now included discussions relating to wider debates on entrepreneurial policies in the theory section by adding 6 new references on the topic into the theory section. These are listed below and followed by extracts of their use. We hope that this rectifies the issue. Just to note we also follow up on these arguments in the results and conclusion sections.

1. Audretsch, D. B., Hülsbeck, M. and Lehmann, E. E. 2012. Regional competitiveness, university spillovers, and entrepreneurial activity. *Small business economics,* 39**,** 587-601, DOI: https://doi.org/10.1007/s11187-011-9332-9.

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2. Cumming, D. and Johan, S. 2019. Government venture capital research: fake science and bad public policy. *Venture Capital,* 21**,** 121-131, DOI: https://doi.org/10.1080/13691066.2018.1558508.
3. Cumming, D., Johan, S. and Macintosh, J. G. 2017. A drop in an empty pond: Canadian public policy towards venture capital. *Economia e Politica Industriale,* 44**,** 103-117, DOI: https://doi.org/10.1007/s40812-016-0063-4.
4. Cumming, D. and Li, D. 2013. Public policy, entrepreneurship, and venture capital in the United States. *Journal of Corporate Finance,* 23**,** 345-367, DOI: https://doi.org/10.1016/j.jcorpfin.2013.09.005.
5. Tuszynski, M. P. and Stansel, D. 2018. Targeted state economic development incentives and entrepreneurship. *Journal of Entrepreneurship and Public Policy,* 7**,** 235-247, DOI: https://doi.org/10.1108/JEPP-D-18-00033.
6. Zikou, E., Varsakelis, N. and Sarri, A. K. 2017. Does public sector crowd out entrepreneurship? Evidence from the EU regions. *International Journal of Entrepreneurial Behavior & Research,* 24**,** 866-881, DOI: https://doi.org/10.1108/IJEBR-03-2017-0100.

"The multiplier effect occurs when (i) firm births increase future firm births (and decrease future firm deaths) or when (ii) firm deaths increase future firm deaths (and decrease future firm births) (Lu *et al.*, 2008; Resende *et al.*, 2015). Organisations like the ERDF and Business Europe seek to increase firm births via investment and lobbying for greater investment in firms (BE, 2020; EC, 2020a). Within the literature some express concerns that public sector investment and incentive schemes may potentially crowd out regional entrepreneurship (Zikou *et al.*, 2017; Audretsch *et al.*, 2012). Others suggest that incentive programmes may actually reduce firm births (Tuszynski and Stansel, 2018).Theoretically, finding the multiplier effect should alleviate some of these concerns because it asserts that firm births should increase future firm births and decrease future firm deaths at a regional level (Kangasharju and Moisio, 1998)."- [Page 5, paragraph 2, line 111-120]

"The competition effect acts as a counterpoint to the multiplier effect. The competition effect exists when (i) firm births increase future firm deaths (and decrease future births) or when (ii) firm deaths increase future births (and decrease future deaths) (Carree *et al.*, 2011; Pe'er and Vertinsky, 2008). Findings relating to competition effects can be considered of great importance because they provide insight into how the stimulation of entrepreneurship will influence future rates of firm birth and deaths. The role of public policy in influencing firm births and deaths is a central question within entrepreneurial literature (Cumming and Li, 2013). Policy makers and industrial agencies seek to provide support for firms which could reduce firm deaths and maintain levels of competitiveness and growth within the economy (EC, 2020b; EI, 2021). Some within the literature express fears that public investment could crowd out or displace private investment (Cumming and Johan, 2019). Some evidence finds support for this concern (Cumming *et al.*, 2017). Theoretically, competition effects mean that firm births could be likely to occur following a period of firm deaths (Johnson and Parker, 1996). Public investment looking to increase regional firm births following a period of firm deaths could therefore

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conceptually be seen as inducing firm births which may have occurred anyway if a competition effect is present.'- [Page 7, paragraph 1, line 154-169]

Contributions/implications.

Comment R1.4.
The abstract mention that the findings "validating the importance of more decentralised regional based entrepreneurial policies which has implications for policies like…" However, this is not discussed in the paper, except mentioned in the third paragraph in the conclusion (see next point).

