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# Does spatial location affect business liquidations?

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# Does spatial location affect business liquidations?

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**Abstract**

Current studies in aggregate business liquidations has paid little attention to the potential importance of firms' geographical (spatial) location. However, there is evidence of spatial agglomeration of economic activity which poses the question of potential implication in business liquidations. This study investigates the potential existence of spatial effects between businesses that enter liquidation in a sample of European countries. Statistically significant spatial effects were detected in the form of SEM and SDM spatial models. Such effects indicate that models that do not account for spatial effects are potentially biased. These results confirm the existence of spatial effects in business liquidations, implying that the spatial location should be considered for modelling and policy making purposes. As such, further research maybe needed in this area so as to further explore the impact of the spatial aspect.

**Keywords**- Business failure, liquidations, Spatial effects, European countries.

**Paper type** Research paper

## 1. Introduction

The empirical evidence regarding the factors that determine aggregate business liquidations focuses on the total business population of one particular country, usually on a time series basis, and considers the impact of specific macroeconomic variables on business liquidations (eg. Liu 2004; Liu, 2009; Jones, 2013). In this literature, the terms insolvency and failure are also used interchangeably to describe the liquidation of the business (Lin et al., 2012; Filipe et al., 2016).

Aggregate business liquidation studies (see for example Liu, 2004; Jones, 2013) have identified the economic environment to be a significant determinant of business liquidation. The economic growth, the credit availability, interest rates, taxation, inflation and potential increased competition from new businesses have been traditionally seen as key determinants of aggregate business liquidations. Likewise, evidence from cross-country studies suggest that the legal environment also affects insolvency procedures and therefore liquidations (see for example La Porta et al., 1997; La Porta et al., 1998; La Porta et al., 2008; Wang, 2012).

However, investigation on the impact of firms' geographical location on business liquidation is limited. To the best of our knowledge, whilst the literature provides evidence of the existence of spatial dependence on business growth (Cravo et al., 2015), the importance of spatial dependence on business liquidations among countries has not been analysed extensively, only a few very specific exceptions where firm-specific data (as opposed to aggregate level) are concerned (see Maté-Sánchez-Val et al., 2018). Yet evidence suggests that spatial data are particularly relevant for business economic-related studies when considering different geographical locations (Wang et al., 2012). The cross-sectional independence assumption between economic participants in a sample is challenging to be confirmed in an increasingly inter-connected, globalised economy where economic agents are trading with each other (Wang et al., 2012).

Spatial interactions in businesses could be spill-overs of regional issues affecting business in certain geographical areas or to competition between businesses (Kapoor et al., 2007). Moreover, regional specialisation within Europe and as such spatial patterns of agglomeration of the economic activity are emerging (Longhi et al., 2014). It is worth noting that this regional specialisation may include countries or even larger geographical parts of Europe. For example, metropolitan areas (such as London,

Amsterdam, Dublin and others) in European countries appear to be more specialised in financial services and others appear to be more specialised in other services or industrial production.

Such effects are difficult to capture without controlling for spatial location. From an econometric perspective, the modelling approach is open to mis-specification problems if spatial effect is omitted.

This study investigates the importance of the geographical (spatial) location on business liquidations in 8 European countries. Specifically, whether spatial effects are directly affecting business liquidation between different European countries and whether spatial effects are affecting business liquidations indirectly. In order to investigate the former, we test spatial autocorrelation in the number of business insolvencies. For the latter, we test the existence of spatial effects in the error terms of the models. Furthermore, the impact of spatial effects in a combination of the error terms and the dependent variable are tested.

This paper contributes to the wider business liquidation literature that looks at the aggregate determinants of business liquidation. The inclusion of spatial effects in the analysis of liquidation determinants can have substantial implications for policy and decision-makers who aim to design policies and strategies to assist failing businesses. One theoretical advantage of spatial panel data is their ability to consider disturbances that are correlated spatially (across countries in this case) in addition to the normal time-wise correlation (Arnold and Wied, 2014). This explains why the usage of spatial econometric techniques has seen growing interest within economic studies; these models use a further dimension in the analysis of relationship between economic agents, in this case the businesses. The focus of such analysis is shifted from an individual business to the interaction between businesses (Anselin, 1999; Diggle, 2013).

