The environmental-financial performance nexus evaluation at a micro-territorial level in the SE Spain: *pollution umbrella effect*

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Abstract

Groundwater pollution is a growing hazard to human health and to the correct functioning of ecosystems. This study examines the impact of groundwater pollution on firm performance in an environmentally stressed area in SE Spain. This relationship has been previously analysed in environmental economics and financial studies from a variety of theoretical perspectives leading to very different conclusions. Although the most recent studies find a negative impact of local environmental pollution on firm performance there is still an open question about how to measure the environmental performance. In this sense, this paper introduces the actual groundwater pollution of the last assessment for Spain according to the EU Nitrates Directive 91/676/CEE to test an alternative version of the Porter hypothesis (PH) from a geographical perspective. According to the PH firms' financial performance can improve from a stricter environmental regulation. We postulate an alternative hypothesis around the nexus between environmental performance and financial performance. The main question to be tested in this study is whether the absence of effective regulation against pollution, proxied by the firms' exposure to high levels of pollution, is affecting firm' performance, measured with the probability of failure. To identify the direction and quantify the effect we use firm-level panel data from the SABI database for a five-year period. Then the existence of a spatial contagion effect among close firms is evaluated through a spatial econometric model. The last question is whether some firms are gaining and some others losing from the absence of effective regulation. The main conclusion is that exposure to environmental pollution is more detrimental for firms' survival than firms' size, age and profitability ratios like ROA and ROE, and this

effect is bigger for service sector businesses. Finally, we find no evidence about firms of any economic sector gaining from the absence of effective regulation against nitrate pollution. Therefore, this paper empirically demonstrates the existence of significant environmental-financial nexus and give strong support to a stricter application of EU Directives against pollution.

1. Introduction

Environmental pollution and other effects of climate change are threatening global financial and macroeconomic stability (IMFs; IPCC, 2023; EC, 2019). Then an important question arises around how is the economic activity affected by the natural environmental quality? Nitrate pollution is a growing hazard to the good status of the aquatic and terrestrial ecosystems globally (Bijay-Singh and Craswell, 2021) caused by the agricultural intensive practices. In areas like the Mediterranean Spain these practices are characterized by the use of high fertilizer doses causing eutrophication of water ecosystems (Omondi Oduor et al., 2023; De Paz and Ramos 2002). As a consequence, around the 30% of Spanish aquifers are heavily polluted by nitrates (Pérez-Martín et al., 2024). At the same time, when ecosystems are persistently under high stress like eutrophication of groundwater, surface waters and coastal ecosystems become more fragile. The correct functioning of coastal and water ecosystem services is essential for the maintenance of the ecological-economic system. Individuals and business organizations obtain benefits from ecosystem services [1] which range from clean water supply, food supply, aesthetic or cultural services, pollution abatement or climate change effects regulation, etc. (Costanza et al., 1997; Winn and Pogutz, 2013) and sudden changes in ecosystems natural equilibrium can derive in undesired economic consequences. For example, the occurrence of harmful algae blooms has triggered losses in income per capita in the residents of coastal areas (Aparicio et al., 2024). Financial performance has frequently been analysed within failure rates of businesses and one of the relevant factors explaining the occurrence of failure is precisely the firm location.

[1] We follow the description of ecosystem services and functions definition in Costanza et al. (1997) as the "Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions." And ecosystems functions as the "habitat, biological or system properties or processes of ecosystems".

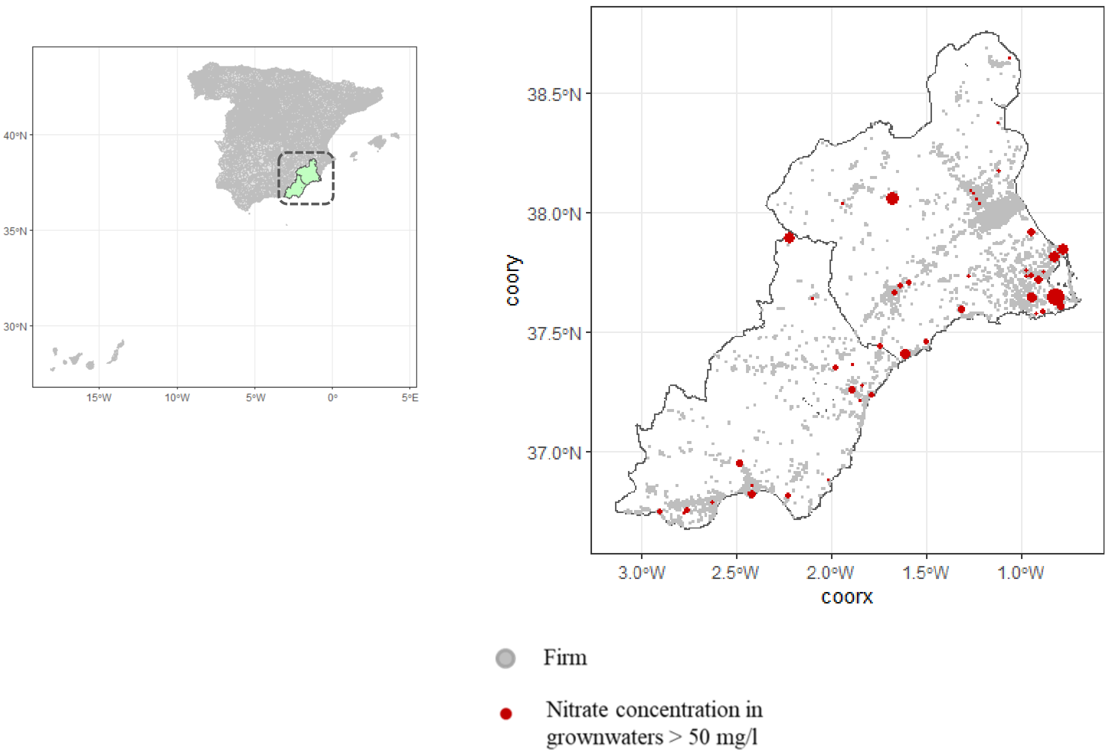
Geographical location of the firm regarding transport facilities, logistic centres, industrial estates, and their proximity to succeed firms have demonstrated to increase the probability of firm survival (Maté-Sánchez-Val et al., 2018). Further research shows that proximity to marine pollution is a detrimental factor for firm survival (Maté Sánchez-Val and Aparicio-Serrano, 2023). We support this idea about the nexus between financial performance – environmental performance from a geographical perspective.

Our intuition rests on Pigou (1920) theoretical approach on how negative externalities cause market failures. When polluting firms only account on their private costs but not with costs generated by pollution and generally assumed by others stakeholders like governmental agents, citizens and other firms; goods causing negative externalities are overproduced. In the case of intensive agricultural production, the negative externalities take the form of nitrate pollution present in surface and groundwater bodies (Abascal et al., 2022). When business organizations overconsume natural services (exploitation of freshwater, emission of pollutants, etc.) over the threshold of recovery capacity of the ecosystems, ecosystem services decrease their capacity of provisioning and resilience (Win and Pogutz, 2013). In such situations prices do not reflect the overall costs of production of polluting firms. If some part of the economy is assuming the additional costs caused by pollution it may lead to worse financial performance, economic losses and even firm failure. We expect this financial distress to be more salient among tourist industry and services sector. Examples of economic losses directly related to poor conservation and environmental degradation are reflected in recent research on the tourism sector which reveals important revenue losses from degraded coastal ecosystems (Lopes Diniz et al., 2026) or atmospheric pollution (Hao et al., 2021).

