Incorporating Related and Unrelated Variety into Firm Dynamic Interrelationships

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Abstract:

This paper uses an incredibly novel dataset from the Central Statistics Office (CSO) of Ireland concerning business demography data at the NACE 4-digit level with over 100,000 observations pertaining to 34 Irish regions between the 2008-2016.The paper seeks to advance knowledge concerning firm dynamic interrelationships (relationships between firm births and deaths over time) by developing related and unrelated variety firm birth and firm death variables. To the best of the authors knowledge, these variables have never been applied before by any other paper examining this topic. The utilisation of these related and unrelated variety firm birth and firm death variables will allow for not only the examination of the relationships between aggregate firm births and firm deaths over time, but also the relationships between firm births and firm deaths in related sectors and unrelated sectors over time. This will provide further insight into the workings of competition and multiplier effects originally tested for by Johnson and Parker (1994). Results for related variety based firm dynamic activity measures show the multiplier effect is present as firm births in related sectors seem to positively influence future firm births and firm deaths in related sectors appear to negatively impact future firm births. Additionally, results for unrelated variety-based variables indicate presence of the competition effect as firm births in unrelated sectors negatively impact future firm births while firm deaths in unrelated sectors positively influence future firm births. In the case of determining firm deaths, unrelated variety measures provide mixed results. These findings have considerable implications or Irish policy concerning entrepreneurship. For example, the *Enterprise Ireland* organisation, who offer several grants and investment schemes for Irish firms and start-ups with the aim of fostering and developing Irish entrepreneurship and approved spending of €43 million to start-ups alone in 2020 (EI, 2020).

1. Introduction

There is a considerable stock of literature concerning firm births and deaths. The interest in firm dynamics[1] research can be attributed to its importance in contributing to employment and growth (Dejardin and Fritsch, 2011; Urbano et al., 2019). Research in this area is increasingly taking a regional focus [see Bishop (2019); Lee et al. (2013); Colombelli and Quatraro (2018)for examples]. The importance of industrial factors like agglomeration economies, industrial specialisation, and diversification have also been incorporated into this area [see Content et al. (2019b); Wixe and Andersson (2017) for examples]. There is less focus however on the role of firm dynamic interrelationships. Empirical research and has found that previous firm dynamic activity plays a significant role in influencing future levels of firm dynamic activity through competition and multiplier effects (Resende et al., 2015a; Gajewski and Kutan, 2018). Yet firm dynamic interrelationships are still seldomly incorporated into models examining the determinants of firm dynamic activity [see Dong (2020); Power et al. (2019a) for examples]. The few studies which do control for previous firm dynamic activity rarely do this while also accounting for sectoral effects [Dejardin (2004) and Carree et al. (2011) are two of few exceptions to this]. This can be considered somewhat remis due to theoretical and empirical evidence that firm sector influences firm dynamic activity [see Carree and Thurik (1996); Herrendorf and Teixeira (2011); Nyström (2006) examples]. The lack of sectoral information within these firm dynamic interrelationship studies also means that variables which are increasingly tested for in firm dynamics literature like related and unrelated variety [see Power et al. (2021) for examples] cannot be accounted for. This presents a knowledge gap to which this paper contributes directly.

This paper conducts a sectoral analysis of firm dynamic interrelationships in Ireland. The geographic and sectoral scope of the data is such that not only can sectoral effects be captured in the model, as they are by Carree et al. (2011); Dejardin (2004), but the paper can further expand on these works and incorporate the importance of related and unrelated variety into examining the determinants of firm dynamic interrelationships. This expands on the conceptual literature originally set out by Johnson and Parker (1994) and their competition, multiplier, and Marshall effects[2], and it also builds on current firm dynamic research by controlling for popular industrial factors like related and unrelated variety as well as more neglected variables like time lagged firm birth and death rates. The findings of the paper can also be considered of interest to current policy measures set out in the European 'Smart Specialisation' and 'Cohesion' policy plans which both seek to encourage the formation and support of firms as a means of improving growth and employment (EC, 2020; EC, 2021).

The paper utilises an extremely novel business demography dataset provided by the Central Statistics Office (CSO) of Ireland pertaining to the years 2008-2016. The dataset has a substantial geographical and scetoral element with a dataset pertaining to 34 Irish regions and 615 Irish sectors at the NACE 4-digit level. Additionally, the paper's mixed effects multilevel

[1] Firm dynamics will henceforth be used to refer to firm births and firm deaths over time.

