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Insights about ultra-peripheral credit risk

Credit risk is a critical consideration for financial institutions, guiding their decision-making in extending credit to individuals or corporations. The study looks at the factors influencing credit risk in an ultra-peripheral region, in this case, the Azores, employing separate models, the companies' one and the households' one. The multiple linear regression models reveal some findings consistent with existing literature, such as the business volume of Azorean corporations in the companies' model, and the average monthly income of individuals in the households' model, whose increases contribute to the reduction of credit risk, in the respective model. Meanwhile, certain variables exhibit unexpected relationships, challenging prior research expectations. The region's gross domestic product and the percentage of corporations with negative net income, in the companies' model. The first one shows that its increase may rise corporations' credit risk. The other one reveals the opposite relation with the dependent variable.

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1. Introduction

Many papers analyze credit risk based on a particular country or group of countries for their study. However, it is also relevant to study the behavior of debtors in ultra-peripheral regions, given their specificities and unique characteristics. Considering the absence of approaches to the topic from this perspective, this paper sought to study the determining factors of credit risk in the Azores, one of the ultra-peripheral regions of the European Union, subdividing the cases between corporations and individuals, through a companies' model for the first one, and a households' model for the second one.

Banks' main activity is granting loans to both corporations and individuals. Thus, there is always a risk associated with these operations, known as credit risk, which can be subdivided into default risk, concentration risk, and collateral degradation risk. To mitigate the risk of credit concession, it is crucial to assess the financing conditions beforehand, including the terms and collaterals provided (Amaral, 2015).

Credit approval by the banking sector involves a rigorous analysis of its clients to assess their risk, typically associated with the granted credit. Therefore, it is of utmost importance to be aware of the most relevant factors leading to default (Bonfim, 2006). In the case of corporations, the likelihood of default mainly derives from their financial situation.

In Portugal, historically, the ratio of non-performing loans (NPL) in nonfinancial corporations (NFC) is the one with the greatest weight in the total of NPL, according to Marques et al. (2020). There has been an increase in NPL in relation to loans granted to the extent that bank credit concession to these corporations showed negative growth rates from 2008 to 2016. From that point on, there was a reversal of the trend until, two years later, these growth rates returned to positive values.

Bucur and Dragomirescu (2014) employed a descriptive and multidimensional statistical analysis to examine the relationship between certain macroeconomic variables and the credit risk ratio in the case of Romania for the period 2008 to 2013. They concluded that there is a negative relationship between the dependent variable and inflation, money supply growth rate, market interest rate, and exchange rate variation, and a positive relationship with the unemployment rate.

Bonfim (2006) sought to evaluate specific factors of corporations that are crucial for the probability of default, using ratios such as return on assets (ROA), financial autonomy, and liquidity indicators. To do so, he used the Credit Responsibility Center (CRC) and the Central Balance Sheet of the Bank of Portugal, employing discrete choice and duration models, namely, probit and Cox regression. The findings indicate that the sector in which the corporation operates, as well as these ratios, impact the probability of default for organizations, specifically liquidity, financial structure, and profitability, as cited by the author, contrary to the size of the corporations.

Aver (2008) analyzed the Slovenian context in relation to the credit risk of the banking system using a multiple linear regression model, incorporating macroeconomic variables such as inflation, gross domestic product (GDP), employment rate, imports, and exports, as well as factors like interest rates for different types of loans, among others. The author concluded that the employment rate negatively influences risk, while the remaining significant variables were mostly interest rates, with no observed significance in GDP or inflation.

Makri et al. (2014) studied the Eurozone between 2000 and 2008, through macroeconomic factors such as GDP, inflation, and unemployment rate, as well as organizational aspects, including ROA, return on equity (ROE), and the loan-todeposit ratio. Through GMM estimations with a sample of 14 different countries, they found that GDP and ROE had a negative relationship with NPL, unlike the unemployment rate. The loan-to-deposit ratio, inflation, and ROA did not show statistical significance.

Kailirai and Scheicher (2002) did not find statistical significance between GDP and NPL, later confirmed by Poudel (2013). The latter used a multiple linear regression model, while Kailirai and Scheicher (2002) used a bivariate regression for their research.

Concerning individuals, their relationship with the banking sector has been increasing for some years, notably in the quantity and frequency of product use. This fact has altered their credit profile and how individuals modify their behavior before defaulting on the banking entity (Farinha & Lacerda, 2010).

Alfaro and Gallardo (2012) looked into the determinants of bank default in both housing and consumer loans in Chile. According to their findings, the primary influencer of NPL is the individuals' income on household, followed by proxies for this variable. In the case of consumer loans, the conclusion is similar, with the same variable that most impacts the number of NPL, along with the number of individuals.