Response R1.4.
Thank you for pointing this out to us. An important aspect of this paper is the validation its findings provide for more decentralised regional based entrepreneurial policies. We agree that it should come out more in the manuscript. In addition, to the discussion in the conclusion we have also added a paragraph discussing the implications for regional policy in the results section which can be seen below. Additionally, as per our previous responses to Comment R1.4, discussion on policy has also been added into the theory section as per your request. We hope that this rectifies the issue to a satisfactory conclusion for you.

This is the section we inserted into the Implications for Policy Subsection 5.3. in the manuscript.

"The ERDF and the Cohesion Fund seek to enhance rates of sustainable growth and job creation by investing into start-ups firms and SMEs (EU, 2021). Other industrial agencies like Business Europe look to achieve similar goals via lobbying for investment (BE, 2020). Our findings have three implications for them. Firstly, evidence for both the multiplier and competition effects are found across all models. This means that firm births appear to increase future firm births, but evidence is also found that over longer time periods firm births can also increase future deaths. Investment into start-ups can therefore be viewed as a positive vehicle for inducing entrepreneurial growth in the immediate future, but it should be noted that over longer periods more negative crowding out-type effects discussed by Zikou *et al.* (2017) are also observable. Secondly, greater rates of 3rd level education appear to increase firm births. This emphasises the potential role human capital can have in regional idea generation and entrepreneurship. It also shows that the ERDF's goal of improving equal access to quality education services does not only promote social inclusivity, but also firm births. This is in line with other empirical findings from Breznitz and Zhang (2022) and Qian *et al.* (2013). Thirdly, higher levels of employment in the industrial sector appear to negatively influence both firm births and deaths within regions. This suggests that having a large amount of a regions' employment share in industrial sectors reduces firm deaths and firm births. Conceptually, this could be because the industrial employment variable captures the degree of specialisation in a region. Collections of firms which all operate in similar industries could produce localisation externalities which may reduce future firm deaths (Basile *et al.*, 2017). The reduction in firm births could be

explained by a lack of diversity which impedes the transfer of different types of knowledge and reduces idea generation due to cognitive lock-ins (Crowley *et al.*, 2021). More diversified regions may better facilitate new knowledge transfer and increase firm births as per Bishop (2012). This finding is of relevance to European Smart Specialisation strategy (S3) which focuses investment into a region's 'relative strengths' to improve economic growth (EC, 2014). Focusing on a regions' relative strengths may make regions more specialised with larger shares of their employment in a certain industry. Our findings suggest this could help reduce firm deaths but also reduce firm births. Decentralised policies, like the S3 strategy (Laranja, 2022), would allow policymakers to harness the benefits of specialised investment into certain prominent sectors within regions. Meaning, as Hausmann and Rodrik (2006) said, policy makers could be 'doomed to choose' between reducing firm deaths and increasing firm births." - [Page 17, paragraph 1, line 383-414]

Comment R1.5.

The paper provides limited implications. The third paragraph in the conclusion provide an important implication. However, I think believe you should be able to tease out more implications from the results than this point, and especially to get a richer discussion of your findings towards prior literature.

Response R1.5.

Thank you for this comment. Please see below extracts from the reworked manuscript which discuss other implications we have now teased out.

The below extract now appears in the introduction. Here we more explicitly outline the implications which our study produces for the literature by increasing the length of time we examine firm interrelationships over. We reference Neumann (2021) and Fritsch and Noseleit (2013) who have both previously called for research to consider the importance of entrepreneurship influencing economic outcomes over the medium-term as well as the short-term. We also explain that doing this allows us to observe which firm interrelationships become apparent over time which is an important implication for the literature as it tends to focus on analysing this over just one year.

"Furthermore, our use of up to 3-year lag lengths of firm births and deaths allows for a more complete picture of the interrelationships between firm births/deaths over time. Increased lag lengths allow us to see whether the competition effect dominates as is evident in other studies (Gajewski and Kutan, 2018) and/or whether this dominance changes over time." [Page 4, paragraph 2, line 90-94]

The following two extracts also now appear in the conclusion section. The first paragraph explains the implications which can be derived from our findings regarding firm interrelationships. This includes implications for policy makers and public investment schemes in light of concerns some in the literature raise regarding crowding out effects. We explain how our finding of the multiplier effect (births inducing births) bodes well for these policies. However, observing that competition effects can emerge over longer time periods speaks to the potential negative consequences of stimulating

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firm births. In the second paragraph below, we show new discussion on the implications of some of our control variables. This includes the positive influence of education on firm births as well as the influence of industrial employment in reducing firm births and deaths. We hope that doing this has provided a much richer discussion of the implications coming from our work.