[2] These effects will be explained in greater detail in the section 2 but a brief explanation will be offered here. The multiplier effect is when firm dynamic activity (firm births or deaths) causes more of the same activity i.e. births cause more births. The competition effect is the opposite, when firm dynamic activity induces the opposite type of activity i.e., firm deaths cause births. The Marshall effect is the natural passing of firms which were previously birthed i.e., the firm births in one year are attributable to a series of births which occurred previously.

method of assessment allows it to control regional effects within Irish counties. The substantial coverage of sectors within the Irish economy in this study is a more robust coverage than papers in the area like Resende et al. (2015), Calá (2014), Nyström (2007), Dejardin (2004) which have tended to focus on single industry rather than the entire economy. The reminder of the paper is outlined in the following manner. Section 2 will discuss the theoretical literature which already exists surrounding competition, multiplier, and Marshall effects like Johnson and Parker (1994) and on the sectoral and regional dimension to firm dynamics. Section 3 will discuss the data and variables which are to be used in this study before Section 4 explains the empirical estimation techniques which will be used to analyse this data. Then Section 5 will provide the results of these estimations and will be proceeded by Section 6 which will interpret these results and provide conclusions and potential policy recommendations and suggestions for future research.

2. Literature Review

From a theoretical perspective, firm dynamic activity is viewed through several paradigms. The eclectic framework, employed by Verheul et al. (2001), emphasises both the importance of demand- and supply-side factors. These can include economic conditions, industrial structure, as well as institutional environment factors (Delfmann et al., 2014). The resource-based view implies that firm dynamic activity is predicted on the availability of key resources within regions (Hart, 1995; Alexy et al., 2018). The availability of these resources varies across regions due to heterogeneous allocation of resources like geography, culture, institutional make-up, investment levels, and social composition (Bishop and Shilcof, 2017). Additionally, the industrial view of the firm emphasises a firm's 'relative efficiency' compared to other firms as a significant factor in firm dynamic activity (Jovanovic, 1982); while the ecological view of the firm posits that changes to a firm's environment and the connections it has in the environment determine firm dynamic activity (Chen and Liang, 2016; Power et al., 2020). It becomes clear from these schools of thought that the composition and structure of areas is of vital importance in determining firm dynamic activity. Consequently, research concerning firm dynamic activity has incorporated these environmental factors into their models by accounting for institutional factors (Acs et al., 2017), agglomeration economies (Knoben et al., 2011), human capital (Marvel et al., 2016), economic performance (Martínez-Rodriguez et al., 2020), industrial composition (Naldi et al., 2020), and levels of related and unrelated variety (Content et al., 2019c). Uptake on accounting for previous levels of firm dynamic activity is not as abundant. The neglection of firm dynamic interrelationships is concerning given that previous levels of firm births and deaths shape the industrial composition of environments which seem to be viewed as integral inputs to firm dynamic activity within the literature [see Fritsch and Kublina (2018)].

2.1. Firm Dynamic Interrelationships

From a conceptual perspective, Johnson and Parker (1994) asserted that previous levels of firm births and firm deaths can induce competition and multiplier effects which influence future levels of firm dynamic activity. The competition effect can be considered present in instances where firm births induce future deaths and deter births or in instances where firm deaths induce future births and deter deaths (Carree et al., 2011; Pe'er and Vertinsky, 2008). This can occur through the process of creative destruction, where new firms become the rivals of current firms

in the market and induce their death (Schumpeter, 1942; Brixy, 2014). This process is also referred to as the displacement effect by Audretsch (1995); Cefis et al. (2020). Alternatively, firm deaths can also induce unemployment which incentivises people to set up their own firms to avoid unemployment (Dvouletý, 2017; Faria et al., 2009). Through these competition effect processes contextual factors like resource availability, economic conditions, and industrial composition become altered and this influences future firm dynamic activity (Delfmann et al., 2014; Hart, 1995; Verheul et al., 2001). Therefore, we propose the following hypotheses regarding competition effects.

H1a: Firm births should positively influence firm deaths and negatively influence firm births.

H1b: Firm deaths should positively influence firm births and negatively influence firm deaths.

This also occurs in this case of the multiplier effect which is present when either firm births cause more firm births and deter firm deaths or when firm deaths cause more deaths and deter births (Lu et al., 2008; Resende et al., 2015b). Multiplier effects can occur due to income or demonstartion effects. Income effects are when a series of firm births increases levels of income in the area and, as a result, there is an increase in firm births to cope with increased consumer demand (Gajewski and Kutan, 2018; Sutaria and Hicks, 2004). The same process can cause firm deaths to occur as a result of previous firm deaths lowering income levels. Demonstration effects occur when firm births induce more firm births as they signal the economic value associated with starting a firm to other individuals who subsequently set up businesses of their own (Nyström, 2007; Dejardin, 2004). Similarly, firm deaths can communicate the lack of economic value associated with owning business and incentivise individuals to exit the market rather than pursue entrepreneurship in a difficult market (Bartoloni et al., 2020). It is also possible for multiplier effects to occur because firm births would positive network externalities for other firms, and firm deaths would do the opposite (Resende et al., 2015a). Conceptually we can see that these processes are also instrumental to changing the context which influences firm dynamic activity and their inclusion in models examining firm dynamic activity is important. Therefore, we propose the following hypotheses regarding multiplier effects.