This hypothesis will be tested from a financial perspective in the SE Mediterranean Spain covering the provinces of Murcia and Almería (Fig. 1). Concretely we examine whether the degree of exposure to nitrate pollution in groundwaters, measured with points or stations declared in “bad status” (NO_3> 50mg/L), affects firm financial performance. We name this hypothesis the *pollution umbrella effect* given the form it takes when the spatial methodology we employ based on concentric rings is represented (Fig.2). This methodology has been previously applied to financial studies to compute geographical density as sectorial inter and intra specialization as determinants of business failure (Maté-Sánchez-Val and Martínez-Victoria, 2025).

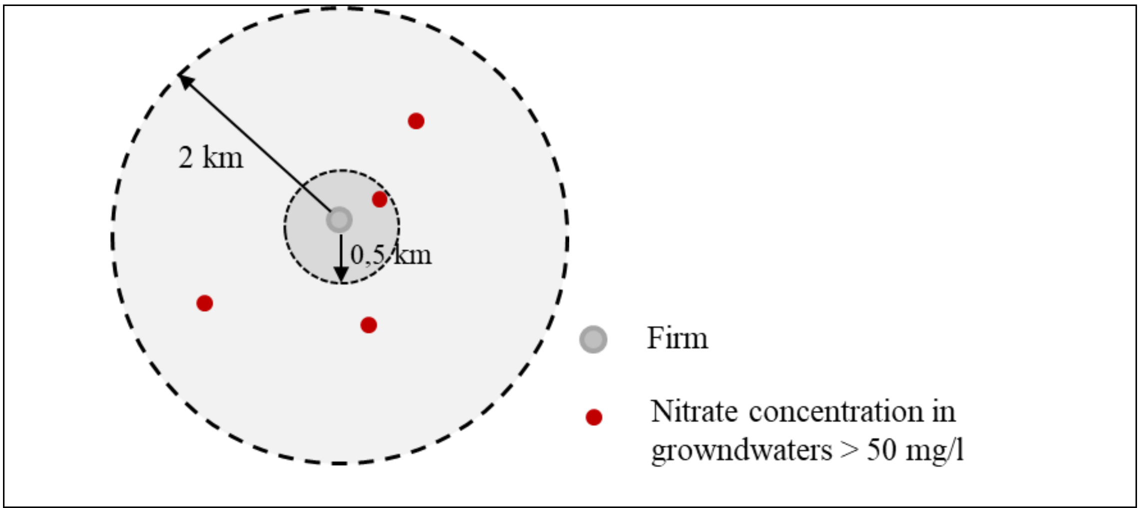
Semi-arid area of Southeast Spain (SE Spain), geographically located at the Murcia and Almería provinces (Fig.1) are one on the major suppliers of horticultural products to the EU. The value of exported F&V accounts with almost the 40% of Spanish exports of F&V to the EU (Jiménez-Aceituno et al., 2021). The cultivated land has increased in size and progressively transformed from rain-fed to intensive agriculture (in the case of Murcia province) and to greenhouses (in the case of Almería) since the 1980s (Jiménez-Aceituno et al., 2021). Production is sustained over time despite water scarcity and the simultaneous generation of negative externalities associated to the overexploitation of aquifers, loss of biodiversity and the destruction of valuable ecosystems.

Figure 1. Firms' location and nitrates pollution in groundwater in Murcia and Almería provinces (SE Spain)



Source: Authors' own elaboration using RStudio based on information from MITECO (2025) and SABI (2025) databases.

Figure 2. Graphical representation of the *pollution umbrella effect.*

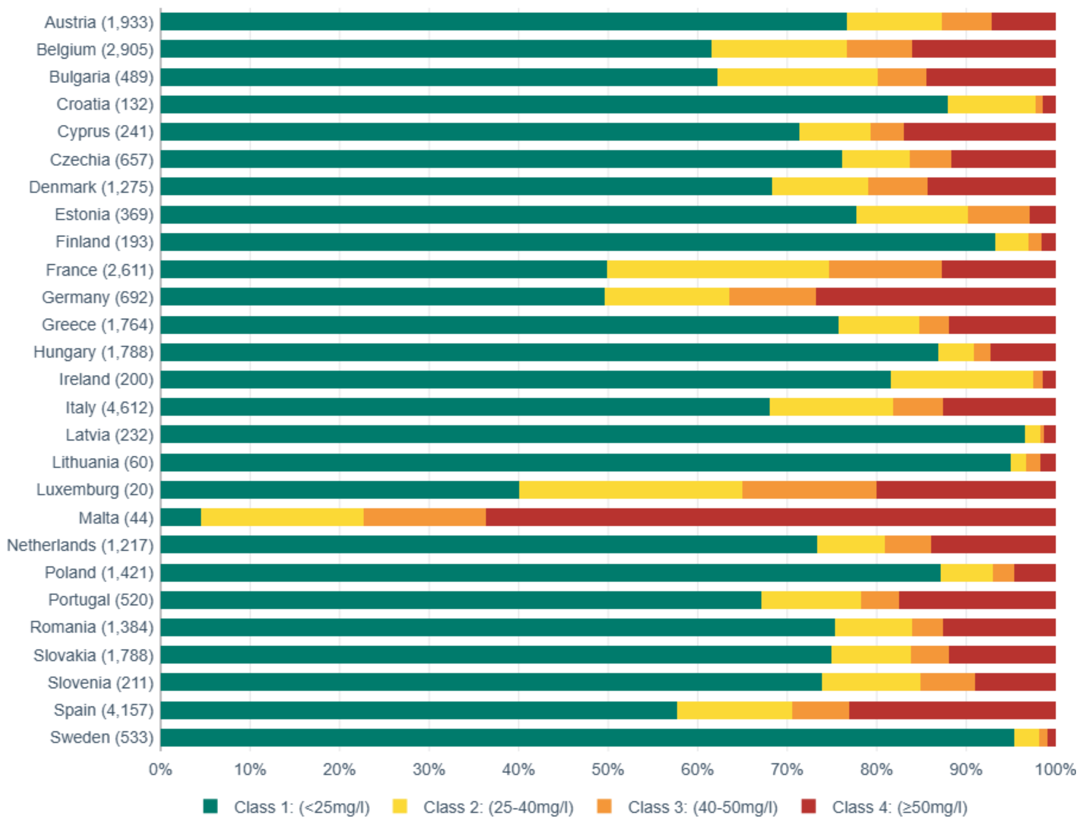


Source: Authors' own elaboration.

To assess the impact of land and soil degradation on firm failure in that area we take the EU Nitrates Directive assessment of Spanish groundwaters for the period 2016-2019 (last available). EU Nitrates Directive has the goal of reducing the ground and surface water pollution from agricultural nitrates and the EU Member States are responsible to monitor and declare contaminated waters according to a concrete threshold set in dissolved nitrates higher than 50 mg/l in the case of groundwater. Currently, a significant proportion of groundwater bodies in Spain fail to comply with the EU Nitrates Directive standards (around the 23%, see Fig. 3) a figure that rises dramatically in the intensive horticultural zones of Murcia and Almería. The last four-yearly monitoring data shows an average NC in groundwaters of 36,46 mg/l in Spain (whole sample). On the other side, for those observations (geographical points) surpassing the threshold while the average NC in Spain is 108,4 mg/l, it reaches 143,3 mg/l in the provinces of Almería and Murcia (32,2 % higher). This study aims to determine the impact of environmental conservation status on business survival within this highly stressed natural environment. We posit that the degradation of common-pool resources (water and soil) is no longer merely an ecological issue but a direct, measurable driver of firm mortality. The central motivation of this research is to challenge the neoclassical assumption that environmental regulation acts solely as a cost burden on the firm.

