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Basis risk and the adoption of parametric insurance among Italian SMEs: Empirical evidence and implications for resilience

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ABSTRACT

Italian SMEs are exposed to natural disasters. However, the adoption of innovative insurance solutions aimed at mitigating these risks and improving both individual and systemic resilience—such as parametric or index-based insurance—remains limited. This paper explores the factors that influence Italian SMEs in adopting these policies, with a particular focus on the role of basis risk, which is the mismatch between pay-outs and actual losses. Using a logit model estimated on a stratified random sample of 362 Italian SMEs, structural, behavioural, and contextual variables are combined through the integration of secondary data and responses to a specially designed questionnaire. The results show that basis risk remains a major concern but can be mitigated through targeted information programmes, as well as technological and regulatory measures. Along with this, factors like the level of losses suffered by SMEs in the recent past, the size and level of digitalisation of the firms, and whether they received adequate information about this type of policy appears to affect the propensity to purchase parametric insurance too. These insights are valuable for policymakers, insurers, and stakeholders involved in insurance innovation, emphasizing the importance of effective communication and contractual solutions.

1. Introduction

In a context characterised by the increasing impact of climate change and the rising frequency and severity of extreme natural events, protecting the national production system has become an even greater strategic priority. Among other measures, the Italian legislator introduced a new mandatory requirement for firms (ref. Art. 1, commas 101–111, Legge di Bilancio 2024 – L. 30 December 2023, n. 213), which mandates them to obtain insurance policies against damages caused by natural catastrophic events (earthquakes,

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floods, landslides, etc.). These policies cover tangible assets on the balance sheet (property, plant, machinery, equipment) and had to be implemented within different deadlines depending on the firm's size.[4]

The most recent available data (ISTAT, 2024) show that Small and Medium Enterprises (SMEs) currently represent more than 95% of Italy's productive system. Some studies (Climate Adapt, 2020; Fatica et al., 2024) also indicate that Italian SMEs are particularly vulnerable to risks arising from catastrophic natural events, mainly due to their small size and geographical location. Despite this, insurance awareness and coverage in Italy remain underdeveloped, with a low penetration of tools against catastrophic risks (ANIA, 2023). However, the introduction of the aforementioned legal requirements should lead to an increase, especially since insurance companies are required, by the regulation cited above, to offer this coverage within the specified timeframe limits.

In this context, parametric insurance, also known as index-based policy, represents an innovative approach in managing risks arising from natural disasters. Broadly speaking, these policies use a compensation model that relies on predetermined thresholds (triggers) instead of calculating the actual damage incurred. Compared to traditional insurance coverage, parametric insurance provides several advantages, including faster payouts, lower loss-adjustment costs, and greater transparency in determining the compensation (Lin and Kwon, 2020).

However, these benefits are counterbalanced by some substantial drawbacks – so creating challenges for both policyholders and insurers, mainly due to (i) significant basis risk (i.e., the risk that triggered pay-outs do not coincide with the occurrence of loss events), (ii) complex mathematical – statistical – actuarial modelling that is heavily dependent on the availability and quality of external data, (iii) greater pricing complexity arising from these modelling challenges, and (iv) the management and supervision of this particular type of product by the Authorities.

On the other hand, traditional policies, although slower and more expensive in terms of claims handling, provide a better fit with actual losses, as well as greater flexibility in customising covers. In this regard, parametric policies often only cover part of the expected losses, and this can make them less attractive as a stand-alone product, so many companies have to integrate them with traditional covers, increasing their management complexity.

In light of all this, parametric insurances are therefore complementary tools, particularly effective in contexts where speed of delivery is critical or where direct damage measurement is impractical, but their adoption certainly requires a careful assessment of the risk profile and underlying operating conditions. Especially when combined with incentives for infrastructural buoyancy (e.g. fortified certification, spatial adaptations, etc.), they can enhance the economic and social resilience of highly vulnerable areas to the consequences of climatic and extreme geophysical events (Kousky et al., 2021; Lonergan et al., 2023; Sheehan et al., 2023; Generali, 2024).

Despite this and the wide application worldwide (Lin and Kwon, 2020), data show that the take-up rate of parametric policies in Italy is still very limited, less than 10% in 2023 (ANIA, 2023; IVASS, 2024), that contracts designed to cover damages suffered by SMEs are still at an experimental stage and are offered by only a limited number of market participants, and that basis risk is seen as a major constraint on adoption.

Therefore, this work aims to empirically analyse the factors influencing the propensity of Italian SMEs to adopt such policies, with a particular focus on the role played in this respect by basis risk.

The innovative contribution of this study, compared with the existing literature (Peacock et al., 2005; Hellmuth et al., 2009; Gall et al., 2014; Dercon et al., 2014; Goyal, 2021; Jaspersen et al., 2022; Louaas and Picard, 2024; Ernst and Joung, 2024), lies in its joint analysis of several heterogeneous determinants affecting the propensity of Italian SMEs to adopt parametric insurance. Indeed, while previous studies have generally examined these factors separately, this paper investigates their combined effect within a unified empirical framework.

Specifically, implementing a logit model estimated on the data of a stratified sample of 362 Italian SMEs combining information provided by structural, behavioural and contextual variables, integrating secondary data and the answers to an *ad hoc* survey, this study aims to answer the following research questions: (i) what are the main factors that, so far, have influenced the propensity of Italian SMEs to buy parametric catastrophe insurances? (ii) among these factors, has basis risk actually played an important role?