In this study the existence of spatial effects is tested against the number of liquidated firms in each country, each year. In line with the previous literature on aggregated business liquidations, variables that control for the economic environment, credit availability and the legal framework of the different countries are used. Details are explained in Section 2.

The remainder of this paper is organised as follows. Section 2 reviews the literature; section 3 describes the data; section 4 explains the methodology; section 5 discusses the empirical results; and Section 6 concludes the study.

## 2. Literature Review

### 2.1 Determinants of Aggregated Liquidations

The empirical evidences on business liquidations can be typically divided into two groups. The first group focuses on company-specific characteristics, including financial performance and managerial efficiency. Such studies typically utilise cross-sectional or panel data structures to empirically identify the determinants of business insolvency. The second group of empirical studies looks at the macroeconomic determinants of aggregate business insolvencies and typically employs time-series analysis to identify the determinants of business insolvencies, at aggregated level.

This study follows primarily the second group, into identifying macroeconomic determinants of business. It employs spatial data analysis and as such it combines techniques and evidence from the relevant spatial analysis literature.

Considering the empirical evidence on aggregated firm liquidations, there is significant evidence that, regardless of the liquidation procedure the macroeconomic determinants do not vary materially between alternative studies. Credit availability has also been a significant determinant of business liquidation. Increased credit availability assists business' survival in the short run but it is associated with increased liquidation in the long run. This is because bank credit is a key instrument for firm financing (especially in small and medium sized firms). To this end there is significant evidence on the importance of credit channel in the transmition of monetary policies (Liu,2004; Gertler and Gilchrist, 1994; Oliner and Rudebusch, 1994).

In addition, changes in the business birth rates can affect business liquidations (Liu, 2004; Love, 1996). In particular, Love (1996) argued that business exits are influenced by business entry rates and changes in unemployment rates whereas the local economic infrastructure may also be important (Love, 1996).

Nominal interest rates have been also seen to be positively related to business liquidations and negatively associated with the money supply (Desai and Montes, 1982). Likewise, Wadhwani (1986) presented evidence that the after tax interest rate, the real wages in manufacturing and the raw material prices, were significant positive

determinates of liquidations. Wadhwani's framework was also applied from Davis (1987) in the UK, US, Germany and Canada, further indicating the significance of the real Gross National Product, the wages, the raw material prices and the level of corporate debt to GNP as significant determinants of the annual rate of business liquidations. Further evidence for the importance of nominal interest rates was provided by Young (1995) who extended Wadhwani's framework and from Vlieghe (2001) who also identified the interest rate as well as the birth rate of new companies, among other statistically significant determinants of business liquidations in the UK, in the long run. Liu (2004) shows that there is a dynamic relationship between macroeconomic conditions and business liquidations. Interest rates and therefore monetary policy directly affect business liquidations due to the impact they have in business' ability to borrow and manage borrowing cost. Likewise, Jones (2013) indicated, that the two most significant macroeconomic determinants of corporate (in this case voluntary) liquidations are the rate of economic growth and the level of nominal interest rates with significant long term and short term effects. Moreover, cross-country studies suggest that the legal environment is important with individual countries' insolvency procedures and current legislation being related to, and influenced by, a country's legal origins (La Porta et al., 1997; La Porta et al., 1998; La Porta et al., 2008; Wang, 2012). In addition, there is evidence that, by controlling for a country's legal origins, certain idiosyncrasies arising from a country's insolvency procedures (such as the power of creditors' rights) are accounted for (La Porta et al., 1997).

### 2.2 Regional Effects

On the other hand, in the last few years there have been developments in the literature on two other fronts. First, increasing evidence suggests that, regional specialisation within Europe, spatial patterns of agglomeration of the economic activity are emerging (Longhi et al., 2014). This implies that geographical location is associated with economic activity. Second, there is increasing evidence that geography can be an important factor on business performance and potentially liquidation.