The relationship between nutrient pollution and the conservation status of aquatic ecosystems has been analyzed in various biophysical studies (Poikane et al., 2022; Grohmann & Feindt, 2023). However, the economic transmission mechanism—how this pollution translates into bankruptcy—is less understood. Using a Spatial Probit Model (as applied in recent advancements, e.g., Maté-Sánchez-Val and Aparicio-Serrano, 2023), this paper analyzes how high concentrations of nitrates in groundwaters increase the probability of business exit, overriding traditional agglomeration economies. To fill this academic gap, we suggest three hypotheses to be tested. The first states that environmental pollution increases the probability of failure of all companies located near pollution (H1). Moreover, it has been posed previously that ecosystem services damaged by nitrates pollution are mainly aquatic ecosystems which may have a direct impact on firms belonging to the service sector (Winn and Pogutz, 2013). Therefore, we examine whether the probability of failure is higher among companies in the service sector (H2).

Figure 3. Nitrates in groundwaters from the last assessment 2016-2019 according to the Nitrates Directive 91/676/CEE



Source: European Environment Agency (EEA) 2025.

On the other side, there is empirical evidence on the contagion effect among firms in terms of failure (Maté-Sánchez-Val et al., 2018; Maté-Sánchez-Val and Aparicio-Serrano, 2023). Therefore, the third hypothesis relies on the assumption that the spatial distribution of firm failure is positively correlated so that the probability of firm to fail is higher when it is surrounded by failed firms (H3).

Our paper introduces new evidence on the debate on how important is to enforce environmental regulation locally for financial and economic sustainability of the entire economic activity.

This paper is structured as follows. The next section lists and describes previous research in the evaluation of the nexus between environmental performance and environmental quality on the firm financial performance. Section 3 described the data sources and variables used later to test the three hypothesis suggested in that section. The section 4 describes the methodological framework and section 5 present the main results. Finally we provide the main conclusions and a discussion oriented to policy recommendations.

2. Literature review

Water and soil nitrate pollution is a severe and growing problem affecting ecosystem services (Fernández-Martínez et al., 2020) and human health (Ryan and Grinsven, 2013; Riaz et al. 2024). The major source of nitrates comes from anthropogenic activities, concretely the first in contribution are pesticides and fertilizers used in agricultural practices (Riaz et al. 2024) and this is an increasing concern worldwide reflected in the exponential growth of academic studies related to groundwater pollution since the 80s (Abascal et al, 2022). On the other side firm performance in terms of profitability, competitiveness and short and long-term financial sustainability is highly dependent on the natural environment and the good status of the ecosystems (D'Amato et al., 2018; Winn & Pogutz, 2013). In recognition of that the EU has adopted a similar posture with several policy processes in the context of the Green Deal. In Spain, the Royal Decree 47/2022, of January 18, *on the protection of waters against diffuse pollution caused by nitrates from agricultural sources*, set the thresholds to identify water bodies affected by nitrate pollution according to the Directive 91/676/CEE. The source points are evaluated through a control and monitoring stations network. According to the EU Directive those areas which do not accomplish with the thresholds must be designated as nitrate vulnerable areas. EU member states are required to report and monitor the status of ground and surface waters and enforce monitoring programs and action plans when those requirements are not accomplished. For example, the compulsory application of codes of good agricultural practice to farmers. Nevertheless, this regulatory framework has proven not to have substantially changed the pattern of pollution in highly stressed areas. Semi-arid Mediterranean regions are more vulnerable to nitrate pollution (Pérez-Martín et al, 2016).

2.1. The nexus between environmental conservation and financial performance.

The environmental performance has become central in recent financial papers (Migliorelli, 2023; Sánchez-García et al, 2025). Research increasingly focuses on climate change effects, environmental pollution and environmental regulation nexus with financial performance and market volatility (Horváthová, 2012; Naseer, 2024; Sánchez-García et al, 2025; Soppelsa et al,2021; Xu and Zhao, 2021; Zhang and Vigne, 2021).

For example, the reinforcement of limited liability of firms has been proven to increase pollution (Aken and Appel, 2021). On the other side, imposition financial constraint firms are not solving pollution production but reallocation of environmental costs (Bartram et al, 2022).

The theoretical approach suggested in Porter (1991) and latter in Porter and van der Linde (1995) supports the idea that pollution generated by the economic activity is a non-productive non-efficient result so that a negative externality. Therefore any environmental improvement is seen as a result of an innovation in production process, product or service and generate positive impact in firms financial performance.

Pollution is a negative externality which reduces local population welfare (Gulati and Kellenberg, 2013) and cannot be easily removed by the current regulatory frameworks (Bartram et al., 2022). The absence of effective regulation against pollution affects firms' performance and therefore social welfare. Governmental measures to correct market failures such as the environmental pollution frequently takes the form of penalties, emission limits and standards, environmental taxes or transferable prices (Wagner, 2003).

2.2 Hypothesis development

Our intuition rests on the Pigou (1952) *The Economics of Welfare*

The resource curse, also known as the "paradox of plenty," refers to the phenomenon where countries rich in natural resources experience lower economic growth and increased underdevelopment compared to those with fewer resources. This situation can lead to various issues, including corruption, violence, and economic volatility.

In the pursuit of economic growth and the fulfilment of expanding population demands, nations frequently demonstrate a tendency to accord precedence to economic advantages, often to the detriment of ecological conservation (Ahmed et al., 2020). The relentless pursuit of economic prosperity can engender unsustainable practices characterized by the overexploitation of resources, the release of pollutants into the environment, and the degradation of natural habitats. (Luo et al., 2024)

Instead, drawing on a spatially dependent version of the Porter Hypothesis (PH), we argue that environmental integrity is a prerequisite for long-term solvency. Porter (1991) and after Porter and van der Linde (1995) argue that better environmental performance may increase firms' competitiveness through innovation and production process improvements. On the other side it has been found that the pollution control measures can deteriorate polluting firms' performance (Zhang and Vigne, 2021). Therefore, the absence of effective regulation against pollution may act conversely. Additionally, the impact of environmental regulation of firm performance can differ between firms belonging to different economic sector in specific location. Whether polluting firms are actually accomplishing or not with environmental regulation can affect firm failure for the whole economic activity and in particular economic sectors. In this sense there is no evidence of how environmental conservation of land and water affects firms form different economic sectors. To address this question, we add a spatial dimension. To quantify the effect of environmental pollution on firm failure accurately, both the measurement of environmental pollution and the methodology is of critical importance. From our perspective the pollution output must be directly incorporated into the equation as the effect of pollution generated by firms is noticeable very near the source of production and the effects of pollution are suffered locally. Our paper innovatively addresses this question by incorporating the actual level of pollution in the territory where the firms are operating.

3. Data sources and variables

3.1. Data

This section describes the data used to examine the *pollution umbrella effect* and to quantify the probability of firm failure. Yearly frequency has been selected to the measurement both for financial, natural environment and contextual control variables. Financial information is taken from the SABI database (Iberian Balance Sheet Analysis System) from Bureau van Dijk. SABI database is a leading provider of firm-level financial information for companies in Spain and Portugal. It reports balance sheets and profit and loss accounts, geographical information (coordinates), management information and the classification of economic activities according to NACE Rev.2.1 (NACE, 2025). Our firm-level analysis is based on a selection of variables included in the firms' financial accounts of two provinces Murcia and Almería (SE Spain) covering the period of the last five years with available information at date of the data request on April 2025, in total 37.350 firm observations. We remove observations with non-informed geographical coordinates and obtain a final sample of 36.734 firm observations. We do not restrict our analysis to concrete economic activity, so that our database includes firms all the economic sectors and sizes. Financial information selection from the firms' annual accounts includes total assets, equity, return on assets, return on equity, indebtedness and the foundation date. It has been necessary to build the financial control variables to be included in the econometric models as follows. *Profitability and indebtedness:* Return on assets (*ROA*), return on equity (*ROE*) and indebtedness ratio (*Debt*) have been calculated as the natural logarithm of the last four years average. *Additional firm controls* are firm size, which is expected to be negatively related to business failure (Assadian and Ford, 1997). Larger businesses have better access to internal and external financial resources (Assadian and Ford, 1997). We include firm size as the log transformed of the last four years average of total assets (*Size*); and firm age (*Age*) as the count of years from the foundation to 2025.