The answers to these questions can be important for many players. Consider, for example, that the Italian National Climate Change Adaptation Plan (Piano Nazionale di Adattamento ai Cambiamenti Climatici - PNACC) 2023–2026[5] provided incentives for firms to adapt to climate change, including the signing up of innovative insurance policies; effectively, the PNACC is a national policy tool for the implementation of actions to minimise the risks from climate change and improve the resilience of socio-economic and natural systems. In this context, insurance companies and InsurTechs, which are currently testing new parametric policy models, can benefit from the information provided in this paper in order to offer increasingly tailor-made products to Italian SMEs, which, as noted, are currently under-protected with respect to damages resulting from natural catastrophic events and, therefore, very vulnerable economically.

[4] The mandatory requirement, originally scheduled for March 31, 2025, was initially postponed by Decree-Law No. 39 of March 31, 2025, which was converted into Law No. 78 of May 27, 2025, published in the Gazzetta Ufficiale on May 30 and effective as of May 31, 2025. No. 78, published in the Gazzetta Ufficiale on May 30 and effective as of May 31, 2025, set different deadlines based on firm size: (i) large firms, mandatory requirement confirmed for March 31, 2025, with a 90-day moratorium – until June 30, 2025 – during which no penalties or exclusion from benefits will be imposed; (ii) medium-sized firms, deadline extended to October 1, 2025; (iii) small and micro enterprises, including fishing and aquaculture operators, deadline set for December 31, 2025 (or January 1, 2026, in some ministerial interventions).

[5] The PNACC 2023–2026 was approved on December 21, 2023, by Decree No. 434 of the Minister of the Environment and Energy Security (Ministro dell'Ambiente e della Sicurezza Energetica). It represents a national policy tool for the implementation of actions aimed at minimizing the risks arising from climate change and improving the resilience of socio-economic and natural systems.

The paper is structured as follows: in Section 2 a literature review on parametric policies, the main critical issues found for them in comparison to traditional insurances and thus also on the main factors that have been identified as impacting on their demand by the public. Section 3 describes the methodology adopted in the analysis to answer the aforementioned research questions, while Section 4 presents the empirical results. Section 5 discusses them and offers the main policy implications, while Section 6 concludes.

2. Literature review

Parametric insurance, an innovative form of catastrophe coverage, has attracted increasing attention in the insurance industry. Unlike traditional policies, which evaluate actual damage, parametric insurance provides payouts when a specific event threshold is overcome. This threshold is based on an objective metric rather than an assessment of the actual losses (Kaplan, 2017; Sengupta & Kousky, 2020; Swiss Re, 2024). Common natural catastrophe (NatCat) events covered include earthquakes, tropical cyclones, and floods. The measurement, referred to as a parameter or index, may involve factors such as earthquake magnitude, wind speed, or water depth. Parametric insurance products generally consist of three main components: the parameter or index (an objective measure of event occurrence, severity, or intensity), the trigger (a set threshold that activates a payout), and the payout structure (how the payout amount is calculated). An independent third party provides the objective measure to ensure it accurately reflects the insured's financial loss. When the parameter reaches or exceeds the threshold, the insured is eligible for a predetermined payout. The 'trigger' explicitly refers to the threshold that triggers the payout. For SMEs, parametric products often use triggers linked to risks like local rainfall or earthquake intensity. In some cases, multiple triggers must be met to activate a payout. Some products also require policyholders to prove a financial loss in addition to fulfilling a parametric trigger.

These hybrid models are primarily used by firms and governments, which often face larger losses and require quick payouts and loss verification. In some regions, proof of loss is legally mandated to ensure payouts correspond to damages, so distinguishing parametric insurance from financial derivatives (Sullivan, 2023).

The term 'parametric' describes the specific factor that triggers a payout. It is not exclusive to insurance. Such triggers are used in various risk transfer mechanisms and financial instruments, such as insurance-linked securities and weather derivatives (Polacek, 2018; Swiss Re, 2011). A parametric product is considered insurance if it meets two criteria: a) insurable interest, where the policyholder has a legitimate financial stake and faces potential loss; and b) risk transfer, where the product shifts risk from the policyholder to the insurer. The parametric trigger must directly relate to the policyholder's potential losses. Traditional indemnity insurance requires detailed post-event loss assessments to determine payouts. This method often excludes specific perils, offers limited reinsurance capacity, and results in slower claims processing, especially during widespread damage.

In contrast, parametric insurance enables quick disbursement of funds based on predefined parameters and offers broader coverage for losses measured by objective factors, such as the severity of a natural event. This approach allows for fast financial support after natural disaster events. Additionally, parametric coverage can reduce underwriting and loss adjustment costs, which often constitute a large part of insurance premiums. As a result, parametric insurance could offer more affordable coverage (Lawrence et al., 2023). Furthermore, advancements in technology, like mobile devices, artificial intelligence (AI), and machine learning (ML), enhance its potential by making it more accessible and providing an affordable, efficient way to manage NatCat risks and improve resilience (Foxe Blader, 2024).