There are theoretical perspectives in relation to transportation costs and external economies that are directly related with the geography of the business and can impact business performance or failure (Maté-Sánchez-Val et al., 2018). Businesses close to

external resources (such as suppliers and banks) minimize transportation costs and industry specialisation can be created between firms (Marshall, 1920; Kapoor et al, 2007; Maté-Sánchez-Val et al., 2018). Longhi et al., (2014) concluded that country specialization is emerging in Europe, pointing out there are spatial patterns of agglomeration of economic activity. In particular, large metropolitan areas with more than 500,000 inhabitants appear to be more specialized in services whereas medium sized cities (of between 50,000 and 500,000 inhabitants) tend to specialize in traditional manufacturing activities such as textiles and food whereas similar sized cities tend to have similar specializations (Henderson, 1997).

In addition, liquidation is influenced by external factors that related to the economic and business environment within an area and these factors can vary significantly between different places (Everett and Watson, 1998; Paspe and van Oort, 2011). In such cases the proximity between businesses can be an important determinant of business liquidation at least partly affected by spatial dependence. Cravo et al., (2014) showed the presence of spatial dependence in growth patterns on a sample of Brazilian SMEs. Similarly, Fernandes and Artes (2016) identified spatial dependence between Brazilian SMEs. Likewise, Maté-Sánchez-Val et al., (2018) confirmed the existence of spatial co-localised patterns in pairs of failed companies in Spain, suggesting that failed companies are likely to be surrounded by other similarly failed companies. Moreover, they found that companies located in the vicinity to certain external agents have lower probability of business liquidation. This positive effect could be explained by the reduction in activity costs as well as by the advantages linked to external information flows (Karlsson et al., 2015).

Given the above, early evidences suggest that spatial location does affect business liquidation. Likewise, other factors that are area-specific but unobservable to a researcher could also affect such events. For example, Buehler et al., (2012) suggests that culture can also affect business liquidations. However, culture cannot be measured directly. Therefore, accounting for spatially correlated unobservable effects is a primary reason to use models that account for such effects.

## 3. Data

This study uses a panel dataset of businesses that liquidated between 2004-2013 in 8 EU countries , sourced from the Europa.eu database. The countries included in the analysis are the United Kingdom, Ireland, Germany, France, Italy, the Netherlands, Spain and Sweden. The selection of these countries reflected the need to have a diverse set of European countries that experienced varying degrees of economic decline during the 2008 financial crisis and, at the same time, had complete data on business liquidation in the period under investigation. As such, for these countries, the annual number of business liquidations was collected as the main variable of interest (dependent variable) in this research. A balanced panel of 80 country-year observations for the business liquidations was created.

A number of macroeconomic variables have also been collected from the World Bank database, covering the same period. These variables have been selected based on evidence from the prior academic literature on aggregate firm liquidations. Specifically:

- Information for the GDP growth for each country (each year) is collected in order to account for the broader macroeconomic environment is used to account for the macroeconomic conditions (Liu,2004; Jones, 2013);
- The credit availability as a percentage of GDP in each country (CR), is used to account for the credit conditions in each country (Liu, 2004; Liu, 2009);
- A dummy variable to account for the legal tradition (Legal) in each county has been created. This is based on information on whether a country's legal tradition can be traced back to the common law system or the civil law sytem (La Porta et al., 1997; La Porta et al., 1998; Glaeser and Shleifer, 2002; Sgard, 2006). Legal traditions associated with the civil law have weaker creditor protection compared to the common law legal traditions (La Porta et al., 1998) and as a result insolvency procedure in countries with common law traditions are more creditor driven as opposed to court-driven.
- The effective company tax and mandatory contributions payable by businesses after accounting for allowable deductions and exemptions as a share of commercial profit (TR) has been used to control for the tax-related impacts on business profitability in each country (Jones, 2013).

- The base interest rate (BR) of each country's Central Bank (Liu, 2004; Liu, 2009; Jones, 2013; Zhang et al., 2013).
- CPI is a measure of inflation (Liu, 2004; Liu, 2009; Jones, 2013).
- The logarithm of the number of new businesses that commence trading in each country (NB), each year which is a measure of the intensity of competition (Liu, 2004; Liu, 2009).
- A dummy variable that controls for the country of the business(CB) is also introduced.