We adopt a financial definition of firm failure based on the persistent erosion of equity so that the firm cannot attend payments to lenders or suppliers (Altman, 1983). Therefore, firm failure (Fr) is defined as a binary variable which is classified as "failed" ($Fr = 1$) if it exhibits negative shareholders equity for three consecutive years ($t, t-1, t-2$) or a combination of negative equity and non-reported information any of the last three years (Maté-Sánchez-Val et al., 2018) or "non failed" ($Fr = 0$) otherwise. In our sample, 5.614 firms (15,3%) are classified as failed, while 31.120 remain active/solvent.

Additional socio-economic control variable: income per capita

Furthermore, we are using a socio-economic control to characterize concrete locations within the analysis. To do that we use the information of the results published in the *Atlas of household income distribution* of the National Institute of Statistics in Spain (INE). INE publishes yearly data on several measures of income per capita and per household, gross and net amounts at different aggregation levels (municipalities, districts and census section levels are the more disaggregated). We have selected the average net income per capita (*Income*) at census section level, the smallest administrative territorial units in Spain for the last available year (2023) in order to capture the micro-territorial economic structure surrounding operating firms. We have then computed the natural logarithm and manually cross with the firm-level panel in order to associate every firm's census section its corresponding socio-economic control. It let us controlling for local economic conditions.

Environmental pollution considered in this paper is groundwater NC from the last four-yearly assessment of the EU Nitrates Directive in Spain. Whereas financial indicators have been slightly transformed, to capture the environmental determinant we have computed spatial metrics relating each firm's location to the location of groundwater points exceeding the EU Nitrate Directive thresholds (NC > 50 mg/L). To account for the exposure to pollution we compute distance matrices as follows. we introduce a spatial weight matrix W to account for the distances between geographical location of firms and polluted stations/points in kilometers. Concretely we define two different matrices to compute pollution exposure. The first one accounts for the immediate exposure to polluted waters, it evaluates distances between a firm i and a polluted station/point j measured with *NC 0,5 km*, a density variable accounting the number of waters failing to comply identified within a 0,5 km radius of the firm. It takes the value 1 when the distance among them (d_{ij}) is inferior to 500 meters (0,5 km), so $imm_{ij} = 1$, if $\mathrm{d}_{ij} < 0.5$ km. We also compute the intermediate exposure of firms to pollution (*NC 2.0 km*) counting the control station of waters failing to comply the Directive threshold within a 2 km radius of the firm. The second matrix aims at gathering the intermediate exposure to pollution so that $int_{ij} = 1$, if $\mathrm{d}_{ij} < 2.0$ km. The distinction between immediate and intermediate exposure will allow the identification of the relevant distance for our hypothesized *pollution umbrella effect.*

3.2. Summary statistics

Table 1 provides descriptive statistics for the variables used to test the main hypothesis of this paper.

Table 1: Summary statistics

Variable	Description	Mean	Std. Dev.	Min	Max
Dependent Variable					
Failure (Fr)	Dummy = 1 if the firm failed (Equity < 0)	0.153	0.360	0	1
Environmental variables					
NC 0,5 km	Count of polluted stations within 0.5 km	0.04	0.20	0	2
NC 2 km	Count of polluted stations within 0.5 to 2 km	0.21	0.55	0	4
Financial controls					
Age	Years since incorporation	18.4	12.1	1	98
Size	Total Assets (Log)	12.55	1.63	6.2	19.8
ROA	Economic Profitability (Log)	2.15	0.85	0	5.2
ROE	Financial Profitability (Log)	2.89	1.10	0	6.1
Socio-economic control					
Income	Avg. net per capita income (Log)	9.85	0.22	9.1	11.2

Source: Authors' own elaboration using RStudio.

4. Methodological framework

To empirically test the hypothesis that environmental degradation acts as a determinant of firm failure, we adopt a multi-stage econometric strategy. This approach allows us to address three specific challenges inherent to the data: the binary nature of the dependent variable, the presence of spatial dependence underlying structure of the dependent variable (contagion), and the type of the spatial dependence in the dependent variable.

4.1.Baseline Specification: The probability of failure

We model firm failure as a latent variable y_i^* representing the unobserved propensity of firm i to enter financial distress. This propensity is a function of firm exposure to environmental pollution (Env), financial intra-firm determinants (F in), and local socio-economic context (Ctx). The structural equation is defined as:

$$y_i^* = \alpha + \beta_{pol\_umb} Env_i + \sum_{k=1}^{K} \beta_{fin,k} Fin_{ik} + \beta_{cta} Ctx_i + \epsilon_i$$

Since y_i^* is unobservable, we observe the binary outcome y_i (Failure), which takes the value of 1 ($y_i^* = 1$) if the firm has negative equity for three consecutive periods or one or two years reporting negative equity and non-reported equity (rest) in the last three years; and 0 otherwise. Assuming the error term ϵ_i follows a standard normal distribution $\epsilon_i \sim N(0,1)$, the probability of failure is estimated via a standard probit model:

$$\Pr(y_i = 1 \mid X) = \Phi(X_i \beta)$$

Where $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution. The parameter of interest is $\beta_{\text{pol\_umb}}$, the $pollution\ umbrella\ effect$ coefficient, which captures the marginal effect of proximity to nitrate pollution (*Env*), measured as a count variable of stations/points reporting concentrations in groundwaters surpassing the threshold: 50 mg/L NO_3 (EC, 2000) on average in the last reporting assessment (2016-2019), on the likelihood of firms' survival.

4.2.Spatial Dependence: SAR and SEM probit models

Standard econometric models assume that observations are independent $\left(\mathrm{Cov}(\epsilon_i, \epsilon_j) = 0\right)$. However, firm failure is rarely an isolated event. It is spatially clustered due to shared local labor markets, supply chain contagion, and common exposure to environmental externalities. We assume that the probability that the probability that a firm faces a financial distress situation is generated by a spatially dependent process, i.e. financial distress of one firm is similar to the financial distress faced by firms in nearby locations (LeSage and Pace, 2009). Ignoring this dependence leads to inconsistent and biased estimators. To correct for this, we introduce a spatial weight matrix (W) which allow us to contrast for the presence of spatial interaction effects on firm's failure. Given the high density of firms in the sample ($N = 36{,}619$) and the localized nature of the pollution, we define W using the distance in kilometers between firms' geographical location as the connection criteria among firms; so that the elements of the matrix, w_{ij} =1 when j firm is one of the ten (k=10) closest neighbors of firm i, and w_{ij} = 0 otherwise; matrix is then row-standardized such that $\sum_j w_{ij} = 1$, following the spatial econometric literature.

We estimate two spatial specifications using the *ProbitSpatialFit* package (Martinetti & Geniaux, 2017) with the full-likelihood method.

Spatial Autoregressive Model (SAR)

The SAR model assumes that a firm's failure risk is directly influenced by the failure of its neighbors (a "contagion" effect). Then the assumed data generating process of the dependent variable (firm failure) is defined as:

$$y^* = \rho W y^* + X\beta + \epsilon, \epsilon \sim N(0, I_n)$$

Where ρ is the spatial lag autoregressive parameter. A significant ρ implies that financial distress spills over across space.