However, the benefits of parametric insurance are offset by several significant drawbacks, creating problems for both policyholders and insurance companies. Firstly, the high basis risk, i.e., the risk that triggered payouts do not coincide with the occurrence of loss events (Barrieu and Albertini, 2009; Meenan, 2017; Figueiredo et al., 2018; Lin and Kwon, 2020), thereby exposing the insurance company to legal challenges from damage to their reputation and image, substantially resulting from customers' dissatisfaction. These policies' design also requires complex mathematical and statistical-actuarial modelling, which is highly dependent on the quality and availability of external data (e.g., provided by meteorological agencies, seismologists, geophysical institutes, etc.) that may be incomplete, out-of-date, late, or even of inadequate quality and, consequently, jeopardize payments or lead to litigation (Gao et al., 2025). As an example, changing climatic conditions make historical models less predictive, leading to considerable difficulties in correctly calibrating triggers that need to be realistic but, at the same time, not too easy to achieve (Lawrence et al., 2023). Moreover, as there is no timely assessment of the damage, pricing is undoubtedly more complex; indeed, it is difficult both to estimate the probability of the parameter being exceeded (Figueiredo et al., 2018) in order to model the risk correctly and to construct balanced portfolios and calculate the appropriate technical reserve. Finally, it is important to note that in many countries, insurance authorities still lack clear guidelines for managing and supervising these types of policies. This lack of clarity can result in legal uncertainty or stricter capitalisation requirements (Lin and Kwon, 2020).

Recent literature highlighted that basis risk is one of the main barriers to adopting parametric policies (Carter et al., 2014; Clarke, 2016; Peter & Ying, 2020; Jaspersen et al., 2022). Basis risk occurs when the index does not exactly reflect the insured's actual losses. This mismatch can arise from several factors, including (PWC, 2024): i) poor data quality or limited historical data can cause a gap between the index and real losses; ii) geographic granularity - an index may not accurately capture localized losses if the covered area is too broad or doesn't match the actual loss area; iii) errors in models used to predict losses based on the index, as well as the complexity of natural phenomena and the potential for models to become outdated over time; iv) misalignment between policy terms and the true risk profile or financial resilience of the insured; v) discrepancies between the index's time frame and the loss period, which can create basis risk. For example, seasonal changes can influence the relationship between the index and actual losses. A robust supervisory system is essential for protecting policyholders and maintaining the stability of the financial system, serving as a key component of sustainable insurance solutions. Risk-based solvency (RBS) frameworks, which establish prudential standards, strengthen insurers' financial stability and their ability to respond effectively to NatCat events.

Market conduct supervision, on the other hand, ensures fair outcomes for consumers and fosters public trust. When implementing prudential and market conduct standards, regulators should apply the principle of proportionality to create a supportive environment that encourages market growth while protecting policyholders. Some insurance regulators have clear mandates to promote market development. Regardless of such mandates, all regulators have an inherent - or explicit - duty to address protection gaps (IAIS, 2023a, 2023b). In certain jurisdictions, insurance regulatory frameworks have deliberately been revised to encourage the development and widespread distribution of appropriate, affordable insurance options. For instance, Chile recently enacted a new Fintech Law that includes a chapter allowing the offering of commercial parametric insurance within the country. The financial market regulator, Comisión Para El Mercado Financiero (CMF), is responsible for issuing regulations regarding requirements, information disclosure, product types, indexes, and other policy features.

Actually, there is limited scientific literature on factors other than basis risk that could affect the propensity to purchase parametric insurance. However, there are some studies conducted by authoritative advisory firms that demonstrate a clear interest in the topic. With reference to the existing literature, other key factors include the past losses (Gall et al., (2009); Gall et al., (2011); Gall et al., (2014); Peacock, et al., (2005), the firm size (Swiss Re, 2024; Ernst and Joung, 2024), the firms' digitalisation level, the availability of information, and familiarity with innovative insurance products, (Hellmuth et al., 2009; Dercon et al., 2014), and the location within a high risk region (Louaas and Picard, 2024; Goyal, 2021). These limitations underscore the importance of core design elements in integrating parametric insurance into broader risk management strategies. The success of a parametric insurance policy mainly relies on its precise design. Accurately defining the event, clearly establishing the coverage scope, setting well-calibrated parameters, selecting reliable data sources, and defining exact triggers are all essential to ensuring its effectiveness. Moreover, policyholders need to trust that the policy will deliver prompt and transparent payouts, reinforcing confidence in its reliability.

Unlike previous contributions, which have mainly examined all the aforementioned determinants separately, this study provides a unified empirical framework that jointly analyses the structural, behavioural, and contextual factors influencing SMEs' adoption of parametric insurance.

3. Methodology

As mentioned in Section 1, this study aims to empirically analyse the factors that affect Italian SMEs' propensity to adopt parametric insurance, with particular attention to the role played by basis risk. Data on SMEs were collected using a specially designed survey.

The survey questionnaire, reported in Appendix 1, consisting of 18 questions and divided into five sections (firm profile, insurance experience, risk perception, aptitude for innovation, interest in parametric insurance in the future) was sent to 3.000 SMEs selected from the Italian Chamber of Commerce register; actually, the sample size was determined in order to achieve a 95% confidence level and a 5% margin of error. In more detail, this (initial) sample was selected using a stratified random sampling method (Cochran, 1946) since, as is well known, especially when it is possible to hypothesise a priori the presence of significant differences between population subgroups, it is able to provide more accurate estimates than those deriving from the use of a simple random sample. (Kish, 1965; Cochran, 1977; Lohr, 2021).