In addition, the spatial location of the countries was identified by means of the latitude and longitude coordinates.

## 4. Methodology

This paper applies spatial panel models with random effects. The use of random effects is due to the inclusion of time invariant independent variables in the model specification (such as the legal origins and the spatial matrix). There are a number of ways to account for the spatial effects. Prior to applying any spatial models we test for spatial effects on the (natural logarithm of) the number of business liquidations, using Moran's I test. In terms of modelling approaches, first, we apply an additional independent variable that represents a spatially lagged (Spatial Autoregressive Model - SAR) dependent variable (Anselin, 1999). This model is primarily used to test whether spatial effects directly affect the dependent variable. In other words, such specification is used to identify the existence and the strength of the spatial interaction on the dependent variable. Second, we employ a model that controls for the existence of spatial effects in the error terms. The spatial effects into the error structure of the model are therefore investigated by using a Spatial Error Model (SEM). Such a specification is useful when the aim is to account for any biasing effects that the existence of spatial autocorrelation may have on the model (Anselin, 1999). Third, a combination of the two approaches is used. Finally, we test the potential interaction of spatial effects with the rest of the exploratory variables which are selected based on the previous academic literature in aggregate business liquidations. It is possible to consider spatial effects in all independent variables of a model in the form of the

Spatial Durbin Model (SDM). For the estimation of the models, a Maximum Likelihood estimator is employed.

The modelling approach undertaken in this paper first specifies a simple (non-spatial) panel model which will be used as a benchmark against the results from the spatial panel model. Subsequently, a spatial panel model is applied with the same control variables and the additional spatial weights from the spatial weight matrix.

**Non-spatial Model**

The simple (non-spatial) model will have the following general specification (ignoring panel effects) for the EU countries:

$$BF = c + \beta_1 GDP + \beta_2 CR + \beta_3 Legal + \beta_4 TR + \beta_5 BR + \beta_6 CPI + \beta_7 NB + \beta_8 CB + u \quad \text{(i)}$$

Where, BF is the logarithm of the number of liquidated businesses for each year in each country; c is the constant; GDP is the gross domestic product growth rate for each country (each year); CR is the credit availability in each country, each year as a percentage of GDP; *Legal* has been used to control for the legal traditions of each country and has used as a proxy for the legal environment of each country. The *Legal* variable takes the value of 1 for countries whose legal tradition is the common law and 0 for those with civil legal traditions**;** TR is the effective company tax and mandatory contributions payable by businesses after accounting for allowable deductions and exemptions as a share of commercial profit; BR is the base interest rate of each country's Central Bank; CPI is a measure of inflation; *NB* is the logarithm of the number of new businesses that commence trading in each country; CB is a dummy is a dummy variable that controls for the country of the business.

**Spatial Models**

In addition to the simple panel model (i) above, models incorporating spatial effects are also specified in the form of SEM, SAR and SDM models.

First, on the SEM specification, this controls for the existence of spatial effects in the error term and has the following generic specification (ii a).

$$y = X\beta + u \quad \text{(ii a)}$$

$$u = \rho W u + \varepsilon \quad \textit{(ii b)}$$

$$y = X\beta + (I_n - \rho W)^{-1}\varepsilon \quad \textit{(ii c)}$$

In this specification the matrix X contains exogenous explanatory variables and the k by 1 vector β represents the associated regression parameters. Any spatial effects are located in the disturbance process. W represents the spatial Weights, associated with each country. Equations (ii b) and (ii c) show the expected data generation process and the expected value from model (ii a) respectively (LeSage and Pace, 2009). The SEM model (ii a) can take the more following specification when the independent variables of this study are considered:

$$BF_{nt} = c + \beta_1 GDP_{nt} + \beta_2 CR_{nt} + \beta_3 Legal_{nt} + \beta_4 TR_{nt} + \beta_5 BR_{nt} + \beta_6 CPI_{nt} + \beta_7 NB + \beta_8 \mathrm{CB} + u_{nt} \quad \text{(ii)}$$