H2a: Firm births should positively influence firm births and negatively influence firm deaths.

H2b: Firm deaths should positively influence firm deaths and negatively influence firm births.

2.2. Related and Unrelated Variety Effects

To date research has examined firm dynamic interrelationships mostly via the competition and multiplier effects outlined originally by Johnson and Parker (1994)[3]. While these effects capture all the different types of possible interrelationships between firm births and firm deaths, they do not indicate anything about the type of firms which are interacting with each other. Given that Carree et al. (2011); Dejardin (2004) have shown that there are significant variations in the presence of multiplier and competition effects across different sectors, it seems effects which captured the effect of firm sector would be a valuable contribution to the literature. Therefore, this paper is proposing the introduction of the related variety (RV) and unrelated variety (UV) into firm dynamic interrelationship research. These effects will illustrate how firm

[3] See Appendix 1 for the expected coefficient signs for these effects as set out by Johnson and Parker (1994).

births or deaths in one sector of the economy induce firm births or deaths in either related or unrelated sectors in the economy and they can be shown illustrated below in Table 1.

Table 1 Related and Unrelated Variety Effects

	Related Variety:			**Unrelated Variety:**	
	Multiplier	Competition		Multiplier	Competition
$\Delta FB_{rst}/\delta FB_{st-1}$	+	-	$\Delta FB_{ust}/\delta FB_{st-1}$	+	-
$\Delta FD_{rst}/\delta FD_{st-1}$	+	-	$\Delta FD_{ust}/\delta FD_{st-1}$	+	-
$\Delta FB_{rst}/\delta FD_{st-1}$	-	+	$\Delta FB_{ust}/\delta FD_{st-1}$	-	+
$\Delta FD_{rst}/\delta FB_{st-1}$	-	+	$\Delta FD_{ust}/\delta FB_{st-1}$	-	+

Where Δ represents change in firm births (FB) and firm deaths (FD) and t is a given time period (a year) and s represents sector, and rs and us are represent related and unrelated sectors respectively.

Conceptually the main mechanism through which competition effects occur are related to the Schumpeterian notion of creative destruction. Firm births place an additional strain on resources and market share leading to the death of other firms (Cainelli et al., 2014; Combes et al., 2012). Findings from Basile et al. (2017) and Boschma and Iammarino (2009) which indicate that a greater level of diversification of industries reduces the likelihood of firm deaths compared to regions with more related industries would suggest that the negative effects of competitive pressures are heightened when the firms in an area are related to one another and rely on the same or similar resources. Therefore, conceptually it can be reasoned that competition effects would be more prevalent between related sectors. Given the above, the following hypothesis is proposed.

H3: Competition effects should be more prominent between related sectors.

Conversely, an other ways competition effects can occur is through firm deaths leading to a reallocation of resources within the economy (Johnson and Parker, 1996). This process alters the allocation of resources which can influence firm dynamic activity (Alexy et al., 2018; Hart, 1995). Conceptually this means that the death of firms, which leads to a reshuffling of valuable resources, is most important when the firm death occurs in a related sector to other firms which can make avail of these apposite resources. Alternatively, competition effects can also occur through push-factor or necessity-based entrepreneurship where individuals lose their jobs due to firm deaths and then pursue entrepreneurship to avoid unemployment (Block et al., 2015). Nyström (2020) asserts that individuals are more likely to pursue entrepreneurship after displacement in similar sectors rather than unrelated ones. Given the above, the following hypothesis is proposed.

H4: Competition effects should be more prominent between unrelated sectors.

Conceptually the key factors which influence multiplier effects discussed above are factors of income and network externalities. Frenken et al. (2007) acknowledges related variety as a potential input for economic growth. They argue that higher levels of related variety would increase the amount of intersectoral knowledge spillovers as knowledge from separate, but related, sectors gets diffused between each other. The greater the level of related variety within a region the more one would expect knowledge spillovers to occur as the knowledge being transferred is of a greater level of relevance to the majority of firms within the region (Content and Frenken, 2016; Frenken et al., 2007). The knowledge spillover theory of entrepreneurship would then indicate that these knowledge spillovers would lead to new business creations (Acs et al., 2013; Audretsch and Lehmann, 2005). These firm births would positively influence income levels and network size thus make the industrial context more conducive towards multiplier effects. Empirical research finds support for this as regions with higher levels of related variety tend to experience higher levels of firm births than regions with lower levels of related variety (Content et al., 2019a; Ejdemo and Örtqvist, 2020). Given the above, the following hypothesis is proposed.

H5: Multiplier effects should be more prominent between related sectors.