Farinha and Lacerda (2010) studied the main characteristics of borrowers' financing concerning non-compliance with these responsibilities in Portugal, for each type of credit, using a logit model and analyzing each credit segment separately. Characteristics such as the maturity and collateral of credit operations, as well as the profile of applicants and credit information, were considered. Among the conclusions, the authors note that the probability of a loan turning into a NPL has a negative relationship with borrowers having a mortgage and a positive relationship with the existence of personal collaterals.

Van Order and Zorn (2000) researched the connection between the Loan-to-Value (LTV) ratio of the credit proposal and the risk of default through Hazard models, proving a positive relationship. In other words, a higher LTV increases the probability of the debtor defaulting on their credit responsibilities.

Given the lack of literature focusing on the study of credit granting risk behavior in ultra-peripheral regions, this paper aims to examine the determining factors of this type of risk in the Azores, a region characterized by its ultra-peripherality, fragmented by the 9 islands that make up the archipelago. To achieve this, the cases of individuals and corporations in the region were considered. Research focused on the determining factors of credit risk for Azorean corporations, and what impact do they have on it (H1), and on the determining factors of credit risk for Azorean individuals, and what impact do they have on it (H2). For this purpose, time series data on the most relevant factors determining credit concession risk was used. These factors include variables derived from the region's macroeconomic conditions or specific parameters for each case. Multiple linear regression estimations were conducted to analyze the influence that each parameter under study has on credit concession risk. For (H1), a companies' model was created, as well as a households' model for (H2).

2. Research method

2.1. Data

The variables data collection came from the Sector Tables portals of the Bank of Portugal, BPStat, and Pordata, in June 2023.

In the case of the companies' model, the period studied was from 2009 to 2021. For households, due to constraints encountered in obtaining historical data, the time interval was contracted to the years 2014 to 2021. It was not possible to use the same common time horizon for both models, as the statistical relevance of the corporate regression would be compromised.

2.2. Variables

To study the impact of certain factors on credit risk, the dependent variables studied were, naturally, the NPL ratio in the Azores. Obtained through the BPStat portal were the number of loans granted and the number of NPL of both corporations and individuals. In the companies' model, the variable used as NPL ratio of corporations was the NPL ratio of NFC. The NPL ratio for each scenario was calculated by dividing the two time-series.

As independent variables, some macroeconomic factors were included in both models. Additionally, for each of the regressions, specific characteristics of corporations and individuals were considered, respectively.

Gross domestic product (*gdp*) - Some authors, such as Bonfim (2006) and Makri et al. (2014), found a negative relationship between GDP and NPL, meaning that an increase in GDP would lead to a decrease in NPL. On the other hand, Bucur and Dragomirescu (2014), Kailirai and Scheicher (2002), Poudel (2013), and Aver (2008) did not observe statistical significance of GDP in their models.

Inflation rate (*ir*) - Makri et al. (2014) and Aver (2008) studies concluded that the inflation rate is not statistically significant for their dependent variables. In contrast, Bucur and Dragomirescu (2014) and Poudel (2013) point to a negative relationship between inflation and credit default. The latter justifies this relationship by the fact that financial institutions seek to grant credit to debtors with a lower probability of default in periods of higher inflation. Therefore, an increase in the inflation rate result in a decrease in NPL. Additionally, the author supports the results obtained with the studies of Shu (2022), Zribi and Boujelbène (2011), as well as Vogiazas and Nikolaidou (2011).

Unemployment rate (ur) / Employed population (ep) - Makri et al. (2014), Bucur and Dragomirescu (2014), as well as Kailirai and Scheicher (2002) observed a positive relationship between the unemployment rate and default, meaning that higher unemployment in each region is associated with a greater number of NPL. Aver (2008) found the opposite relationship between his dependent variable and the employment rate, consistent with the rest of the literature. This variable was only used in the companies' model. In the households' model, due to multicollinearity concerns, the variable was replaced by the total employed population. Therefore, it was expected that the relationship with the dependent variable had the opposite sign. The employed population was obtained from the product of the total population of the Azores by the employment rate.

Business volume (bv) - The relationship between the business volume of corporations relative to their assets and the probability of credit default was studied by the authors (Barbosa & Pinho, 2017), resulting in a negative relationship. The probability of default is expected to be lower when the business volume of the entity is higher. This variable was included only in the companies' model. The time series was obtained by multiplying the total annual business volume of national corporations by the weight of the Azores in that amount.

Percentage of corporations with negative net income (*nni*) - Zarai and Baazaoui (2013) found that the ratio between the *nni*of corporations and the total of their assets has a negative relationship with credit risk. This variable was exclusively incorporated into the companies' model.