With regard to the stratification criteria, the variables considered were geographical location (North, Centre, South and Islands) and the ATtività ECOnomiche (ATECO) code of SMEs.[6] Actually, we would have also liked to consider the size of the firms (measured by their number of employees or turnover class), but, unfortunately, it was not possible to obtain sufficiently up-to-date data on the distribution of these values at the geographical area level in order to be able to select the same shares within the sample of 3.000 SMEs.

It should be noted that, for the purposes of this work, the definition of SMEs compliant with the provisions of the Decree issued by the Italian Minister of Economic Development on 18 April 2005, in addition to those of European Commission Recommendation n. 2003/361/CE dated 6 May 2003 (European Commission, 2003; 2020) has been adopted. So, it will be considered as micro, small, and medium-sized enterprises all firms employing fewer than 250 employees, an annual turnover below euro 50 million or an annual balance sheet total below euro 43 million.

Based on the number of answers received, a new stratified random sample was built, again considering the geographical location and the ATECO code of SMEs as layers, in order to preserve the pre-fixed statistical significance of the results. Thus, it is the information obtained in such a way that will be used in a logit regression (Berkson, 1944) to estimate the parameters of a model capable of estimating the probability of adopting a parametric insurance to the main factors that can influence the propensity to purchase it.

Although, as is well known, the differences between estimates provided by a logit model and those derived from a probit approach (Bliss, 1934) are generally minimal, the former was preferred because preliminary analyses indicated substantial dispersion in the data and also because the aim was to interpret the results in terms of odds ratios.

[6] ATECO is the Italian classification of economic activities adopted by the Italian Istituto Nazionale di Statistica (ISTAT) to identify and categorize firms according to the type of activity they perform. ATECO codes represent the national version of the European NACE (Nomenclature of Economic Activities), with additional specifications tailored to the Italian context where necessary. In more detail: A = Agriculture, Forestry and Fishing; B = Mining and Quarrying; C = Manufacturing; D = Electricity, Gas, Steam and Air Conditioning Supply; E = Water Supply; Sewerage, Waste Management and Remediation Activities; F = Construction; G = Wholesale and Retail Trade; H = Transportation and Storage; 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; S = Arts, Sports and Recreation.

The logit regression that will be implemented in this work, which, as anticipated, models the probability of adopting a parametric insurance, is as follows:

$$Y_i = \beta_0 + \beta_1 \text{Basis Risk Index}_i + \beta_2 \text{Past Loss}_i + \beta_3 \text{Firm Size}_i + \beta_4 \text{Digitalisation Score}_i + \beta_5 \text{Info Access}_i + \beta_6 \text{Insurance History}_i + \beta_7 \text{Risky Region}_i + \varepsilon_i \quad (1)$$

where

- $i = 1, \ldots, n$ are the statistical units (SMEs) that make up the sample;
- Y is the dependent variable, which takes the following form

.

$$Y_i = \begin{cases} 1 \text{if SME has taken out } a \text{ parametric insurance} \\ 0 \text{otherwise} \end{cases}.$$

and Table 1 contains a description of each regressor together with their statistical nature, as well as the expected sign which, according to the existing literature, links each of them to the dependent variable.

It should be noted that all these variables values were collected through the survey, with the exception of (i) the proxy used for the basis risk (to which the study refers to as Basis Risk Index), which was found by combining specific information from the survey with data on climate change for each geographical area provided by the Copernicus service[7] in turn linked to some Joint Research Centre (JRC)[8] spatially explicit indicators of expected economic damage, and (ii) of the values of the risky region variable, obtained merging information on the geographical location of the firm derived from the survey with assessments provided by ISPRA[9] and Protezione Civile[10] about the danger level of each particular Italian region, so as to obtain the value of a dummy variable.

In more detail, the procedure that describes, step by step, how each firm Basis Risk Index was constructed is reported below:

1.Firm-level damage measure. For each firm, the reported damage caused by extreme events that occurred in the previous five years (answer to Question 11) was considered. This variable captures the realized loss experienced by the firm.

2.Geographical matching. Starting from the answers to Question 4 (Region and Province), each firm was geolocated and assigned to the corresponding spatial unit j used in the Copernicus datasets (e.g., municipality, grid cell, or Nomenclature des Unités Territoriales Statistiques - NUTS - area). This allows matching firm-level observations with the relevant environmental and risk information.

3.Historical triggers. For each spatial unit j, as it is well known, in the Copernicus database detailed risk information is reported (e.g., maps of event intensity, extent, or probability for different natural risks). These physical risk layers are combined with exposure and vulnerability information developed by the Joint Research Centre (JRC) that provides spatially explicit indicators of expected economic damage, expressed in euros. In particular, this study referred to the JRC Expected Annual Damage (EAD). Thus, these monetary indicators were considered as proxies for the historical triggers representing the expected economic impact of extreme events in the area in which the firm is located.

4.Construction of the Basis Risk Index. For each firm i, the difference between its actual damage reported in the survey (referred to the previous five years) and the sum of the historical triggers' proxies of the last five years – i.e. the sum of the EADs provided by JRC for the spatial unit j in which firm i is located referred to the previous five years - was computed as follows

$$\text{Basis Risk Index}_i = \text{Actual Damage}_{i,5y} - \sum_{t=1}^{5} \text{EAD}_{t,j}. \quad (2)$$

.