Alternatively, Nooteboom (2000) highlights the potential issue of cognitive lock-in obstructing the possibility of knowledge spillovers if levels of relatedness are too high. Arguments for the diversification of industry better facilitating the transition knowledge and thus leading to the generation of new ideas and innovations have also been put forward (Boschma et al., 2012). This generation of new knowledge as a result of diversification can produce positive location externalities referred to as Jacobs externalities. These positive externalities have been captured using unrelated variety as a measurement by Content et al. (2019a); Frenken et al. (2007). Unrelated variety has been shown to be positively influence firm births by Fritsch and Kublina (2018) and Antonietti and Gambarotto (2020). This would suggest it is also possible that unrelated variety would greater facilitate multiplier effects occurring due to its ability to positively influence income and network levels. Thus, the following hypothesis is proposed.

H6: Multiplier effects should be more prominent between unrelated sectors.

3. Data

The data being used for this study is taken from the business demography (2008-2016) dataset supplied by the Central Statistics Office (CSO) of Ireland. All enterprises in NACE Rev 2 sectors B - N excluding K64.20 are contained in the dataset and are broken down geographically at the county and sub-county level into 34 different regions. These 34 regions can be seen listed in Table 2 below.

Table 2 County Codes for the 34 Irish Regions

Region:	County Code:	Region:	County Code
Carlow	1	Cork County	18
Dublin City	2	Kerry	19
South Dublin	3	Limerick City	20
Dublin Fingal	4	Limerick County	21
Dun Laoghaire-Rathdown	5	North Tipperary	22
Kildare	6	South Tipperary	23

Kilkenny	7	Waterford City	24
Laois	8	Waterford County	25
Longford	9	Galway City	26
Louth	10	Galway County	27
Meath	11	Leitrim	28
Offaly	12	Mayo	29
Westmeath	13	Roscommon	30
Wexford	14	Sligo	31
Wicklow	15	Cavan	32
Clare	16	Donegal	33
Cork City	17	Monaghan	34

Variables on firm births and deaths in this data set are count variable which pertain to the death and birth of firms within Irish regions and sectors. A firm birth occurs when an enterprise starts from scratch and actually starts activity. An enterprise creation can be considered an enterprise birth if new production factors, in particular new jobs, is created.[4] An enterprise death amounts to the dissolution of a combination of production factors for 2 years with the restriction that no other enterprises are involved in the event.[5] Because there are years where there are no firm births and or deaths in a given region or sector, these two variables contain a considerable number of zero counts. These can be seen in Appendix 1 and 2.

The large number of zero counts within this data set will have to be taken into consideration when estimating this model with regard to econometric technique. It will probably be necessary to correct for this distribution. This will be discussed in greater detail in section 4. Other variables of interest to this study from this data set include the sector, age, and size of firms. The firm's sector variable shows the sector the firm operates in within the private business economy in the NACE Rev 4-digit sectors B-N (excluding 64.20 Activities of holding companies). The firm's age is the calculated by taking the number of years the firm existed since its birth until 2016 or the year it became inactive (died). Firm size is measured by taking the number of employees they have paid a wage or salary to for a reference year.[6] The business demography data has been used previously in enterprise based studies by Power et al. (2019b) and O'Connor et al. (2018). Key variables taken from this dataset for this study will include firm births and deaths as well as size of firm measured by number of employees. Summary Statistics for this study can be seen in Table 3 below.

Table 3 Summary Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
Death Rate	102096	0.0956	0.1860	0	4

[4] If a dormant unit is reactivated within two years, this event is not considered a birth.
[5] Deaths do not include exits from the population due to mergers, takeovers, break-ups or restructuring of a set of enterprises. It does not include exits from a sub-population resulting only from a change of activity.
[6] The file can contain individuals paid a wage by an employer as well as self-employed individuals who pay themselves a working wage. An individual may be counted more than once for a reference year they work multiple jobs in that reference year.

Birth Rate	102096	0.1148	0.2512	0	7
RV Birth Rate	118307	0.0882	0.0815	0	5
UV Birth Rate	102096	0.1054	0.0408	0.0438545	0.5492139
RV Death Rate	118307	0.0774	0.0489	0	1.333333
UV Death Rate	102096	0.0956	0.0242	0.0562977	0.3429048
Herfindahl	118307	122.7087	75.8528	4.21E-06	258.8221
RV	118307	0.1363	0.1953	0	0.7844523
UV	118307	-10.0305	2.9767	-16.745	-2.320829
Year	118307	2012.0330	2.5825	2008	2016
Average Size	118307	13.0367	106.4114	0	10074
Proportion	118307	0.0025	0.0003	0.0018868	0.0035088
Population	114797	320738.0000	410773.1000	31798	1347359
Income per person	114797	24838.9800	3296.0880	18216	33635
LQ	118264	1.6659	5.0024	0	175.7722
County	114797	17.0422	9.7727	1	34