> "This paper examines the extent to which firm births and deaths influence future firm births and deaths across European regions through competition, multiplier and Marshall effects. The results indicate that the multiplier effect is the dominant effect. Meaning that across all models, the coefficients indicating the presence of the multiplier effect are more prevalent or greater in size than the coefficients indicating the presence of the competition effect. Evidence for the multiplier effect was found through firm births increasing future births. However, evidence for the competition effect can also be found when two- and three-year lag lengths are added to the model. Indicating that both effects can be observed but that the multiplier effect can be observed more immediately than the competition effect. This provides important insights for public policy initiatives looking to increase firm births. Some express concerns that government investment ends up 'crowding out' or reducing entrepreneurship (Zikou *et al.*, 2017; Cumming and Li, 2013). Others find support for policy initiatives looking to increase firm births (Tuszynski and Stansel, 2018; Bruce and Deskins, 2012). These mixed findings are why it has been suggested that bespoke interventions are required to positively influence entrepreneurial conditions (Brown and Mason, 2017). Our findings suggest that inducing firm births is not straightforward. Multiplier effects are observed over one year but as time lapses we begin to see evidence of competition effects whereby firm births can increase firm deaths. Therefore, industrial support agencies must be mindful of both the positive effects and more negative 'crowding out' effects discussed by Zikou *et al.* (2017).' - [Page 18, paragraph 2, line 416-434]

> "Other implications from this analysis include the positive association which third level education has on firm birth rates. This could be attributable to university education positively influencing a regions' entrepreneurial ecosystem and fostering greater rates of firm births (Breznitz and Zhang, 2022; Wright *et al.*, 2017). Additionally, the results show that regions with larger shares of employment in industrial sectors have reduced firm birth and death rates. Conceptually, this could be explained by the industrial employment variable capturing the degree to which a region is specialised. Collections of similar firms which operate in a certain industry could produce positive localisation externalities reducing firm deaths (Basile *et al.*, 2017). However, the lack of diversity within a specialised region may impede on the transfer of different knowledge and fail to lead to the generation of new ideas due to cognitive lock-in issues (Crowley *et al.*, 2021). Diversification of a region may better facilitate new knowledge transfer and increase firm births as per the findings of Bishop (2012). This finding is of key relevance to the European Smart Specialisation strategy which focuses investment into a region's 'relative strengths' to improve economic growth (EC, 2014). Focusing on the relative strengths of a region may reduce firm deaths but come at the expense of also reducing firm births."- [Page 19, paragraph 2, line 447-462]

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Comment R1.6.
Page 3, line 10 you mention a knowledge gap on the "influence on country specific factors on firm dynamics". However, are you really filling this knowledge gap?

Response R1.6.
Thank you for this comment. The paper's multilevel mixed effects estimation allows for the controlling of regional and national effects. Our manuscript explains that firm interrelationship studies accounting for national effects are not in great abundance within the current literature and it is important to account for them. While we do not explicitly account for national-type variables like institutional quality or fiscal policies, these are to a certain degree captured in the national effects. So it can be said that our estimation approach contributes towards a methodological knowledge gap within firm births/deaths literature. While we cannot explicitly measure national-type variables like institutional quality or fiscal policies due to limited data availability from the OECD and Eurostat database, we can control for the role of country in our estimation. Given this, we amend the sentence accordingly and no longer state we are contributing to the knowledge gap on how national factors affect firm births/deaths. Instead, we will emphasise that our estimation allows for the controlling of the national influence which is not done in other firm interrelationship studies to date. Please see the amended sentence below.