This measure captures the extent to which realized damages experienced by firms deviate from the historical triggers used in the index-based framework. Larger values indicate a greater mismatch between actual losses and the trigger, and therefore higher basis risk.

In order to make the results for the regression parameters comparable, the quantitative independent variables will be standardised, given that they imply different scales or units of measurement. Standardisation will transform the initial data into a new dataset in which each variable values distribution will have a mean of zero and a standard deviation of one, thus allowing the position of each value to be evaluated independently of the original unit of measurement.

For a better interpretation of the results coming from the regression, the answers provided by the firms to some additional questions in the survey, specifically designed so that each of them could be used as a control variable, will be analysed. In greater detail, these are the answers to the following questions:

- Question 9: If you have never taken out a parametric insurance, why not?

[7] Copernicus is the European Union's Earth observation programme for monitoring the planet and its environment. https://cds.climate.copernicus.eu.

[8] The Joint Research Centre is the science and knowledge service of the European Commission. https://joint-research-centre.ec.europa.eu.

[9] Istituto Superiore per la Protezione e la Ricerca Ambientale. https://www.isprambiente.gov.it/it.

[10] Dipartimento della Protezione Civile. https://www.protezionecivile.gov.it.

Table 1
Model's independent variables description.

Variable	Type	Description	Expected relationship sign
Quantitative:			
Basis Risk Index	Continuous	Difference, in euros, between the actual damage (from the survey) and the average of the historical triggers' proxies in the area in which the firm is located (from the Copernicus database combined with exposure and vulnerability information developed by the Joint Research Centre).	(-) Carter et al., (2014); Clarke, (2016); Peter and Ying (2020); (Jaspersen et al., 2022).
Past Loss	Continuous	Sum of damages suffered in the last 5 years in euro.	(+) Gall et al., (2009); Gall et al., (2011); Gall et al., (2014); Peacock, et al., (2005)
Firm Size	Discrete	Number of Employees	(-) Swiss Re, (2024) Ernst and Joung, (2024)
Qualitative:			
Digitalisation Score	Ordinal	Firm's digitalisation level.	(+) Hellmuth et al., (2009); Dercon et al., (2014); Swiss Re, (2024)
Info Access	Dummy	It assesses if the firm received adequate information about parametric insurance.	(+) Hellmuth et al., (2009); Dercon et al., (2014)
Insurance History	Dummy	It assesses if the firm had previously subscribed policies against natural risks.	(+) Hellmuth et al., (2009); Dercon et al., (2014)
Risky Region	Dummy	It assesses if the firm is located in a region prone to high natural risks, merging information on the geographical location of the firm (from the survey) with assessments provided by ISPRA and Protezione Civile.	(+) Louaas and Picard, (2024); Goyal, (2021)

- Question 12: How high do you consider the probability of suffering an extreme natural event in the next 5 years?
- Question 13: Do you think that the available climate and environmental data are reliable enough to take out a parametric insurance?
- Question 15: Do you already use digital insurance/InsurTech products?
- Question 16: Are you interested in new, fast and automatic insurance solutions, even if they are not perfect?
- Question 17: If you were offered a parametric insurance with a competitive price and automatic activation, would you take it out?

4. Empirical results

The delivery of 3.000 questionnaires for data collection began in January 2025. At the time of writing, 447 responses had been received. Based on the number of answers received, a new stratified random sample of 362 SMEs was built, again considering the geographical location and the ATECO code of SMEs as layers, in order to preserve the pre-fixed statistical significance of the results (95% confidence level and a 5% margin of error).

Fig. 1 presents the sample composition by SMEs' geographical location and ATECO classification; in the lower part the table shows the stratified random sample's representativeness with respect to the population of Italian SMEs.

Table 1 shows the main descriptive statistics of all the quantitative variables used in this analysis, while Table 2 contains some information about the other variables which will be referred to in the regression.

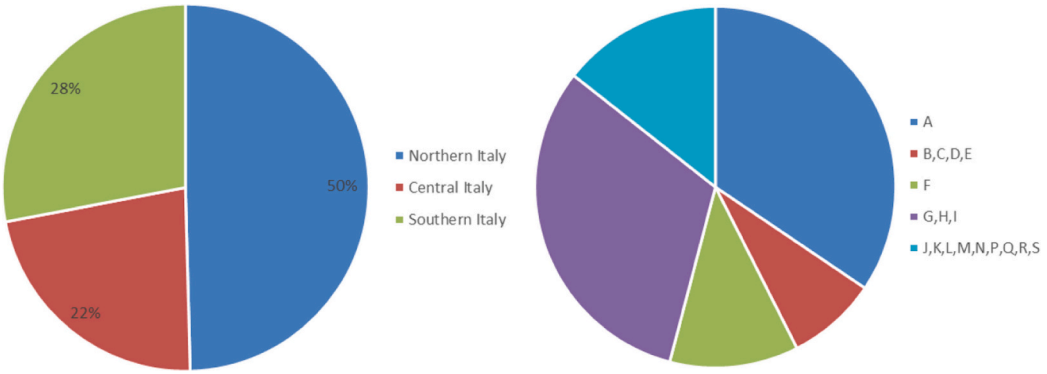
As is standard practice, the robustness of the estimates was assessed through multicollinearity diagnostics using Variance Inflation Factors (VIF), which did not reveal any significant collinearity among the explanatory variables. In addition, further checks for potential outliers were performed, without identifying any critical observations.[11]

In Table 4 the logit regression results.