3.1. Constructed Variables:

The dependant variables for this study will be constructed from the count variables of firm birth and death variables. The firm birth variable will be constructed by dividing the count of firm births in year t by the total stock of businesses in year t-1, and the firm death variable will be constructed the same way but by substituting the count of firm births with the count of firm deaths. Similar methods are used by similar studies such as Dejardin (2004); Nyström (2007); Resende et al. (2015b) to capture the intertemporal element of firm births and deaths. Further discussion will be provided on this in section 4. The notation for the construction of these two variables can be seen below in equation 1 and 2.

$$Firm\ Births = \frac{BirthCount_{sjt}}{Stock_{jst-1}} \quad (1)$$

$$Firm\ Deaths = \frac{DeathCount_{sjt}}{Stock_{jst-1}} \quad (2)$$

Where *Firm Births* is the count of firm births in NACE 4-digit sector s in region j in time period t divided by the total count of firms (i.e. stock) in sector s in region j in time period t-1, $FirmDeaths/Stock_{jst-1}$ is the count of firm deaths in NACE 4-digit sector s in region j in time period t divided by the total count of firms (i.e. stock) in sector s in region j in time period t-1. In order to capture RV and UV effects there will also have to be a variable constructed to show firm births and deaths in related or unrelated sectors. These can both be seen below in equation 3 and 4.

$$RFB = \frac{BirthCount_{js2t}}{Stock_{js2t-1}} \quad (3)$$

$$RFD = \frac{DeathCount_{js2t}}{Stock_{js2t-1}} \quad (4)$$

Where *RFB* is the count of firm births in NACE 2-digit sector s2 in region j in time period t divided by the total count of firms (i.e. stock) in sector s in region j in time period t-1, and *RFD* is the count of firm deaths in NACE 2-digit sector s2 in region j in time period t divided by the total count of firms (i.e. stock) in sector s in region j in time period t-1.

Standard measurements consistent with those used by Power et al. (2019b) and Boschma and Iammarino (2009) to capture levels of variety are adopted in this paper. This entropy measurement of variety is estimated at the four-digit NACE classification level. This measurement increases in size the more diversified the types of businesses within a region. It is calculated in the following manner:

$$V_s = \sum_{s=1}^{N} P_s log_2(1/P_s) \quad (5)$$

Where P_s measures the share of the four-digit NACE sector *s*. Using standard measurements consistent with Power et al. (2019b) and Antonietti and Cainelli (2011) we develop a measurement for employment concentration within regions. The variable for employment can be expressed as follows:

$$EMP_{s,r} = \frac{E_{s,r}/E_r}{E_{s,n}/E_n} \quad (6)$$

Where $EMP_{s,r}$ is the concentration of employment in a sector *s* and region *r* and *E* is employment in sector *s* and region *r* while $E_n$is the employment nationally.

4. Methodology

Standard OLS and fixed effects regression estimations are performed to obtain preliminary results. The below equations 7 and 8 illustrate the models which will be estimated in this paper.

$$FB_{rt} = \alpha_1 FB_{rt-1} + \alpha_2 FD_{rt-1} + \alpha_3 RVFB_{rt-1} + \alpha_4 RVFD_{rt-1} + \alpha_5 UVFB_{rt-1} + \alpha_6 UVFD_{rt-1} + \alpha_7 X_{rt} + \varepsilon_t \quad (7)$$

$$FD_{rt} = \beta_1 FB_{rt-1} + \beta_2 FD_{rt-1} + \beta_3 RVFB_{rt-1} + \beta_4 RVFD_{rt-1} + \beta_5 UVFB_{rt-1} + \beta_6 UVFD_{rt-1} + \beta_7 X_{rt} + \mu_t \quad (8)$$

Where FB and FD are the firm birth and death rate respectively in year t and region r. RVFB and RVFD represent the firm birth and death rate respectively in related sectors whereas UVFB and UVFD represent the firm birth and death rate respectively in unrelated sectors. X represents a matrix of control variables and μ and ε both represent the error term.

5. Results

Basic results from an OLS model can be seen below in Table 4. Robust standard errors were used to account for heteroscedasticity.