> "Regional analyses will account for these factors but this comes at the expense of controlling for relevant country specific effects as regional studies do not typically examine multiple countries (Spigel, 2017; Spigel, 2016). Differences in fiscal paradigms, legislation and institutions/government policies can all influence firm births/deaths (Bartik, 1989; Harrison and Kanter, 1978; North, 1990; Yang *et al.*, 2018; Darooghe Arefi *et al.*, 2022). While we cannot analyse the effects of these specific factors due to data limitations, we can control for the influence of country in our estimation. Thus, we can contribute towards this methodological knowledge gap within the literature by conducting an analysis of firm birth and death interrelationships while controlling for regional factors and the influence of country. This will allow for cross-national comparisons of firm birth and death activity which Terjesen *et al.* (2016) and Reynolds (1991) advocate." - [Page 3, paragraph 1, line 58-68]

Comment R1.7.
Relatedly, you next on line 17-28, page 3, mention factors such as "government regulations/funding educational institutions, and entrepreneurial culture can affect firm dynamics. However, are you really filling this knowledge gap?

Response R1.7.
Thank you for pointing this out. Mentioning these factors made it seem as if we were looking to examine their influence on firm births/deaths. Considering this, we are now careful to specify that we are only discussing these factors so as to establish that there is a conceptual reasoning for controlling for the influence of country in our regional analysis. We state explicitly that we do not analyse the impact of these specific factors, but rather control for the role of country using random effect parameters in our estimation. Thus, allowing us to observe variations in firm birth/death activity across

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countries. We have included the text below where we mention this and also state explicitly that we do not control for these national factors specifically but attempt to capture their influence by controlling for country. Thus, assuring transparency in our asserted contribution. We hope this is satisfactory.

> "Differences in fiscal paradigms, legislation and institutions/government policies can all influence firm births/deaths (Bartik, 1989; Harrison and Kanter, 1978; North, 1990; Yang *et al.*, 2018; Darooghe Arefi *et al.*, 2022). While we cannot analyse the effects of these specific factors due to data limitations, we can control for the influence of country in our estimation. Thus, we can contribute towards this methodological knowledge gap within the literature by conducting an analysis of firm birth and death interrelationships while controlling for regional factors and the influence of country. This will allow for cross-national comparisons of firm birth and death activity which Terjesen *et al.* (2016) and Reynolds (1991) advocate." - [Page 3, paragraph 1, line 60-68]

Firm dynamics:

Comment R1.8.

As an innovation/entrepreneurship scholar, I found the term firm dynamics to be a bit off. Because the paper does not go into any dynamics of how/why firms are created, develops and/or dies. Hence, I tried to look if this is an established term or not. And it seems to be used, but often related to why firms are born or die, with variables such as cyclicality, regulations etc.

Response R1.8.

Thank you for this comment. As you rightly point out, some studies which examine firm births and deaths in the context of cyclicality do use the term 'firm dynamics' (Clementi and Palazzo, 2016). We were using the term to solely to refer to firm births and deaths as is done by Bottasso *et al.* (2017) and Sutaria and Hicks (2004). However, given that this may spark confusion for wider audiences we now simply use the term 'firm birth/deaths' to refer to the creation of and closing of businesses respectively. This is in line with other authors like Jauregui *et al.* (2021), Bishop and Shilcof (2017) and Anyadike-Danes *et al.* (2005). Just to note, the term ' firm interrelationships' is used to refer to the influential relationships between firm births and deaths over time as is done in the seminal piece by Johnson and Parker (1994). However, in light of the Reviewers' comment we will instead opt for the use of the terms "firm births/deaths" or "firm interrelationships" for the sake of clarity. We hope this solves the issue to your satisfaction.

Comment R1.9.

In the first sentence, you reference Hundt and Sternberg (2016), but the term firm dynamics are not used in their paper.

Response R1.9.

Thank you for this comment. The matter has now been rectified. The sentence has been removed in the reworked introduction. And as per the previous comment we have removed reference to the term firm dynamics throughout the paper.

Comment R1.10.
Page 2, line 53: It is claimed that Audretch et al (2019) calls for "additional insights on the regional determinants of firm dynamics". To me, it looks like their call are not that specific for your paper, but to investigate national business regulations and how it affects entrepreneurship. So, your claim seems to be somewhat legit when it comes to within- and between-country effects, but to far when it comes to firm dynamics (entry and deaths).