Spatial Error Model (SEM)

The SEM model assumes that spatial dependence arises from omitted variables or unobserved common shocks (e.g., specific regional regulation, localized environmental pollution, etc.) that affect the error term:

$$y^* = X\beta + u, u = \lambda W u + \epsilon, \epsilon \sim N(0, I_n)$$

Where $\boldsymbol{\lambda}$ captures the spatial correlation in the errors. Comparing SAR and SEM allows us to disentangle whether the clustering of failure is due to direct contagion (ρ) or shared environmental/contextual shocks (λ).

5. Empirical results

This section documents our empirical analysis investigating whether the firms' exposure to environmental pollution diminish financial performance through an increase in the probability of firm failure of the companies located at the SE Spain.

5.1. Econometric specifications.

Following the baseline and spatial econometric specifications documented in sections 4.1 and 4.2 we present our three estimation equations: baseline probit model (1), Spatial SAR probit model (2) and Spatial SEM probit (3) as follows. In the previous section we have described the structural equation in which the interest is posed on the *Env* variable and in the sign, size and significance on the $\beta_{pol-umb}$ whose interpretation would allow us to identify the *pollution umbrella effect.* This coefficient is measured through β_1 and β_2 of the variables *NC 0.5km* and *NC 2km* respectively, which account for the points/stations of NC surpassing the EU Nitrate Directive threshold (>50 mg/L of NO3) within a distance of a 500 metres and 500 metres to 2 km of radio from each firm location. We expect both coefficients to be statistically significant and positively related to the probability that the firm is considered as failed.

The following variables (age, size, ROE, ROA and Debt) are part of the *Fin* set of explanatory variables. Whereas we expect a positive relationship between the probability of failure and the Debt, the rest of financial variables are expected to be negatively related to the probability of failure. Finally, the *Ctx* control is measured with the income per capita at census section level (Income) and we expect to be negatively related to the probability of firm failure.

$$y_i^* = \beta_1 NC\ 0{,}5km_i + \beta_2 NC\ 2km_i + \beta_3 Age_i + \beta_4 Size_i + \beta_5 ROE_i + \beta_6 ROA_i + \beta_7 Debt_i + \beta_8 Income_i + \epsilon_i;\ \ \epsilon \sim N(0,1) \tag{1}$$

$$y_i^* = \rho W y^* + \beta_1 NC\ 0{,}5km_i + \beta_2 NC\ 2km_i + \beta_3 Age_i + \beta_4 Size_i + \beta_5 ROE_i + \beta_6 ROA_i + \beta_7 Debt_i + \beta_8 Income_i + \epsilon_i;\quad \epsilon \sim N(0, I_n) \tag{2}$$

$$y_i^* = \beta_1 NC\ 0{,}5km_i + \beta_2 NC\ 2km_i + \beta_3 Age_i + \beta_4 Size_i + \beta_5 ROE_i + \beta_6 ROA_i + \beta_7 Debt_i + \beta_8 Income_i + u_i\ ;\ u = \lambda W u + \epsilon, \epsilon \sim N(0, I_n) \tag{3}$$

5.2. Baseline regression results. Pollution umbrella effect (H1)

The baseline and spatial estimation results, presented in Table 2, corroborate the hypothesis that environmental degradation acts as a significant, albeit spatially constrained, determinant of firm failure and give support to the *pollution umbrella effect*. The next question is about the size of the *umbrella effect*. A key finding emerges from the comparison between the immediate and outer rings of pollution. The variable *NC 0,5 km* (density of pollution within 0 to 0,5 km) exhibits a positive and statistically significant coefficient across all specifications indicating that firms located in the immediate proximity of degraded water bodies face a structurally higher probability of failure. The β_1 coefficient ranges from 0,176** to 0,202** for all NACE codes (columns 2 and 4), and from 0,239** to 0.296** across specifications of the service sector (columns 3, 6 and 7 in table 2). Therefore the positive sign of β_1 indicates that an increase in the density of NC points around 500 metres from firm location, increases the probability of failure for the firm. Nevertheless, the coefficient measuring the impact of the intermediate exposure to pollution (β_2) is not statistically significant in any of the econometric specifications implying that the intermediate pollution exposure (from 500 metres to 2 km) is not a relevant explanatory variable for predicting failure.

Table 2: Baseline and spatial SAR and SEM model results.

(1)	(2) Baseline model	(3) Baseline model	(4) Spatial probit model SAR	(5) Spatial probit model SEM	(6) Spatial probit model SAR	(7) Spatial probit model SEM
	All NACE codes	Services sector: NACE =47; NACE>55	All NACE modes	All NACE modes	Services sector: NACE =47; NACE>55	Services sector: NACE =47; NACE>55
Dependent variable	Failure rate	Failure rate	Failure rate	Failure rate	Failure rate	Failure rate
NC 0,5 km	0.202** (0.094)	0.296* (0.145)	0.176**	0.195**	0.239**	0.268**
NC 2 km	0.007 (0.025)	0.014 (0.038)	-0.000	-0.000	-0.001	-0.003
Age	-0.023*** (0.001)	-0.026*** (0.002)	-0.023***	-0.022***	-0.026***	-0.026***

Size	-0.238*** (0.006)	-0.191*** (0.009)	-0.234***	-0.239***	-0.188***	-0.192***
ROE	-0.036*** (0.006)	-0.016* (0.008)	-0.035***	-0.035***	-0.015***	-0.016***
ROA	-0.091*** (0.008)	-0.117*** (0.012)	-0.092***	-0.091***	-0.117***	-0.117***
Debt	0.316*** (0.011)	0.267*** (0.014)	0.313***	0.317***	0.266***	0.269***
Income	-0.046*** (0.006)	-0.043*** (0.008)	-0.032***	-0.046***	-0.028***	-0.043***
Rho (autoregressive coefficient)			0.118***	0.183***	0.136***	0.203***

*This table shows that immediate pollution (NC 0,5 km) increases failure risk, while the outer ring (NC km2) is irrelevant. Note: standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.*

This sharp distance decay suggests that the negative externalities of nitrate pollution are not diffuse regional phenomena but are strictly localized stressors. We find empirical support to accept the *H1* hypothesis about the localized effects of negative externalities on firm performance, called *pollution umbrella effect*, although restricted to short distances from firms location (in our analysis up to 500 meters).

5.3. Sector specific regressions. Pollution umbrella effect for services sector firms (H2)

Next, we run the three econometric specifications of section 5.1. for a subset of the sample to test our second hypothesis -whether the probability of failure is higher among companies in the service sector (H2)-. We consider services sector firms if their main activity is one of the following, according to NACE Rev 2.1.: G (only code 47: retail trade); I (accommodation and food service activities), J (publishing, broadcasting, and content production and distribution activities); K (telecommunication, computer programming, consulting, computing infrastructure and other information service activities); L (financial and insurance activities); M (real estate activities); N (professional, scientific and technical activities); O (administrative and support service activities); P (public administration and defense; compulsory social security); Q (education); R (human health and social work activities); S (arts, sports and recreation); T (other service activities); U (activities of households as employers and undifferentiated goods- and service producing activities of households for own use); V (activities of extraterritorial organisations and bodies). Results are shown in Table 2 columns 3, 6 and 7. Our results indicate that the immediate pollution exposure negative impact on financial performance is even higher for firms in the services sector. This can be seen in the differences in the β_1 coefficient size for the baseline, SAR and SEM model specifications comparing the results of the full sample to the service sector regressions. We find empirical evidence supporting the *H2* hypothesis: the impact of exposure to high levels of pollution penalizes survival of companies in the service sector more than the whole economic activity.