Variable	(1) FB OLS	(2) FD OLS	(3) FB FE	(4) FD FE
Birth Rate t-1	0.0965***	0.0398***	-0.0870***	0.0021
	(0.0050)	(0.0033)	(0.0053)	(0.0036)
Death Rate t-1	0.0461***	-0.0319***	-0.0632***	-0.2179***
	(0.0085)	(0.0050)	(0.0097)	(0.0054)
RV Birth Rate t-1	0.0116	-0.0098	0.0607***	0.0143
	(0.0142)	(0.0220)	(0.0172)	(0.0143)
UV Birth Rate t-1	-0.1657**	-0.0040**	0.0596	0.1083***
	(0.0729)	(0.0566)	(0.0490)	(0.0371)
RV Death Rate t-1	-0.0603**	0.0385	-0.0406	0.0228
	(0.0267)	(0.0244)	(0.0289)	(0.0235)
UV Death Rate t-1	0.0047	-0.1692	0.1654*	0.0712
	(0.1509)	(0.1163)	(0.0934)	(0.0679)
Herfindahl	0.0231***	0.0130***	0.0011	0.0068**
	(0.0020)	(0.0016)	(0.0036)	(0.0026)
RV	-0.0169***	0.0034	0.4754***	0.3761***
	(0.0036)	(0.0029)	(0.0736)	(0.0557)
UV	-0.0041***	-0.0019*	-0.0013	0.0009
	(0.0014)	(0.0011)	(0.0014)	(0.0010)
Population	0.0000***	0.0000***	0.0000**	0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Total Income per person	0.0000	0.0000	0.0000***	0.0000

	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Average Size	0.0000***	0.0000***	-0.0002***	-0.0001**
	(0.0000)	(0.0000)	(0.0001)	(0.0000)
LQ	-0.0015***	-0.0019***	0.0019***	-0.0017**
	(0.0002)	(0.0000)	(0.0006)	(0.0007)

Models 1 and 2 are OLS models with county and year dummies. Model 3 and 4 are Fixed Effects Panel Models.
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
VIF for model 1=1.75, model 2=1.75, model 3=1.75, and model 4 =1.75.

5.1. Firm Birth Results:

Regarding the results of model 1 for firm births, we see that the coefficients associated with previous firm births (α_1) and deaths (α_2) indicate partial support for both the multiplier and competition effect as both firm births and firm deaths appear to induce future firm births. However, it should be noted that the coefficient size of firm births is greater than that of firm deaths (i.e., $\alpha_1 > \alpha_2$) implying that the multiplier effect may potentially be the more dominant effect. This provides partial support for both H1a (Stating:*"Firm births should positively influence firm deaths and negatively influence firm births."*) and H1b (Stating: *"Firm deaths should positively influence firm births and negatively influence firm deaths."*) and is in line with the findings of Albiol (2014), Arcuri et al. (2019), and Gajewski and Kutan (2018) who find support for the competition effect whereby firm births and death are positively associated with future firm births. Regarding the relationships between firm births and previous firm births and deaths in related and unrelated sectors in model 1, results provide support for only the competition effect with a lagged UV firm birth rate coefficient (α_5) of -0. 1657 ($p<0.05$), however, the coefficients for the RV firm births (α_3) are statistically insignificant. This would indicate partial support for the competition effect regarding firm births in unrelated sectors where lagged firm births in unrelated sectors negatively influence future firm births. Additionally, the coefficient result for the RV firm death variable (α_4) is -0.0603 ($p<0.05$) indicating that lagged firm deaths in related sectors have a negative and statistically significant relationship with future firm births, however, the results for the RV firm death variable in all other models are insignificant. This would indicate partial support for the multiplier effect regarding firm births and deaths in related sectors as lagged firm deaths in related sectors appear to be negatively associated with future firm births.

Regarding the results of model 3 for firm births, we see that the coefficients associated with previous firm births and deaths indicate partial support for both the multiplier and competition effect as both firm births and firm deaths appear to be negatively associated with future firm births. Though it should be noted that the coefficient size for firm births is larger than firm deaths (i.e., $\alpha_1 > \alpha_2$) which implies that the multiplier effect (firm births inducing firm births) could dominate the competition effect (firm deaths inducing firm births). These results suggest partial support for H1a (Stating: *Firm births should positively influence firm deaths and negatively influence firm births.*) and H2b (Stating *"Firm deaths should positively influence firm deaths and negatively influence firm births."*). The coefficients for the RV and UV firm births and deaths are all statistically insignificant indicating that firm births are not influenced in a statistically significant fashion via previous firm births and deaths from related or unrelated sectors, just from previous levels of aggregate firm dynamic activity.

5.2.Firm Death Results:

Regarding the results of model 2 for firm deaths, we see that the coefficients associated with previous firm births and deaths indicate complete support for the competition effect as firm births appear positively associated with future firm deaths and firm deaths appear positively associated with future firm deaths (i.e., β_1 = + and β_2 = +). This finds support for the acceptance of H1a (Stating: *"Firm births should positively influence firm deaths and negatively influence firm births."*). This finding is in line with the results of Albiol (2014); Arcuri et al. (2019); Gajewski and Kutan (2018)who also find supportive evidence for the competition effect. The coefficient for lagged RV firm deaths (β_4), 0.0549 ($p<0.01$), indicates that firm deaths are positively associated with inducing firm deaths in a related sectors. Conversely, the coefficient for lagged UV firm deaths (β_6), -0.2596 ($p<0.05$), indicates that firm deaths are negatively associated with future firm deaths in unrelated sectors. The coefficients for lagged RV and UV firm births are both insignificantly related to firm deaths in model 2. This would find partial support for the acceptance of H3 (Stating: "*Competition effects should be more prominent between related sectors."*) and H4 (Stating: *"Competition effects should be more prominent between unrelated sectors."*) as there appears to evidence of a competition effect between firm births in unrelated sectors and firm deaths in related sectors and future firm deaths. However, this does not appear to extend to lagged RV and UV firm births influencing future firm deaths.