The results appear to be broadly consistent with previous findings in the literature that examined the possible determinants of the decision to take out a parametric insurance (or natural disaster cover in general), although this has been done in studies that analysed the relationship of each variable separately, whereas, as a novelty of this study, they were considered jointly in model (1). From the previous table, it is possible to infer that (i) basis risk has a significant negative effect on the propensity of SMEs to take out parametric insurance, (ii) firms with greater past losses due to natural disasters and greater digitalisation are more likely to use parametric insurance, (iii) the larger the SME, the lower its propensity to adopt parametric insurance (therefore, smaller SMEs seem to be the most interested in taking out such policies), (iv) the fact that the firm received adequate information about parametric insurance increases the propensity to adopt it.

As anticipated in Section 3, for a better interpretation of these results, the answers to the Questions 9, 12, 13, 15, 16 and 17 have

[11] Data available upon request.



	Population	Stratified random sample
Northern Italy	50,0%	49,6%
Central Italy	22,0%	22,4%
Southern Italy	28,0%	28,0%
	100,0%	100,0%

ATECO code	Population	Stratified random sample
A	34,4%	34,4%
B,C,D,E	8,2%	8,1%
F	11,5%	11,5%
G,H,I	31,3%	31,5%
J,K,L,M,N,P,Q,R,S	14,6%	14,4%
	100,0%	100,0%

Fig. 1. SMEs' geographical location (left) and ATECO code (right). Source. ISTAT.

Table 2
The main descriptive statistics of all the quantitative variables used in this analysis.

	Minimum	Maximum	Mean	St. Deviation	Skewness	Curtosis
Basis Risk Index	−0,15	1,27	0,49	0,20	0,06	0,45
Past Loss	20,60	100.223,52	20.109,45	19.499,41	1,69	2,94
Firm Size (Employees)	6	27	15,12	3,86	0,16	0,12

Table 3
Information about the other variables which will be referred to in the regression.

Y = Dependent Variable	**Frequency**	**%**
0 = otherwise	237	65,5
1 = if the SMEs has taken out a parametric insurance.	125	34,5
Digitalisation Score		
1 = very low	54	14,9
2 = low	57	15,7
3 = intermediate	72	19,9
4 = high	74	20,4
5 = very high	105	29,0
Info Access		
0 = no	182	50,3
1 = yes	180	49,7
Insurance History		
0 = no	223	61,6
1 = yes	139	38,4
Risky Region		
0 = no	267	73,8
1 = yes	95	26,2

Table 4
Logit regression results.

	β	S.E.	Wald	D.F.	Sign.	Exp(β)
Basis Risk Index	−0,473	0,132	12,845	1	0,000	0,623
Past Loss	0,676	0,140	23,285	1	0,000	1966
Firm Size	−0,464	0,130	12,808	1	0,000	0,628
Digitalisation Score	0,145	0,088	2686	1	0,099	1156
Info Access	0,561	0,250	5033	1	0,025	1752
Insurance History	0,008	0,254	0,001	1	0,974	1008
Risky Region	0,242	0,301	0,644	1	0,422	1274
Constant	−1584	0,399	15,763	1	0,000	0,205

been analysed.[12]

The negative impact of basis risk is also confirmed by the information collected through the answers to Questions 9 and 13. In the first case, there is a high proportion (52,7%) of responses indicating basis risk as the reason for the past decision not to take out parametric insurance. In the second case, as many as 61,6% of the answers reveal a lack of trust in the reliability of the available climate and environmental data which, as is well known, being one of the main causes of basis risk, indirectly confirms the negative impact of the latter on the demand for parametric insurance.

Support for the regression result showing that SMEs that suffered greater losses due to natural disasters in the past are more likely to use parametric insurance is obtained by matching the answers to Question 12 with the location of SMEs in a risky region (and therefore in those areas that suffered the greatest damage and economic losses in the past). Moreover, the existence of a link between the answers to Question 12 and the location of SMEs in a risky region is confirmed by statistically significant Cramer's V values of meaningful magnitude. More specifically, 37,5% of SMEs located in less risky regions declared that they considered the probability of experiencing an extreme natural event in the next five years to be very low, while only 11,6% of those located in a high-risk region gave the same answer. Conversely, 44,2% of firms located in a high-risk region consider the probability of experiencing an extreme natural event – and therefore significant losses, as has already happened in the past – in the next five years to be very high.

The negative sign that the regression attributes to the parameter linking the size of firms to their propensity to adopt parametric insurance is indirectly confirmed by the answers provided to Questions 16 and 17. More specifically, by crossing the answers to Question 16 with the size of SMEs, it is possible to note, first of all, that most of those (61%) declare that they are not interested in purchasing a new, fast and automatic insurance solution, but also that, among those who say they are interested, there is a clear prevalence of the smallest ones (94%). As further support, 54% of those who are not at all interested in purchasing are represented by larger SMEs. As regards Question 17, which investigates the popularity of parametric insurance with a competitive price and automatic activation, although more than half (54%) of answerers say they are not interested (indirectly confirming the findings of Question 16), approximately 80% of small and medium-sized firms would do so. This may be due to the fact that, if they are required by law to take out insurance, a policy that is relatively less expensive than a traditional one would be more attractive to them. Conversely, 83% of medium-to-large SMEs say they are not interested in purchasing parametric insurance with a competitive price and automatic activation, perhaps because they have greater financial resources, sufficient to purchase more expensive tailor-made traditional policies which, in theory, should perform better.