Where u is:

$$u_{nt} = \rho W\_u_{nt} + \varepsilon_{nt}$$

Secondly, the general SAR model specification includes a spatially lagged dependent variable (iii a) (LeSage, 2008):

$$y = \rho W_y + X\beta + \varepsilon \quad \text{(iii a)}$$

$$y = (I_n - \rho W)^{-1} X\beta + (I_n - \rho W)^{-1}\varepsilon \quad \text{(iii b)}$$

$$E(y) = (I_n - \rho W)^{-1} X\beta \quad \text{(iii c)}$$

. $$\varepsilon \sim N(0, \sigma^2 I_n) \quad \text{(iii d)}$$

Where y is the dependent variable vector of n by 1 dimension. The matrix X contains exogenous explanatory variables and the k by 1 vector β represents the associated regression parameters. The n by 1 spatial lag vector Wy reflects the distance of neighbouring countries specified by the matrix W, and the associated

scalar parameter ρ reflects the strength of spatial dependence. When the scalar parameter ρ takes on a value of zero, the model (iii a) simplifies to the conventional linear regression model. The n by 1 disturbance vector ε contains independent, normally distributed terms. Equations (iii b) and (iii c) show the expected data generation process and the expected value from model (iii a) respectively (LeSage and Pace, 2009).

Given the independent variables incorporated in this research, (iii a) takes the more specific form of (iii)

$BF_{nt} = c + \rho W_{nt} BF_{nt} \quad \beta_1 GDP_{nt} + \beta_2 CR_{nt} + \beta_3 Legal_{nt} + \beta_4 TR_{nt} + \beta_5 BR_{nt} + \beta_6 CPI_{nt} + \beta_7 NB_{nt} + \beta_8 \mathrm{CB}_{nt} + \varepsilon_{nt}$ (iii)

Finally, the general SDM model specification includes an average of the explanatory variables from neighbouring countries, created using the matrix product WX. (iv a) (LeSage, 2008):

$$y = Wy + ai + X\beta + WX\theta + \varepsilon \quad \text{(iv a)}$$

$$y = (I_n - \rho W)^{-1}(ai_n + X\beta + WX\theta + \varepsilon) \quad \textit{(iv b)}$$

$$E(y) = (I_n - \rho W)^{-1}(ai_n + X\beta + WX\theta) \quad \textit{(iv c)}$$

. $$\varepsilon \sim N(\sigma^2 I_n) \quad \textit{(iv d)}$$

In the above general specification of the model (iv a) the geographical (spatial) distance allows business liquidations for each country to be influenced by the country-specific independent variables as well as the same factors averaged over the number of neighbouring countries, WX. In line with LeSage and Pace (2009), in the SDM model we need to separate the intercept from the independent variables contained in matrix X because $Wi_n = i_n$ where the n by i vector is denoted by $i_n$.

Given the independent variables of this research the SDM model, which includes spatial effects on all independent variables, takes the following form (iv b):

$$BF_{nt} = c + \rho W_{nt} BF_{nt} \;\; \beta_1 GDP_{nt} + \beta_2 W_{nt} GDP_{nt} + \beta_3 CR_{nt} + \beta_4 W_{nt} CR_{nt} + \beta_5 Legal_{nt} + \beta_6 W_{nt} Legal_{nt} + \beta_7 TR_{nt} + \beta_8 W_{nt} TR_{nt} + \beta_9 BR_{nt} + \beta_{10} W_{nt} BR_{nt} + \beta_{11} CPI_{nt} + \beta_{12} W_{nt} CPI_{nt} + \beta_{13} hNB_{nt} + \beta_{14} W_{nt} BNB_{nt} + \varepsilon_{nt} \qquad \text{(iv)}$$

Equation (iv) shows that the SDM model has additional spatially lagged effects in all the independent variables. This specification does not apply the (CB) dummy variables to control for the country of business' liquidations due to multicollinearity reasons.