Average monthly income of individuals (*amii*)- Agarwal et al. (2010) found a positive relationship between individuals' salaries and their probability of not defaulting on their credit responsibilities. The variable was only included in the households' model.

2.3. Regression model

Given the literature review, we have chosen to employ a multiple linear regression model. This decision aimed to assess the influence of various factors on the credit risk associated with both cases in the Azores. Two distinct regressions were created, with macroeconomic variables alongside case-specific characteristics for the corporations and individuals, respectively, through the companies' model and the households' model. The multiple linear regression is summarized by a formula like Equation (1), in which *Y* represents the dependent variable, β the model parameters, *X* the independent variables, and *u* the errors from the model.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + u$$
(1)

Modifying the generalized expression of a multiple linear regression, previously represented by Equation (1), we get Equations (2) and (3), corresponding to the two models under study, for companies (*nplc*) and households (*nplh*), respectively.

$$nplc = \beta_0 + \beta_1 gdp + \beta_2 ir + \beta_3 ur + \beta_4 bv + \beta_5 nni + u$$
⁽²⁾

$$npli = \beta_0 + \beta_1 gdp + \beta_2 ir + \beta_3 ep + \beta_4 amii + u$$
(3)

with *nplc* and *npli* as dependent variables, *gdp*, *ir*, *ur*, *bv*, *nni*, *ep* and *amii* as independent variables, all explained, sign expectation and hypothesis testing across Figure 1.

Variable	Value	Sign	Hyp.
<i>nplc</i> – NPL ratio of corporations	number of credit conceded to corporations number of NPL on corporations	n/a	n/a
<i>npli</i> – NPL ratio of individuals	number of credit conceded to individuals number of NPL on individuals	n/a	n/a
<i>gdp</i> – GDP at 2016 constant prices	n/a	-	H1/H2
<i>ir</i> – inflation rate	n/a	-	H1/H2
<i>ur</i> – unemployment rate	n/a	-	H1

Figure 1. Regression model variables

Variable	Value	Sign	Нур.
<i>bv</i> – business volume	total annual BV of national corporations * rate of the Azores in that amount	-	H1
<i>nni</i> - percentage of corporations with negative net income	n/a	+	H1
<i>ep</i> – employed population	total population * employment rate	+	H2
<i>amii</i> – average monthly income of individuals	n/a	_	H2

It is essential to verify whether the errors from the models conform to a normal distribution. The Kolmogorov-Smirnov test was conducted for both regressions to assess the normality of non-standardized residuals. The results indicated that the p-values in the "Significance (2-tailed)" test exceed the 5% significance level. Therefore, there is no statistical evidence suggesting that the residuals from both models follow a normal distribution.

To test multicollinearity, Variance Inflation Factor (VIF) and Tolerance tests were employed. The maximum VIF recorded in the companies' model was 5.00, for the variable *bv*, while in the households' model, it was the *amii* variable, with a VIF of 6.54. Tolerance levels were above 0.1 for all variables. Thus, it was concluded that neither of the models shows multicollinearity issues, according to Bowerman and O'Connell (1990) and Myers (1990), as also cited by Field (2018).

To test heteroscedasticity, we employed the Breusch-Pagan and White tests. The outcomes suggest that both models show homoscedasticity, as the p-values exceed the 5% significance level.

The Durbin-Watson test for both models yielded inconclusive results. Consequently, we conducted the Durbin test to examine the presence of autocorrelation in the residuals. The findings indicated an absence of autocorrelation in both the companies' and households' models, as the respective p-values surpass the 5% significance level.

3. Results analysis

After conducting all the necessary preliminary tests, the analysis of both models was carried out using the Fisher F-test. As presented in Table 1, both models are collectively significant, as both p-values, represented in the "Sig." column, are below the 5% significance level.

Model	Adjusted R ²	Sig. (F-test)
Companies	0.822	0.002
Households	0.891	0.024

Table 1. Collective statistical significance of the models and F-test

According to the adjusted R^2 values, the companies' model is explained by the selected and previously described independent variables at 82.2%. The households' model is explained by the respective independent variables at 89.1%. In both, the quality of fit is confirmed with values exceeding 80%.

The t-Student test was employed to assess the sign and magnitude of each coefficient in both regressions, explaining the nature of the relationship between each independent variable and its corresponding dependent variable, along with the quantification of the observed impact. In Table 2, the results of the t-Student test, as well as the values of the coefficients for the explanatory variables in the companies' model, are presented.