Although digital and/or InsurTech products do not yet appear to be very widespread, with only 26,2% of respondents to Question 15 stating that they purchased them in the past, where used, they are linked to firms that report a higher level of digitalisation. In other words, the prevalence of positive answers to Question 15 is found among SMEs that reported having a medium-high level of digitalisation (73%). In this regard, it should be noted that, as confirmed by the values and significance of the connection indices, the link between the answers to Question 15 and the level of digitalisation of the SMEs surveyed is sufficiently strong. Therefore, these results reinforce the evidence emerging from the regression regarding the existence of a positive relationship between the level of digitalisation of SMEs and their propensity to use parametric insurance products.

The positive sign associated with the regression coefficient of the variable (Info Access) describing whether the firm received adequate information about parametric insurance is confirmed by a significant percentage of SMEs (30,4%) who, as answerers to Question 9, stated that they had not taken out parametric insurance in the past because they were unaware of its existence or how it worked. In general, therefore, it would seem to be confirmed that greater access to information about the technical characteristics of a policy can increase the probability of purchase and, therefore, in the case of parametric policies, can increase the probability of their subscription.

These findings are also highly relevant within the broader European policy debate on the insurance protection gap for climate-related risks, which remains substantial, particularly for SMEs. Across the European Union, a significant share of economic losses caused by natural disasters is still uninsured, limiting firms' recovery capacity and increasing the burden on public finances. By identifying the key determinants influencing SMEs' willingness to adopt parametric insurance, this study contributes to a better understanding of how innovative risk transfer mechanisms can help reduce this gap and enhance financial resilience.

In this respect, the results are consistent with the objectives of the European Union Strategy on Adaptation to Climate Change,

[12] Detailed data referring to all the answers to these questions, as well as the values of the main statistics computed (including the main connection indices), which also include the respective significance levels, are available upon request.

which explicitly recognises the role of insurance and financial instruments in strengthening business resilience and supporting faster recovery after extreme events. Parametric insurance, given its ability to ensure rapid and transparent payouts, may represent a complementary solution within this framework, particularly in contexts where traditional indemnity insurance proves insufficient or slow.

From a policy perspective, the findings also highlight the importance of strengthening public-private collaboration to support the development of parametric insurance markets, especially by improving the availability, quality, and transparency of climate and environmental data, which are crucial to reducing basis risk. Regulatory authorities, both at national and European level, could further foster innovation through targeted instruments such as regulatory sandboxes, allowing insurers to test new products while ensuring adequate consumer protection.

More broadly, within the context of European disaster risk management and resilience policies, promoting the diffusion of innovative insurance solutions appears essential to strengthening the economic stability of SMEs, which constitute the backbone of the European productive system. Ultimately, improving access to reliable information, enhancing trust in underlying data, and designing policies that reduce perceived basis risk emerge as key priorities for fostering the wider adoption of parametric insurance and contributing to a more effective closure of the climate-related protection gap.

5. Discussion and policy implications

The results in Section 4, concerning a stratified random sample of Italian SMEs, confirm previous research findings that basis risk can reduce firms' trust in parametric insurance, which can lead to reluctance to purchase it.

As also highlighted in this study, limited availability and accuracy of information and data on climate phenomena and natural disasters are certainly among the causes of basis risk. Therefore, appropriate policy measures should focus on improving data quality and transparency and encouraging the development of more reliable local indicators. Some supervisory authorities recognised this need and started setting up regulatory sandboxes or frameworks for pilot projects that let insurers test new natural risk coverage products on a small scale. Greater use of these tools would allow insurers to test different underwriting models, pricing strategies, and risk assessment methods in a heavily controlled environment. Regulatory sandboxes usually focus on technology and involve collaboration between authorities and insurers to develop guidelines for innovations and create products that meet consumer needs. In this context, improving the quality of parametric insurance and helping customers make informed choices through the establishment of a quality certification system could represent a key factor for the growth and expansion of this particular market.

The results also show that, alongside basis risk, the likelihood of purchasing parametric insurance is influenced by the level of losses experienced by SMEs in the recent past (positively), the size (negatively), and the level of digitalisation (positively) of the firms, as well as whether they have received adequate information about this particular type of policy (positively).

Based on these findings, several targeted strategies could be effective in increasing the uptake of parametric insurance by SMEs. Improving knowledge of parametric products is crucial. This could involve educational campaigns, workshops, case studies, and user-friendly online tools that clearly explain how such insurance works and, in particular, its advantages. Incentivising new buyers through various forms of premium modulation could reduce barriers to entry. Targeted outreach to SMEs that have recently suffered losses can capitalise on increased risk awareness. Integrating parametric insurance into disaster recovery programmes can further encourage adoption during reconstruction efforts. Using digital channels and forming partnerships with digital service providers can help reach more digitised SMEs, which are already more inclined to adopt such products. As larger SMEs appear to be less inclined to adopt parametric insurance, offering mixed solutions that combine parametric and traditional insurance can highlight their complementary nature rather than positioning one as a replacement for the other.