The key variable of interest in spatial analysis is the spatial weights which was represented by Wij in the above equations. For that reason, a spatial weights matrix has been created. The spatial matrix is a n-by-n matrix capturing for each location of i rows the other location of j columns that belong to neighbouring locations (Anselin and Bera, 1998). As a result, each location is associated with a Wij weight which measures the degree of spatial proximity between i and j (Pisati, 2012).

Geographical coordinates are used to develop the matrix (Pisati, 2001; 2012). Data from the online geographic database, LatLong.net, have been obtained in the form of geographic co-ordinates. The centroid geographical location of each country or region has been used as a reference point of location for which the geographical co-ordinate have been obtained.

In this study, the proximity is measured by the inverse distance, in a spectral normalised matrix, having the advantage of preserving symmetry without altering the model specification (Drukker et al., 2013; Plummer, 2010). Table 1 shows the spatial weights matrix for the EU countries.

Table 1: Spatial Weights Matrix – EU Countries

| Nr. | Country | LATITUDE | LONGITUDE | W1 | W2 | W3 | W4 | W5 | W6 | W7 | W8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | FRANCE | 46.228 | 2.214 | 0.000 | 0.104 | 0.083 | 0.089 | 0.150 | 0.121 | 0.046 | 0.093 |
| 2 | GERMANY | 51.166 | 10.452 | 0.104 | 0.000 | 0.055 | 0.105 | 0.190 | 0.056 | 0.082 | 0.069 |
| 3 | IRELAND | 53.142 | -7.692 | 0.083 | 0.055 | 0.000 | 0.043 | 0.077 | 0.075 | 0.037 | 0.208 |
| 4 | ITALY | 41.872 | 12.567 | 0.089 | 0.105 | 0.043 | 0.000 | 0.079 | 0.061 | 0.052 | 0.048 |
| 5 | NETHERLANDS | 52.133 | 5.291 | 0.150 | 0.190 | 0.077 | 0.079 | 0.000 | 0.068 | 0.064 | 0.107 |
| 6 | SPAIN | 40.464 | -3.749 | 0.121 | 0.056 | 0.075 | 0.061 | 0.068 | 0.000 | 0.034 | 0.067 |
| 7 | SWEDEN | 60.128 | 18.644 | 0.046 | 0.082 | 0.037 | 0.052 | 0.064 | 0.034 | 0.000 | 0.044 |
| 8 | U.K. | 55.378 | -3.436 | 0.093 | 0.069 | 0.208 | 0.048 | 0.107 | 0.067 | 0.044 | 0.000 |

These weights effectively measure the intensity (in terms of distance) of the relationship between two countries. A higher weight placed in closer locations and lower weights are associated with more distant locations. As such a stronger relationship exists between countries that are close to each other, for example the UK and Ireland (0.208); a weaker relationship exists between countries that are further away such as Italy and Ireland (0.043).

## 3. Results and Discussion

### 3.1 Empirical Results

First, we test for any spatial effects directly on the dependent variable by using Moran's I test, in each year separately. This approach shows that there is no evidence of spatial autocorrelation in the logarithm of business liquidations between countries. Therefore, it is possible that the SAR model will also show no evidence of spatial autocorrelation in the dependent variable. However, this approach does not account for the panel structure of the data and as such we propose to proceed with the full panel models.

Then, the panel regression (i) is run with the number of business entering liquidation. Then the spatial panel regressions are run. Subsequently, four specifications of spatial panel regressions were tested, broadly in line with the literature that suggests that in spatial econometrics the spatial error model (SEM), the spatial autoregressive model (SAR) and the spatial Durbin model (SDM) are the most commonly used models (LeSage and Pace, 2009). In addition, a spatial model combining spatial error and spatial autoregressive components has been tested (denoted as SAR/SEM in the table below).

Tables 3 shows the results of simple panel and the spatial panel models where the spatial effects are accounted for.