5.4. Spatial regressions results. Location dependence of firm failure (H3).

Furthermore, the significance of the spatial lag parameter in the SAR model for the whole sample ($\rho = 0.118, p < 0.01$) and in the SEM model ($\rho = 0.183, p < 0.01$) and ($\rho = 0.136$, $p < 0.01$) and in the SEM model ($\rho = 0.203$, $p < 0.01$), for service sector, confirms the existence of failure contagion due to geographical proximity in line with recent literature (Maté-Sánchez-Val et al., 2018). Financial distress is spatially clustered, meaning a firm's survival is partly conditional on the solvency of its neighbors, validating the use of spatial econometrics over standard discrete choice models (*H3*). Moreover, firm failure in the service sector is more dependent on the geographical proximity, although we did not expect this result it is interesting from a financial corporate management point of view. Given the spatial distribution of firms, service sector can act as a cluster where external shocks (negative or positive externalities) and the spatial interaction among firm affect all firms more profoundly than firms in other economic activities.

Financial controls behave according to established theory, with indebtedness acting as the primary driver of failure, while age, size, and local income levels function as protective buffers.

6. Conclusions

Environmental conservation and pollution emission reduction policies in the EU are today at the root of the EU Commission agenda for the 2030, not only from an ecosystem conservation objective but also to ensure the future of regional economic development within the EU. The main objective of EU Directives to protect the environment from nutrient pollution, ie.: Nitrates Directive (ND) and the Water Framework Directive (WFD), includes the evaluation of the minimum requirements to the “good status” of ecosystems, defining thresholds of pollution emissions and enforcing EU states to monitor and report periodically the status of the ecosystems under evaluation. Nevertheless, the results of this reports show that there are many EU countries where the conservation status is poor or bad in a great part of the ecosystems. So that it can be thought that current framework of environmental regulation is not enough to effectively control pollution. However current measures can be financially constraining smaller businesses (Bartram et al, 2022). Therefore, the unexpected results of environmental regulation against pollution in our view are two. From one side it can generate additional costs to smaller firms; and on the other side, it is not enough to maintain the ecosystem services provision conditioning firm survival in specific economic activities (D’Amato et al., 2018; Winn & Pogutz, 2013). This study exploits the results of the last evaluation from the Spanish government according to the EU Nitrates Directive of Spanish groundwaters for the period 2016-2019 to examine the degree of exposure of firms to water and soil pollution. This is a real environmental status indicator which provides a natural experiment to evaluate the effect of exposure to high levels of pollution on firms’ financial distress. Through a series of empirical exercises three main research questions are estimated and answered. The main findings are discussed below.

Regarding the objectives of the ND, in the context of the EU Green Deal, on the reduction of nitrate pollution it has been proven not to have substantially changed the pattern of pollution in highly stressed areas like semi-arid Mediterranean regions in Spain (Pérez-Martín et al, 2016). Our baseline econometric specification analyses the potential impact on firm performance, measured with the probability of failure, of firms’ exposure to high levels of pollution; testing the dependence of the economic activity on the natural environment and the good status of the ecosystems. We called this the *pollution umbrella effect.* It allows us to determine the significant radio of impact in terms of distance to pollution by using spatial econometric techniques. This effect is statistically significant for firms belonging to any economic activity within a radio of 500 metres. Recent literature exploring the impact of pollution on firm performance confirm this finding. Xue et al. (2021) find that higher skilled workers decide to move to more other locations in response to air pollution, resulting in a loss of human capital and finally on firm performance (*brain drain*). The authors conclude that firms facing high levels of pollution present lower levels of total factor productivity and firm value than firms located in in healthier environments.

Further, the exposure of excessive pollution levels is more harnessing for firms in the services sector, this can be understood from the ecosystem – organization dependence. This result supports the idea that businesses operating income is closely dependent on the ecosystem services provision (Win and Pogutz, 2013) and their vulnerability to "*shortages in the availability of these services: depletion of fish stocks threatens global fisheries and companies operating in the food industry; growing pressure on water resources affects both the supply and the quality of water and undermines businesses' continuity in sectors such as agriculture, forestry, beverages, or energy."* For example the aesthetic services from water and coastal ecosystems is key to maintain businesses in the touristic sector. Therefore, our findings add empirical evidence on the hypothesis that environmental pollution is a nonneutral factor in firm survival. Poor environmental status (proxied by nitrate pollution) acts as a location-specific stressor significantly increases the likelihood of firm failure.

Finally, we further investigate the spatial interaction among firms and our results show a statistically significant autoregressive coefficient in the spatial econometric specifications. This provides additional insights on the spatial dependence structure in the failure rate of firms, suggesting that this structure is positively correlated so that firms surrounded by failed firms have a higher probability of failure, and conversely.

This study provides several managerial implications and policy recommendations. Regarding firms, business managers should make additional investments to control pollution emissions. The impact of this additional investments can not only affect the financial stability of firms but improving the probability of survival of their peers. Second, non-polluting firms should demand governmental action against pollution that effectively addresses the financial issues caused the impoverishment of the level of provision of ecosystem services due to environmental pollution. Third, EU Directives must include enforcement of the policies by incorporating additional measures to deter illegal practices harnessing the natural environment and enforcing the accomplishment of the maximum threshold of pollution emissions.

References

Ambec, S., Cohen, M. A., Elgie, S., & Lanoie, P. (2013). The Porter Hypothesis at 20: Can environmental regulation enhance innovation and competitiveness? *Review of Environmental Economics and Policy*, 7(1), 222. https://doi.org/10.1093/reep/res016

Andries, D. M., Garrido, A., & De Stefano, L. (2025). Addressing drivers and data gaps in Spain's non-compliance of drinking water quality standards. *Science of The Total Environment*, 963, 178412. https://doi.org/10.1016/j.scitotenv.2025.178412

Aparicio, G., Camacho, M., & Maté-Sánchez-Val, M. (2024). Quantifying the impact: Are coastal areas impoverished by marine pollution? *Ecological Economics*, 221, 108213. https://doi.org/10.1016/j.ecolecon.2024.108213

Aparicio, G., Jiménez-Aceituno, A., & Maté-Sánchez-Val, M. (2025). Reducing income gaps among Spanish Mediterranean municipalities: The role of environmental quality. *Journal of Environmental Management*, 393, 127146. https://doi.org/10.1016/j.jenvman.2025.127146

Chen, Y., & Xie, X. (2024). The Impact of Environmental Regulation on Agricultural Productivity: From the Perspective of Digital Transformation. *Sustainability*, 16, 10794. https://doi.org/10.3390/su1610794

Coppola, A., Ianuario, S., & Chinnici, G. (2024). Financial sustainability of Italian farms: An analysis of FADN data. *Frontiers in Sustainable Food Systems*, 8, 1474903. https://doi.org/10.3389/fsufs.2024.1474903

EC, (2000). Water Framework Directive. Directive 2000/60. Official journal of the European communities, 327(1), 1-71.

European Environment Agency (EEA). (2024). *Europe's state of water 2024: The need for improved water resilience*. Publications Office of the European Union. https://doi.org/10.2800/02236

European Commission (EC). (2025). *Vision for Agriculture and Food: Shaping together an attractive farming and agri-food sector for future generations*. COM(2025)0075.

Fabrizi, A., Gentile, M., Guarini, G., & Meliciani, V. (2024). The impact of environmental regulation on innovation and international competitiveness. *LEAP Working Paper 4/2024*. Luiss University.

Firgo, M., & Pennerstorfer, D. (2024). Agritourism and farm survival: Evidence from a big data approach. *Journal of Agricultural Economics*, 75(2), 567-589. https://doi.org/10.1111/1477-9552.12558

Förell, N., Nadeu, E., & Muro, M. (2025). *From sustainability to competitiveness: What shifting narratives means for EU agricultural policy*. IEEP Policy Brief.