6. Conclusions

Parametric insurance provides a strategic way to increase the resilience of Italian SMEs operating in areas highly exposed to climate-related and natural disaster risks. By ensuring faster and more predictable financial support in the aftermath of extreme events, these policies allow firms to maintain continuity, safeguard jobs, and reduce long-term disruptions. For SMEs facing increasing environmental uncertainty, adopting such innovative risk management tools enhances their ability to withstand shocks, adapt to changing conditions, and invest in more sustainable growth, ultimately supporting the economic stability and resilience of entire communities and regions.

This study contributes to understanding the barriers to the adoption of parametric policies in Italian SMEs.

The basis risk remains a major concern, but can be addressed through targeted information programmes, as well as via technological, and regulatory measures. Along with this, factors like the level of losses suffered by SMEs in the recent past, the size and level of digitalisation of the firms, and whether they received adequate information about this particular type of policy seem to affect the propensity to purchase parametric insurance too.

Although robust, the results could be improved with further analysis as soon as the data allow, by examining longitudinal or panel information from a larger sample. This would enable studying whether the current explanatory variables change over time and help identify new trends and causal relationships. Unlike cross-sectional data (which capture a snapshot at a single point in time), longitudinal data would allow observing how the phenomenon evolves, monitoring changes, and detecting individual differences.

An additional consideration relates to potential non-response bias, as firms more exposed to natural risks or recently affected by extreme events may have been more likely to participate in the survey; as a consequence, although the sample, being stratified, is broadly consistent with the population of Italian SMEs along key observable characteristics, it may not be fully representative with

respect to exposure to natural risks, and the results should be interpreted with this in mind.

Furthermore, as possible extensions of this study, it might be useful to consider including additional variables in the regression model (among them, for example, the age of the SMEs), to construct a synthetic index of 'exposure to basis risk' for each SME (based on the distance from the historical average trigger and the type of risk covered), as well as to analyse the potential demand for parametric insurance policies via a Discrete Choice Experiment (DCE), simulating choices between policies with different levels of basis risk, premium and payment speed.

Author Contribution Statement

All authors have equally contributed to the conception, execution, and finalization of this paper. Each author was actively involved in the research design, data analysis, interpretation of results, and manuscript preparation. The authors collectively endorse the integrity and accuracy of the work.

CRediT authorship contribution statement

Francesca Pampurini: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Elisabetta D'Apolito:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Anna Grazia Quaranta:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix 1

Questionnaire for primary data collection.

Questionnaire for Italian SMEs - Adoption of parametric policies.

Dear entrepreneur,

We invite you to participate in this survey aimed at understanding the perception of natural disasters risk and the adoption of innovative insurance policies, in particular parametric catastrophe policies, among Italian SMEs.

Parametric policies offer rapid and simplified coverage against natural events such as floods, droughts or earthquakes, based on objective and measurable parameters (e.g. rainfall levels, seismic intensity) rather than traditional damage calculations. However, this innovation still presents challenges related to risk perception and actual adoption by firms.

Your contribution is essential to improving understanding of these dynamics and guiding the development of more effective and accessible insurance products.

The questionnaire takes about 10 min to complete and the data collected will be treated anonymously and confidentially.

We thank you in advance for your time and cooperation.

Section 1 : Firm Profile

1. Main activity field (ATECO code): _____
2. Number of employees: _____
3. Annual turnover:
   - ▫ < 500.000 €
   - ▫ 500.000–2 mln €
   - ▫ 2–10 mln €
   - ▫ > 10 mln €
4. Region and Province: _____
5. Year of establishment of the firm: _____

Section 2 : Insurance experience

6. Has your firm ever taken out insurance against natural risks?
   - ▫ Yes
   - ▫ No
7. Do you know how parametric policies work?
   - ▫ Yes
   - ▫ No
8. Have you ever taken out a parametric policy?
   - ▫ Yes
   - ▫ No

9. If you have never taken out a parametric insurance, why not? (tick all the answers you think are correct)
   - ▫ I knew neither of its existence nor how it worked
   - ▫ Costs too high
   - ▫ Basis risk too high
   - ▫ I prefer traditional insurance policies
   - ▫ Lack of trust in the insurance company
   - ▫ Other: _____

Section 3 : Risk Perception

10. Has your firm suffered significant damage from natural events in the last five years?

▫ Yes.
▫ No

11. If so, what is the total estimated value of the damage suffered in the last 5 years? € _____
12. How high do you consider the probability of suffering an extreme natural event in the next 5 years? (1 = very low; 5 = very high)

.

1–2 - 3–4 - 5

13. Do you think that the available climate and environmental data are reliable enough to take out a parametric insurance? (1 = in no way; 5 = yes, completely)

.

1–2 - 3–4 - 5.

Section 4 : Attitude towards innovation

11. How would you rate the level of digitalisation in your firm? (1 = very low; 5 = very high)
    1–2 - 3–4 - 5
12. Do you already use digital insurance/InsurTech products?
    - ▫ Yes
    - ▫ No
13. Are you interested in new, fast and automatic insurance solutions, even if they are not perfect?

▫ Yes.
▫ No.
▫ Maybe.

Section 5 : Future interest on parametric policies

17. If you were offered a parametric insurance with a competitive price and automatic activation, would you take it out?

▫ Yes.
▫ No.
▫ Maybe.

What kind of risk would you be most interested in insuring?

▫ Floods.
▫ Earthquakes.
▫ Heat.
▫ Blackouts.
▫ Other.

Data availability

The data that has been used is confidential.

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