Regarding the results of model 4 for firm deaths, we see that the coefficients associated with previous firm births (β_1) and deaths (β_2) indicate partial support for the competition effect as firm deaths appear negatively associated with future firm deaths (i.e., β_2 = -). However, lagged firm births appear to have no statistically significant relationship with future firm deaths. These results find partial support for the acceptance of H1b (Stating: *"Firm deaths should positively influence firm births and negatively influence firm deaths."*) and is in line with the findings of Albiol (2014); Arcuri et al. (2019); Gajewski and Kutan (2018) who find support for the competition effect. The coefficients for the RV and UV firm births and deaths are all statistically insignificant indicating that firm deaths are not influenced in a statistically significant fashion via previous firm births and deaths from related or unrelated sectors, just from previous levels of aggregate firm dynamic activity.

5.3. Industrial Factors Results

The coefficient results for the Herfindahl index (indicating industrial specialisation) are significant across 3 of 4 models and positive in all three of these cases indicating that industrial specialisation appears to positively influence both firm births and firm deaths. The coefficient results for the related variety variable is significant across 3 of 4 models and positive in the case of firm deaths in model IV indicating that industrial related variety appears to positively influence firm deaths. In the case of models I and III it finds mixed results as industrial related variety appears to negatively influence firm births in a pooled regression, but positively influence them in a fixed effects regression. The coefficient results for the unrelated variety variable is significant across 2 of 4 models and negative in both cases for firm births in model I and firm deaths in model II indicating that industrial unrelated variety appears to negatively influence firm births and firm deaths. This provides support for the results of Naldi et al. (2020) in the case of firm births and Bishop (2012) and Basile et al. (2017) in the case of firm deaths.

6. Conclusion

This paper has conducted a sectoral analysis of firm dynamic interrelationships within Irish regions and quantified the extent to which previous firm dynamic activity and other regional/industrial factors determines firm births and firm deaths. The paper considerably advances the stock of sectoral/industrial focused firm dynamic research e.g., Arcuri et al. (2019) and Carree et al. (2011); by being the first paper to develop and incorporate related and unrelated variety firm birth and firm death measures into its model for determining firm births and firm deaths.

Results are mixed for the case of firm births and deaths influencing future firm births and firm deaths. Firm births are found to positively affect future firm deaths which would indicate the presence of the competition effect whereby firm births would induce increased levels of competition and cause future firm deaths (Carree et al., 2011; Pe'er and Vertinsky, 2008). Also, it appears that firm births both positively and negatively affect future firm births across models depending on whether the model is a pooled or fixed effects model respectively, which would provide partial evidence for both the multiplier effects whereby firm births can induce more firm births via income or signalling effects, and competition effects whereby firm births negatively impact future firm births due to competitive pressures (Gajewski and Kutan, 2018; Nyström, 2007). Regarding the related and unrelated variety measures for firm births and firm deaths, results indicate presence of the multiplier effect in the case of related variety firm births in affecting firm births as firm births from related sectors seem to positively influence future firm births and we also observe that firm deaths in related sectors appear to negatively impact future firm births. Regarding the unrelated variety measures of firm births and firm deaths, the findings show that in the case of determining firm births, there is evidence of the competition effect as firm births in unrelated sectors negatively impact firm births while firm deaths in unrelated sectors positively influence future firm births. In the case of determining firm deaths, unrelated variety measures provide mixed results depending on whether they are in a pooled or fixed effects regression; the coefficient sign switching positive to negative respectively. This indicates that in the case of determining firm births, the multiplier effect is present among related sectors and the competition effect is present in unrelated sectors. Mixed results are found for the case of determining firm deaths via unrelated variety firm births and no effect is found form unrelated variety firm deaths.

The findings of this paper are of potential concern to policy organisations like Enterprise Ireland who invest millions of Euro into Irish firms and start-ups, €43 million into start-ups alone in 2020 (EI, 2020), each year and consequently affect they rate of firm births and firm deaths within Irish regions. These findings would suggest that investment into firms in related sectors within a region would help to encourage further firm births in the future via multiplier effects, whereas investment into firms in unrelated sectors could bring about future firm births via competition effects.

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Appendix 1 Expected Coefficient Signs for Multiplier, Competition, and Marshall Effects

	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 represents change in firm births (FB) and firm deaths (FD) and t is a given time period (a year) and NA is not applicable.