Fraile-Nuez, E., Ruiz, J. M., et al. (2025). Characterization and potential causes of a whiting event in the Mar Menor coastal lagoon (Mediterranean, SE Spain). *Science of The Total Environment*, 978, 179391. https://doi.org/10.1016/j.scitotenv.2025.179391

Grohmann, P., & Feindt, P. H. (2023). The governance of the nitrate problem in Germany: A wicked problem analysis. *Journal of Environmental Policy & Planning*, 25(3), 289-304. https://doi.org/10.1080/1523908X.2023.2286653

Hallberg, L., Bieroza, M., & Wynants, M. (2024). Climate change accelerates water and biogeochemical cycles in temperate agricultural catchments. *Science of The Total Environment*, 912, 169542. https://doi.org/10.1016/j.scitotenv.2023.169542

Huang, E. W., & Zhu, Y. (2024). Off-farm work, adoption of resource-conservation technology, and farm performance: evidence from banana farmers in China. *Applied Economics*, 56(12), 1432-1448. https://doi.org/10.1080/00036846.2024.2364926

Hult, E. (2025). *Economic impact of Nitrates Directive implementation in Sweden*. SLU Master Thesis. https://stud.epsilon.slu.se/21544/

Johansson, E., Nilsson, P., & Hansson, H. (2025). Transition dynamics of hybrid farmers: a survival analysis of exits and entries into full-time farming. *European Review of Agricultural Economics*, Advance Access. https://doi.org/10.1093/erae/jbaf003

Kim, J., Roh, T., & Park, B. I. (2024). Effects of open innovation on eco-innovation in meta-organizations: Evidence from Korean SMEs. *Asian Business & Management*, 23, 1-25. https://doi.org/10.1057/s41291-023-00256-w

Lamas-Rodríguez, N., & Maté-Sánchez-Val, M. (2023). The environmental degradation impact in Mar Menor on Airbnb prices. *Revista de Métodos Cuantitativos para la Economía y la Empresa*, 36, 256-274.

Latruffe, L., & Desjeux, Y. (2016). Common Agricultural Policy support, technical efficiency and productivity change in French agriculture. *Review of Agricultural, Food and Environmental Studies*, 97, 15-28. https://doi.org/10.1007/s41130-016-0007-4

Liu, Y., Failler, P., & Chen, L. (2022). Can environmental regulation promote the coordination of economy and environment in China's coastal areas? *Ocean & Coastal Management*, 218, 106008. https://doi.org/10.1016/j.ocecoaman.2021.106008

Maté-Sánchez-Val, M., & Aparicio-Serrano, G. (2022). Seawater deterioration and the tourist beta convergence process: A geospatial big data analysis of the Spanish Mediterranean coast. *Current Issues in Tourism*, 25(18), 2922-2938. https://doi.org/10.1080/13683500.2021.2012433

Maté-Sánchez-Val, M., & Aparicio-Serrano, G. (2023). The impact of marine pollution on the probability of business failure: A case study of the Mar Menor lagoon. *Journal of Environmental Management*, 332, 117381. https://doi.org/10.1016/j.jenvman.2023.117381

Maté-Sánchez-Val, M., & Harris, R. (2018). The paradox of geographical proximity for innovators: A regional study of the Spanish agri-food sector. *Land Use Policy*, 73, 458-467. https://doi.org/10.1016/j.landusepol.2018.02.024

Martínez-Vicente, V., Pérez-Ruzafa, A., & Gilabert, J. (2023). Phytoplankton dynamics in the Mar Menor, a Mediterranean coastal lagoon strongly impacted by eutrophication. *Frontiers in Marine Science*, 10, 1011342. https://doi.org/10.3389/fmars.2023.1011342

Ministerio para la Transición Ecológica y el Reto Demográfico (MITECO). (2024). *Informe de seguimiento de la contaminación por nitratos de origen agrario en España 2020-2023*. Gobierno de España.

Musacchio, A., Re, V., Mas-Pla, J., & Sacchi, E. (2020). EU Nitrates Directive, from theory to practice: Environmental effectiveness and influence of regional governance on its performance. *Ambio*, 49, 504-516. https://doi.org/10.1007/s13280-019-01197-8

OECD. (2025). *OECD Environmental Performance Reviews: Sweden 2025*. OECD Publishing. https://doi.org/10.1787/91dcc109-en

Oosterbaan, M., Gómez-Jakobsen, F., Barberá, G. G., et al. (2025). Characterization and potential causes of a whiting event in the Mar Menor coastal lagoon. *Science of The Total Environment*, 978, 179391. https://doi.org/10.1016/j.scitotenv.2025.179391

Oumer, A. M., Burton, M., & Kassie, M. (2025). Dynamics of multiple sustainable agricultural intensification practices adoption: Application of the intertemporal multivariate probit model. *PLoS ONE*, 20(2), e0314172. https://doi.org/10.1371/journal.pone.0314172

Oumer, A. M., & Neves, P. (2025). Does wealth gain from land appreciation cause farmers to expand acreage or buy land? *Land Use Policy*, 138, 106915. https://doi.org/10.1016/j.landusepol.2023.106915

Pacheco, J. P., López-Ballesteros, A., Mesman, J., & Senent-Aparicio, J. (2025). Coupling SWAT+ and GOTM-WET models to assess agricultural management practices for mitigating harmful algal blooms in Mar Menor, Spain. *Journal of Environmental Management*, 380, 125033. https://doi.org/10.1016/j.jenvman.2024.125033

Persakis, A. (2024). Climate policy uncertainty and firm performance: The moderating role of ESG. *Journal of Environmental Management*, 351, 119697. https://doi.org/10.1016/j.jenvman.2023.119697

Poikane, S., Kelly, M., Varbiro, G., et al. (2022). Estimating nutrient thresholds for eutrophication management: Novel insights from understudied lake types. *Science of The Total Environment*, 827, 154242. https://doi.org/10.1016/j.scitotenv.2022.154242

Poikane, S., & Phillips, G. (2024). Comparison of eutrophication assessment for the Nitrates and Water Framework Directives: Impacts and opportunities for streamlined approaches. *Science of The Total Environment*, 908, 168342. https://doi.org/10.1016/j.scitotenv.2023.168342

Ramanathan, R., He, Q., Black, A., Ghobadian, A., & Gallear, D. (2017). Environmental regulations, innovation and firm performance: A revisit of the Porter hypothesis. *Journal of Cleaner Production*, 155, 79-92. https://doi.org/10.1016/j.jclepro.2016.08.116

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F.,... & Foley, J. A. (2009). A safe operating space for humanity. *Nature*, 461(7263), 472-475. https://doi.org/10.1038/461472a

Rousselière, S., Coisnon, T., Rousselière, D., & Petit, G. (2024). Beyond Porter hypothesis: Empirical evidence of heterogeneous and contextual economic returns of eco-innovations on a sample of European SMEs. *Journal of Cleaner Production*, 484, 144329. https://doi.org/10.1016/j.jclepro.2024.144329

Rubio-Martin, A., & Macian-Sorribes, H. (2024). Comparative analysis on policy coordination arrangements and options for improvement in water management. *RETOUCH Nexus Project Deliverable 4.2*.

Ruiz, M., Álvarez-Rogel, J., & González-Alcaraz, M. N. (2022). The role of soils in delivering Nature's Contributions to People: The case of Mar Menor eutrophication. *Philosophical Transactions of the Royal Society B*, 377, 20210222. https://doi.org/10.1098/rstb.2021.0222

Salazar-Ortuño, E., & Vicente-Giménez, M. T. (2025). Mar Menor: Europe's first ecosystem with legal 'personhood'. *Heinrich Böll Stiftung Case Study*.