Response R1.10.
You are right to point out that the call of Audretsch et al. (2019) syncs up more with within- and between-country effects rather than specifically firm births and deaths. Therefore, we have amended the sentence to the below. We hope this rectifies the issue.

> 'While cross-country analyses have value, their aggregate nature omits important nuanced factors which has seen Audretsch *et al.* (2019) ask for research concerned with entrepreneurial activities to consider "the hierarchical spatial structure of entrepreneurship determinants" (pg. 249)." [Page 2, paragraph 2, line 49-52]

Minor:
Comment R1.11.
The paper, and the theory section, has some lengthy written paragraphs and sentences. For instance, the sentence starting with "however" on page 8, line 41.

Response R1.11.
This is a good observation and I feel amending this has improved the paper. Thank you. Please note that the line in question (among others) have now been shortened. The sentence which previously read:

"However, it is difficult to distinguish whether these firm deaths took place as a result of the Marshall effect or the Competition effect given the similar nature of their effect which creates a difficulty in distinguishing between them when examining the effect of firm births on future firm deaths as negative relation is expected in both cases (Johnson and Parker, 1994; Dejardin, 2004)"

Now reads:

> "However, it is difficult to distinguish whether these firm deaths are attributable to the Marshall effect or the competition effect. This is because both effects share a similarity which makes differentiating between them difficult. They both state firm births should induce firm deaths and so a negative relation is expected in both cases (Johnson and Parker, 1994; Dejardin, 2004)." - [Page 9, paragraph 1, line 199-203]

Additionally, the rather lengthy sentence which read:

> "Our paper analyses the extent to which firm births and deaths influence future firm births and deaths across European NUTS 2 regions through competition, multiplier and Marshall effects."

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Now reads:

> "This paper concerns itself with the investigation of interrelationships between firm births and deaths.' – [Page 2, para 1, line 27-28]

We hope this sufficiently resolves this matter to your satisfaction.

Comment R1.12.
Figure 2: the note mentions colours, which are not shown in the figure.

Response R1.12.
We would like to extend our apologies for this mistake. There was a mention to colour which was used in previous figures in earlier drafts of this manuscript. The mention of this now in the text has been removed.

Comment R1.13.
Line 10, page 2: "emphasised by" are superfluous

Response R1.13.
This has now been resolved.

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Supplementary Material

Appendix 1 Overview of the Hypotheses

By way of summary, the Table below illustrates the expected association between firm births (FB) and firms deaths (FD) and past firm births and firms deaths for the competition, multiplier, and Marshall effects. For the multiplier effect to be present, we would expect a positive relationship between future firm births and previous firm births ($\Delta FB_t/\delta FB_{t-1}>0$) meaning that firm births would positively influence future firm births where Δ and δ represent change in firm births and firm deaths and t denotes a given year. In contrast, for the competition effect we would expect a negative relationship between future firm births and previous firm births ($\Delta FB_t/\delta FB_{t-1}<0$) meaning that firm births negatively influence future firm births. Analogously, we would expect $\frac{\Delta FD_t}{\delta FD_{t-1}} > 0$ when there is a multiplier effect with past deaths positively influencing future deaths. Under the competition effect the opposite effect is observed $\frac{\Delta FD_t}{\delta FD_{t-1}} < 0$ with higher previous firm deaths positively influencing less future firm deaths. The effects of firm deaths on future firm births $\Delta FB_t/\delta FD_{t-1}$ or firm births on future firm deaths $\Delta FD_t/\delta FB_{t-1}$ differs for the multiplier ($\Delta FB_t/\delta FD_{t-1}$ <0) and competition effect ($\Delta FB_t/\delta FD_{t-1}$ >0) but as explained above the effect of firm births on future deaths is similar for the competition and Marshall effects ($\Delta FB_t/\delta FD_{t-1}$ <0).

Firm Activity	Multiplier	Competition	Marshall
$\Delta FB_t/\delta FB_{t-1}$	+	-	NA
$\Delta FD_t/\delta FD_{t-1}$	+	-	NA
$\Delta FB_t/\delta FD_{t-1}$	-	+	NA
$\Delta FD_t/\delta FB_{t-1}$	-	+	+

Where Δ and δ represent change in firm births (FB) and firm deaths (FD) and t is a given time period (a year) and NA is not applicable. Source: Adapted from Johnson and Parker (1994).