Appendix 2 OLS Results for Country and Year Dummies

birth_rate	Coef.	Std.	P	death_rate	Coef.	Std.	P>t
L1.birth_rate	0.0991	0.0050	0.000		0.0416	0.0033	0.000
L1.death_rate	0.0522	0.0085	0.000		-0.0268	0.0050	0.000
L1.rv_birth_rate	0.0351	0.0144	0.015		0.0092	0.0192	0.631
L1.uv_birth_rate	-0.0440	0.0784	0.574		0.0390	0.0614	0.525
L1.rv_death_rate	-0.0298	0.0239	0.213		0.0549	0.0207	0.008
L1.uv_death_rate	-0.2208	0.1690	0.191		-0.2596	0.1298	0.045
herf	0.0000	0.0000	0.046		0.0000	0.0000	0.328
UV	0.0000	0.0000	0.152		0.0000	0.0000	0.202
RV	0.0000	0.0000	0.001		0.0000	0.0000	0.221
average_size	0.0000	0.0000	0.000		0.0000	0.0000	0.000

Population	0.0000	0.0000	0.377		0.0000	0.0000	0.344
totalincomeperpersoneuro	0.0000	0.0000	0.004		0.0000	0.0000	0.143
region_n							
Cavan	-0.2073	0.0942	0.028		-0.0744	0.0742	0.316
Clare	-0.1218	0.0568	0.032		-0.0493	0.0449	0.272
Cork	-0.1285	0.0539	0.017		-0.0658	0.0431	0.127
Cork	-0.1647	0.0576	0.004		-0.0815	0.0462	0.078
Donegal	-0.2203	0.0956	0.021		-0.0920	0.0755	0.223
Dublin City	-0.0907	0.1009	0.369		-0.0595	0.0789	0.451
Dublin Fingal	-0.0831	0.0920	0.366		-0.0703	0.0722	0.330
Dun	-0.1233	0.0912	0.176		-0.0809	0.0717	0.259
Galway City	-0.1635	0.0761	0.032		-0.0632	0.0602	0.294
Galway	-0.1866	0.0780	0.017		-0.0797	0.0619	0.198
Kerry	-0.1583	0.0697	0.023		-0.0697	0.0551	0.206
Kildare	-0.0660	0.0345	0.056		-0.0313	0.0274	0.254
Kilkenny	-0.0856	0.0410	0.037		-0.0312	0.0323	0.334
Laois	-0.0776	0.0432	0.073		-0.0256	0.0342	0.455
Leitrim	-0.1915	0.0891	0.032		-0.0803	0.0702	0.253

Limerick	-0.1062	0.0704	0.131		-0.0421	0.0554	0.447
Limerick	-0.1639	0.0700	0.019		-0.0599	0.0554	0.280
Longford	-0.1113	0.0457	0.015		-0.0366	0.0360	0.309
Louth	-0.0877	0.0436	0.044		-0.0297	0.0345	0.389
Mayo	-0.2000	0.0877	0.023		-0.0782	0.0691	0.258
Meath	-0.0809	0.0437	0.064		-0.0313	0.0347	0.367
Monaghan	-0.2347	0.1010	0.020		-0.0890	0.0796	0.264
North Tipp	-0.1952	0.0735	0.008		-0.0752	0.0582	0.196
Offaly	-0.1157	0.0501	0.021		-0.0367	0.0396	0.354
Roscommon	-0.2079	0.0924	0.024		-0.0825	0.0728	0.257
Sligo	-0.1938	0.0934	0.038		-0.0763	0.0736	0.300
South Dublin	-0.0540	0.0947	0.569		-0.0611	0.0743	0.411
South Tipperary	-0.1302	0.0763	0.088		-0.0614	0.0603	0.308
Waterford City	-0.1475	0.0793	0.063		-0.0480	0.0625	0.442
Waterford County	-0.1764	0.0790	0.026		-0.0648	0.0623	0.298
Westmeath	-0.1050	0.0504	0.037		-0.0414	0.0398	0.299
Wexford	-0.1033	0.0510	0.043		-0.0487	0.0402	0.226

Wicklow	-0.1065	0.0533	0.046		-0.0402	0.0421	0.340
year							
2011	0.0037	0.0043	0.390		-0.0081	0.0033	0.015
2012	0.0115	0.0046	0.013		-0.0022	0.0035	0.539
2013	-0.0319	0.0036	0.000		0.0057	0.0031	0.062
2014	0.0179	0.0042	0.000		0.0008	0.0032	0.803
2015	0.0249	0.0038	0.000		0.0002	0.0029	0.941
2016	0.0302	0.0040	0.000		0.0088	0.0031	0.005
_cons	0.1906	0.0376	0.000		0.1302	0.0293	0.000