Schaub, S., & Huber, R. (2023). The Role of Behavioural Factors and Opportunity Costs in Farmers' Participation in Voluntary Agri-Environmental Schemes: A Systematic Review. *Journal of Agricultural Economics*, 74(3), 617-660. https://doi.org/10.1111/1477-9552.12516

Siddique, M. A., & Sen, S. (2024). Climate policy uncertainty and energy markets: Evidence from wavelet coherence and quantile-based models. *Energy Economics*, 129, 107234. https://doi.org/10.1016/j.eneco.2023.107234

Středa, T., Fukalová, P., Chuchma, F., Haberle, J., & Středa, T. (2024). Nitrates directive restriction: To change or not to change in terms of climate change, that is the question. *Science of The Total Environment*, 917, 170381. https://doi.org/10.1016/j.scitotenv.2024.170381

Sun, Y. C., Bi, S., & Yin, S. (2022). Environmental regulation, agricultural green technology innovation, and agricultural green total factor productivity. *Frontiers in Environmental Science*, 10, 955954. https://doi.org/10.3389/fenvs.2022.955954

Tang, K., & Wang, J. (2025). Green credit policy's impact on polluting firms' market performance: the role of financing constraints. *Ecological Economics*, 218, 108102. https://doi.org/10.1016/j.ecolecon.2024.108102

Thobane, J., Ndoro, J., Molepo, S., Serote, B., Hlophe-Ginindza, S., Mpandeli, S., Nhamo, L., & Mokgehle, S. (2025). A Review on the Adoption of Sustainable Agricultural Practices in Southern Africa: Focus on Smallholder Farmers. *Agriculture*, 15(20), 2125. https://doi.org/10.3390/agriculture15202125

Van Grinsven, H. J., Holland, M., Jacobsen, B. H., Klimont, Z., Sutton, M. A., & Willems, W. J. (2013). Costs and benefits of nitrogen for Europe and implications for mitigation. *Environmental Science & Technology*, 47(8), 3571-3579. https://doi.org/10.1021/es303804g

Velthof, G. L., Lesschen, J. P., Webb, J., Pietrzak, S., Miatkowski, Z., Pinto, M.,... & Oenema, O. (2014). The impact of the Nitrates Directive on nitrogen emissions from agriculture in the EU-27 during 2000–2008. *Science of The Total Environment*, 468, 1225-1233. https://doi.org/10.1016/j.scitotenv.2013.04.058

Wang, Z., Wang, X., & Chen, H. (2024). Green credit policy, financing constraints and the green innovation of pollution-intensive enterprises. *Journal of Cleaner Production*, 434, 139866. https://doi.org/10.1016/j.jclepro.2023.139866

Wu, H., Hao, Y., & Ren, S. (2022). How do environmental regulation and environmental decentralization affect green total factor energy efficiency: Evidence from China. *Energy Economics*, 91, 104880. https://doi.org/10.1016/j.eneco.2020.104880

Xiao, S. S., Roh, T., & Park, B. I. (2025). The Porter Hypothesis Revisited: The Cross-Border Spillover Effects of Foreign Environmental Regulations on National Competitiveness. *Hitotsubashi Journal of Economics,* 66(1), 28-45. https://doi.org/10.15057/hje.2025002

Zeng, J., Jiang, X., & Li, B. (2024). Environmental regulation, digital transformation and agricultural green productivity. *Journal of Integrative Agriculture*, 23(5), 1588-1602. https://doi.org/10.1016/j.jia.2023.11.023

Zhang, F., Song, X., & Dong, Y. (2024). Impact of industrial integration on agricultural sustainable development: dynamic marginal effects and impact mechanism. *Environmental Science and Pollution Research*, 31, 12345-12360. https://doi.org/10.1007/s11356-024-31890-w

Zhou, Q., Du, M., & Ren, S. (2025). Facilitating and motivating farmers to adopt standardized pro-environmental production technologies: An ordered probit model analysis. *Frontiers in Sustainable Food Systems*, 9, 1590726. https://doi.org/10.3389/fsufs.2025.1590726

Xin, M., Tan, S., Qiu, H., & Tang, J. (2025). Environmental Regulations and Smallholder Farmers' Technical Efficiency: Empirical Evidence From Pastoral China. *Journal of Agricultural Economics*, 76(3), 555-569. https://doi.org/10.1111/1477-9552.12638

D. Zhang, P. Du How China “going green” impacts corporate performance? J. Clean. Prod., 258 (2020), Article 120604

Dongyang Zhang, Samuel A. Vigne, The causal effect on firm performance of China's financing–pollution emission reduction policy: Firm-level evidence, Journal of Environmental Management, Volume 279, 2021, 111609, ISSN 0301-4797, https://doi.org/10.1016/j.jenvman.2020.111609.

Eva Horváthová, The impact of environmental performance on firm performance: Short-term costs and long-term benefits?, Ecological Economics, Volume 84, 2012, Pages 91-97, ISSN 0921-8009, https://doi.org/10.1016/j.ecolecon.2012.10.001.

Porter, 1991. America's green strategy. Scientific American, 264 (4) (1991), p. 96

Porter, 1990. The Competitve advantage of Nations

M.E. Porter, C. van der Linde. Toward a new conception of the environment–competitiveness relationship. The Journal of Economic Perspectives, 9 (4) (1995), pp. 97-111

Shuyu Xue, Bohui Zhang, Xiaofeng Zhao, Brain drain: The impact of air pollution on firm performance, Journal of Environmental Economics and Management, Volume 110, 2021, 102546, ISSN 0095-0696, https://doi.org/10.1016/j.je

Söhnke M. Bartram, Kewei Hou, Sehoon Kim, Real effects of climate policy: Financial constraints and spillovers, Journal of Financial Economics, Volume 143, Issue 2, 2022, Pages 668-696.

AKEY, P. and APPEL, I. (2021), The Limits of Limited Liability: Evidence from Industrial Pollution. The Journal of Finance, 76: 5-55. https://doi.org/10.1111/jofi.12978

IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001

EC,a. European green deal. Striving to be the first climate-neutral continent. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en#document

A.C. Pigou. The Economics of Welfare. Macmillan and Co., London (1920)

Mas-Pla, J., Menció, A. Groundwater nitrate pollution and climate change: learnings from a water balance-based analysis of several aquifers in a western Mediterranean region (Catalonia). Environ Sci Pollut Res 26, 2184–2202 (2019). https://doi.org/10.1007/s11356-018-1859-8

Brian Omondi Oduor, Miguel Ángel Campo-Bescós, Noemí Lana-Renault, Javier Casalí, Effects of climate change on streamflow and nitrate pollution in an agricultural Mediterranean watershed in Northern Spain, Agricultural Water Management, Volume 285, 2023, 108378, ISSN 0378-3774, https://doi.org/10.1016/j.agwat.2023.108378.

E. Abascal, L. Gómez-Coma, I. Ortiz, A. Ortiz, Global diagnosis of nitrate pollution in groundwater and review of removal technologies, Science of The Total Environment, Volume 810, 2022, 152233, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2021.152233.

Lorrana Lopes Diniz, Phillipe Mota Machado, Leonardo Lopes Costa, Nayra Bento Côgo, Julyana Figueiredo Madureira, Ilana Rosental Zalmon, Visitors' perception, coastal scenery quality and tourism profitability on sandy beaches - Southeastern Brazil, Marine Policy, Volume 187, 2026, 107065, ISSN 0308-597X, https://doi.org/10.1016/j.marpol.2026.107065.

Yan Hao, Xinsong Niu, Jianzhou Wang, Impacts of haze pollution on China's tourism industry: A system of economic loss analysis, Journal of Environmental Management, Volume 295, 2021, 113051, ISSN 0301-4797, https://doi.org/10.1016/j.jenvman.2021.113051.

NACE (2025). Eurostat. NACE Rev. 2.1 – Statistical classification of economic activities in the European Union 2025 edition. https://ec.europa.eu/eurostat/