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Appendix 2 Regional Data by Country for Firm Births and Deaths

Country	Spatial Scale	Years	Source
Austria	NUTS 2	2009-2016	Eurostat
Belgium	NUTS 2	2009-2015	Eurostat
Bulgaria	NUTS 2	2009-2016	Eurostat
Cyprus	NUTS 2	2009-2015	Eurostat
Czech Rep	NUTS 2	2014-2016	Eurostat
Germany	NUTS 0	2009-2017	OECD
Denmark	NUTS 2	2009-2013	Eurostat
Estonia	NUTS 2	2009-2017	Eurostat
Spain	NUTS 2	2009; 2011-2013	Eurostat
Finland	NUTS 2	2009-2017	Eurostat
France	NUTS 2	2015-2017	Eurostat
Croatia	NUTS 2	2012-2016	Eurostat
Hungary	NUTS 2	2009; 2011-2016	Eurostat
Ireland	NUTS 0	2009-2017	OECD
Iceland	NUTS 0	2010-2017	Eurostat
Italy	NUTS 2	2009; 2011-2016	Eurostat
Lithuania	NUTS 2	2009-2017	Eurostat
Luxemburg	NUTS 2	2009-2017	Eurostat
Latvia	NUTS 2	2009-2017	Eurostat
Netherlands	NUTS 2	2009[1]	OECD
Norway	NUTS 2	2009-2016	Eurostat
Poland	NUTS 2	2009[1]	Eurostat
Portugal	NUTS 2	2009; 2011-2016	Eurostat
Romania	NUTS 2	2009; 2011-2016	Eurostat
Sweden	NUTS 0	2009-2017	Eurostat
Slovakia	NUTS 2	2009-2016	Eurostat

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UK	NUTS 2	2010-2016	OECD

Appendix 3. Correlation Matrix

	Birth Rate	Death Rate	Log of GDP per inhabitant	Education	Industrial Employment	Year
Birth Rate	1					
Death Rate	0.4231***	1				
Log of GDP per inhabitant	-0.1454***	-0.1760***	1			
Education	0.2747***	0.0322	0.6037	1		
Industrial Employment	-0.1730***	-0.0532	-0.5509***	-0.5572***	1	
Year	0.0461	-0.1075***	0.0708***	0.2750***	-0.0546**	1

*** p<0.01, ** p<0.05, * p<0.1

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Appendix 4 Year Results

Variables	Firm Birth Rate Models			Firm Death Rate Models		
	I	II	III	IV	V	VI
Birth Rate$_{t-1}$	0.34***	0.44***	0.22***	-0.22**	0.13***	0.02
	(-0.27)	(-0.04)	(-0.04)	(-0.10)	(-0.04)	(-0.04)
Birth Rate$_{t-2}$		0.14***	0.16***		0.06*	0.02*
		(-0.04)	(-0.04)		(-0.04)	(-0.04)
Birth Rate$_{t-3}$			0.20***			0.13***
			(-0.04)			(-0.04)
Death Rate$_{t-1}$	-0.05**	-0.04	0.01	0.78***	0.15***	0.25***
	(-0.01)	(-0.05)	(-0.07)	(-0.19)	(-0.06)	(-0.08)
Death Rate$_{t-2}$		0.39***	0.31***		0.30***	0.27***
		(-0.04)	(-0.06)		(-0.04)	(-0.07)
Death Rate$_{t-3}$			-0.03			0.02
			(-0.04)			(-0.05)
Log of GDP per inhabitant	-4.59E-03	-2.31e-03	5.28e-04	7.49e-04	-3.04e-03	1.00e-03
	(-3.61e-03)	(-2.55e-03)	(-3.18e-03)	(-0.01)	(-2.87e-03)	(-3.44e-03)
Education	4.63e-04**	3.58e-04**	1.72e-04	1.97e-04	1.67e-04	1.05e-04
	(-1.82e-04)	(-1.45e-04)	(1.68e-04)	(-1.99e-04)	(-1.56e-04)	(-1.90e-04)
Industrial Employment	-7.06e-04***	-2.51e-04*	-2.87e-04**	-3.64e-04***	-1.11e-04	1.53e-05
	(-1.48e-04)	(-1.32e-04)	(1.36e-04)	(-1.27e-04)	(1.38e-04)	(-1.68e-04)
Years						
2011	-1.15E-03	NA	NA	-4.96E-03	NA	NA
	(3.05E-03)			(0.01)		
2012	-1.74E-04	-0.01***	NA	-0.01	-0.01	NA
	(2.46E-03)	(3.76E-03)		(0.01)	(3.41E-03)	
2013	0.01***	3.26E-03	-2.64E-04	0.01	-0.01**	-0.01***
	(2.46E-03)	(3.49E-03)	(3.29E-03)	(0.01)	(3.21E-03)	(3.50E-03)
2014	0.01***	6.86E-04	5.68E-04	-1.54E-03	-0.01***	-0.01***
	(2.54E-03)	(3.57E-03)	(3.24E-03)	(0.01)	(3.33E-03)	(3.49E-03)
2015	0.01**	-3.29E-03	-2.86E-03	3.93E-03	-0.01***	-0.01***