Table 3: Spatial Panel Data Results – EU Countries

| | No Spatial Effects | Spatial Effects | | | |
|---|---|---|---|---|---|
| | Panel | SEM | SAR | SAR/SEM | SDM |
| | | Coeff. Pr>\|z\| | | | |
| Column: 1 | 2 | 3 | 4 | 5 | 6 |
| W_BF | | | 0.224 | -0.254 | -0.579 * |
| W_error | | 0.329 *** | | 0.506 * | 0.665 ** |
| W_GDP_gr | | | | | 0.029 ** |
| W_CR | | | | | 0.000 |
| W_NB | | | | | 0.397 |
| W_TR | | | | | 0.000 |
| W_CPI | | | | | -0.098 *** |
| W_BR | | | | | 9.521 *** |
| W_Legal | | | | | 0.324 |
| c | 2.746 *** | | | | 0.485 ** |
| GDP_gr | -0.014 *** | -0.015 *** | -0.011 *** | -0.016 *** | -0.015 *** |
| CR | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 |
| Legal | 0.447 *** | 2.902 *** | 1.853 | 4.404 * | 0.099 * |
| TR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| BR | -0.551 | -1.228 | -0.987 | -1.137 | 0.903 |
| CPI | -0.006 | -0.007 | -0.007 | -0.007 | -0.022 ** |
| NB | 0.389 ** | 0.462 *** | 0.432 ** | 0.430 ** | 0.903 *** |
| CB_France | 0.395 *** | 2.824 *** | 1.642 | 4.488 | |
| CB_Germany | 0.551 *** | 2.985 *** | 1.857 | 4.585 | |
| CB_Ireland | -0.624 *** | -0.561 *** | -0.566 ** | -0.627 ** | |
| CB_Italy | 0.104 | 0.065 | 0.330 ** | -0.215 | |
| CB_Netherlands | -0.318 *** | -0.300 *** | -0.575 *** | -0.010 | |
| CB_Spain | 0.048 | 0.039 | 0.291 * | -0.241 | |
| CB_Sweden | 0.000 | 2.475 *** | 1.869 * | 3.437 * | |
| /sigma_u/STD error sigma_u | 0.000 | 0.001/0.007 | 0.000/0.007 | 0.001/0.007 | 0.046/0.016 |
| /sigma_e/ STD error sigma_e | 0.075 | 0.066/0.005 | 0.067/0.005 | 0.065/0.006 | 0.061/0.005 |
| Wald Test of spatial terms | | 3.990 ** | 2.360 | 8.950 ** | 44.660 *** |

The results from the simple panel model (i) suggest that, when controlling for the countries of firms (with the dummy variables, some of which are statistically significant), that decreasing GDP growth, the legal tradition and the logarithm of (increasing) new business births are significant determinants of firms aggregated liquidation across the countries in the sample. These results are in line with evidence from the academic literature in single country studies (see for example Liu, 2004; Liu, 2009).

Subsequently spatial effects are introduced with the error term (SEM model), column 3 (ii). There is little change in the significance of the main exploratory variables but the spatial effects in the error term are highly significant despite controlling for the location of the businesses liquidations with the dummy variables. This is a significant result because it implies that the original non-spatial model does not account for the statistically significant spatial effects, suggesting that the results are potentially mis-specified. This is confirmatory to the Moran's I test that we run at the beginning.

Moreover, the Wald test for the spatial terms suggests that they are significantly different to zero, further confirming the statistical significance of the spatial effects.

The SAR model (iii), column 4, controls for the existence of spatial effects in the spatially lagged dependent variable. There are small differences in the significance of the exploratory variables, notably that the Legal variable that controls for the legal traditions of each country is no longer statistically significant. However, there is no evidence of statistically significant spatial effects in the autoregressive variable. In addition, the Wald test for the spatial terms is not significant, suggesting that the spatial terms are not significantly different from zero. As a result, one can conclude that the SAR model does not offer any advantages over the simple panel model as there is no evidence of spatial effects in the (spatially) lagged dependent variable.

The combination of spatial autoregression and spatial error terms in the model (SAR/SEM), column 5, further confirms the existence of statistically significant spatial effects in the error term but not in the autoregressive element. As a result, the SEM model is more appropriate than either SAR or the combination of SAR/SEM since there is limited evidence on the existence of spatial effects in the spatially lagged dependent variable.