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	(2.62E-03)	(3.68E-03)	(3.32E-03)	(0.01)	(3.40E-03)	(3.58E-03)
2016	0.01***	2.33E-03	-9.01E-04	0.01	-0.01***	-0.01**
	(2.59E-03)	(3.72E-03)	(3.45E-03)	(0.01)	(3.46E-03)	(3.74E-03)
2017	0.01***	0.01**	0.01	0.01	-0.01**	-3.74E-03
	(2.84E-03)	(3.87E-03)	3.64E-03	(0.01)	(0.01)	(0.01)

*** p<0.01, ** p<0.05, * p<0.1 Standard errors are reported in parentheses.

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Appendix 5 Interclass Correlation Estimates for Firm Birth and Death Rates Between Regional and National Level

Variable	Estimate	Std. Err.	Confidence Interval 99%	
Firm Birth Rate	0.33	0.09	0.15	0.58
Firm Death Rate	0.29	0.09	0.12	0.56

Appendix 6 Hypotheses Decisions

Hypothesis	**Definition**	**Decision**	**Effect**
H1a	*Firm births increase future firm births.*	Supported	Multiplier
H1b	*Firm births decrease future firm deaths.*	Supported	Multiplier
H1c	*Firm deaths increase future firm deaths.*	Supported	Multiplier
H1d	*Firm deaths decrease future firm births.*	Supported	Multiplier
H2a	*Firm births increase future firm deaths.*	Supported	Competition
H2b	*Firm births decrease future firm births.*	Not Supported	Competition
H2c	*Firm deaths increase future firm births.*	Supported	Competition
H2d	*Firm deaths decrease future firm deaths.*	Supported	Competition
H3	*Firm births increase future firm deaths.*	Supported	Marshall

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Appendix 7 Random Effects Parameters from Mixed Effects Estimation

The random effects parameter displayed above in Table 3 indicates that country effects play a statistically significant part in influencing the rate of firm births. The estimate value of 0.01 indicates that the firm birth rate varies from the grand mean firm birth rate by roughly 1%. Given that the confidence interval is not overlapping with '0', this indicates statistical significance at the 0.05 level of significance. Results for NUTS 2 regions indicate that region also plays a statistically significant role in influencing firm birth rates. The very low estimate value of 5.71e-10 indicates that the firm birth rate varies by less than 1% from the grand mean firm birth rate. However, given the confidence interval is not overlapping with '0' again indicates statistical significance at the 0.05 level of significance.

In the case of firm death rates, both country and NUTS 2 regions appear to play a statistically significant role in influencing firm death rates. The estimate value of 0.01 indicates that the firm death rate varies from the grand mean firm birth rate by roughly 1% and the confidence interval is not overlapping with '0' indicating statistical significance at the 0.05 level of significance. The very low estimate value of 8.06e-12 indicates that the firm death rate varies by less than 1% from the grand mean firm death rate. However again, the confidence interval is not overlapping with '0' indicating statistical significance at the 0.05 level of significance.

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