Finally, a further spatial specification was tested in the form of the SDM model, column 6, which tests whether any of the independent variables have spatially lagged effects. To do this, we had to remove the dummy variables that control for the country of business liquidations due to multicollinearity problems. In this specification both the spatially lagged dependent variable and the spatially lagged error term are statistically significant (in Sig. <0.10 and Sig.<0.01, respectively). Likewise, a number of spatially lagged independent variables are statistically significant (GDP_gr, CPI, BR). We also find that the statistically significant independent variables remain the same, with the addition of a statistically significant metric for the inflation rate (CPI).

The results above suggest that both the SEM and the SDM models can be used to estimate the determinants of business liquidations across a number of European countries. Depending on the specification of the model and whether one wishes to include dummy variables to control for the countries or not, both the SEM and the SDM specifications can be appropriate. Critically, the above results suggest the existence of spatial effects when business liquidations are considered in more than one country. As a result, liquidation to include such effects when investigating the determinants of

business' liquidation between countries could lead to mis-specified models and incomplete results.

### 3.2 Implications on business liquidations

The presence of spatial effects in the error terms implies spatially correlated with the error term, determinants that are not captured in the independent variables of the model have a significant impact on the dependent variable. The sign of the coefficient, denoting spatial effects in the error term, is difficult to be interpreted directionally. However, the positive sign is associated with increased spatial weights and therefore with decreased distance. The fact that the spatial patterns in the error term are statistically significant implies that a model that did not control for these effects would probably have spatial autocorrelation in its residuals, making that model mis-specified from a statistical perspective (LeSage and Peace, 2009).

It is possible that these spatial error patterns are down to unobservable effects that cannot be measured and therefore the researcher or the policy maker should be aware that such effects exist between businesses in liquidation in the EU countries.

Whilst there is no evidence of the application of spatial econometric models in the business liquidation literature, there is some implied evidence from the wider literature that underlying business conditions have some spatial characteristics. For example, Buehler et al., (2012) suggests that culture affects firms' bankruptcy rates but culture cannot be measured directly. Likewise, considering local industries in Italy, Cainelli et al., (2013) stated that firms' failure (as well as mergers and acquisitions) experience time (temporal) effects that are territorially bounded. Additionally, there is evidence shows that region-specific characteristics may be different and start-up costs may vary considerably between regions in a country (Gries and Naude, 2008), a finding further confirmed from our analysis. Glass et al., (2012) makes the economic case for spatial error models, noting that they should be used (when necessary) because they are able to capture spatial dependence beyond what non-spatial models can capture. Therefore, accounting for spatially correlated unobservable effects is a primary reason

to use models that account for such effects, because the researcher cannot obtain the necessary variables to account for these effects and therefore a non-spatial error model would be mis specified.

## 4. Conclusions

This paper provides one of the first evidences that shows that in the context of business liquidations, the location of the firm, along with a number of macroeconomic and business environment variables, previously identified in the literature, can be a significant determinant of aggregate liquidations between different countries. The results indicate that spatial effects are significant determinants of aggregated business liquidations, when different countries are considered. Failure to include spatial effects when modelling business liquidations between different countries could result in mis-specified models and incomplete results. Such evidence provides significant implications for decision and policy makers who are tasked to design policies to support businesses avoiding liquidation. Specifically, this analysis demonstrated the existence of spatial effects in the error terms by means of a SEM model, implying that unobserved determinants of business liquidations are (spatially) correlated with the error term, leading to potentially mis-specified calculations when the spatial effects are not considered.

On the other hand, there was no evidence of the existence of spatial effects on the lagged dependent variable. Such a result would imply that business liquidations in a country directly affect those of another country based on some function of distance. This result was not confirmed at the highly aggregated level of this analysis.

There is some scope for further research on the impact that spatial effects may have in predicting future liquidation rates. As such, future research should focus on extending the sample of liquidated business to more countries to cover wider populations of business in the EU. Moreover, granular investigation on the impact of spatial effects on business liquidations is an area for further research.

These findings suggest that there may be a number of other location-specific factors that affect business liquidations that are not observed from the researcher and influence businesses liquidations

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