Table 2. t-Student test of the companies' model

Variable	Sig.	β
gdp	0.018	5.533E-06
ir	0.139	-

Variable	Sig.	β
ur	0.196	-
bv	0.002	-8.435E-06
nni	0.035	-0.313

As evident from the results in Table 2, both *ir* and *ur* lack statistical significance in the model, as their p-values exceed the 5% significance level. Thus, for both variables, the values of their respective β coefficients are irrelevant for the study and should not be interpreted.

On the other hand, the remaining variables, namely *gdp*, *bv* and *nni*, exhibit p-values below the 5% significance level.

The coefficient for the *gdp* variable suggests that a one-thousand-euro increase in the region's GDP results in a 0.000005533 percentage point increase in the NPL ratio of Azorean corporations, and vice versa.

Furthermore, a $1,000 \in$ increase in the total BV of Azorean corporations leads to a decrease of 0.000008435 percentage points in the NPL ratio of corporations. In opposition, a decrease of one thousand euros in this business volume results in an increase in the ratio, proportionally.

Lastly, a 1 percentage point increase in the number of corporations with negative NI leads to a decrease of 0.313 percentage points in the dependent variable, while a 1 percentage point decrease in the independent variable has the symmetrical effect.

Table 3 presents the p-values for the variables in the households' model, as well as the coefficients of the explanatory variables.

Variable	Sig.	β
gdp	0.515	-

Table 3. t-Student test of the households' model

Variable	Sig.	β
ir	0.411	-
ер	0.295	-
amii	0.044	-0.020

In this regression, the variables common to both models are statistically insignificant, as the p-values for *gdp*, *ir*, and *ep* exceed the 5% significance level. Therefore, the coefficients should not be considered concerning their relationship with the dependent variable.

Only the *amii* variable exhibits statistical significance, with a p-value below the 5% significance level, thus the β should be interpreted. From the coefficient value, it is suggested that a 1€ increase in the average monthly income of individuals in the Azores results in a 0.02 percentage point decrease in the NPL ratio of individuals. On the contrary, a similar decrease in that average income has the opposite effect on the dependent variable, in the same amount.

In summary, the variables in each model that exhibit statistical significance are those that have the most impact on the credit risk of the Azores within their respective cases. Conclusions can be drawn from the results regarding the implications of variations in these factors for both corporations and individuals, as well as for the financial institutions themselves, which assess the inherent risk in credit proposals based on criteria determined by credit risk most influential aspects.

The literature review suggests there is a negative correlation between GDP and credit risk of corporations. During economic upturns, it is more likely for corporations to investment more. This study suggests that in the Azores, the positive relationship observed could be due to financial institutions easing credit standards among GDP growth, which, along with the increased demand for investment funds and relaxed lending criteria, might lead to general corporate over-borrowing. Essentially, corporations might take on more debt than they can handle. The link observed between BV and the dependent variable is supported by existing research, but the same can't be said for the percentage of corporations with negative net income. This fact could be because financial institutions tighten their credit policies, especially considering the higher number of corporations with deficits in the region, which implies that funding such entities presents greater risk for financial institutions. As for the households' model, the observed connection between AMII and the NPL ratio of individuals in the Azores supports findings in the reviewed literature.

Thus, an increase in credit risk due to the previous stated factors could directly and negatively impact the profitability of financial institutions. This impact may result not only from the implications of credit recovery but also from reduced credit granting and the necessity to rely on more severe criteria for financing both corporations and individuals. The heightened regulatory requirements for accessing bank credit could be a result of internal measures or regulatory mandates, such as those imposed by the Bank of Portugal

In this scenario, both corporations and individuals would experience reduced access to bank credit. It is expected that corporations would face a period of increased financial difficulties with insufficient cash-flows to meet their banking commitments and sustain business operations, whether due to over-indebtedness, a reduction in BV, or negative NI. Individuals may encounter challenges in maintaining their standard of living, considering that the credit risk associated with this situation depends on their income. The decline in individuals' income may also endanger their current debt servicing, potentially leading to banking defaults and, in more extreme scenarios, the execution of collaterals by financial institutions.

4. Conclusions

This paper wanted to determine the key factors contributing to credit risk in the case of the Azores, aiming to comprehend how this risk behaves in an example of an ultra-peripheral region, given their unique characteristics and some quirks due to insularity, since the existing literature mainly focuses on credit granting risk behavior in a specific country or group of countries. Accordingly, two models were developed to study the cases of Azorean corporations and individuals, separately. Macroeconomic variables common to both models were used, along with specific factors for each context.

The applied methodology was the multiple linear regression model, allowing for the quantification of the impact of independent variables on the dependent variable of each model and observing whether this relationship is positive or negative.

The test revealed that both models hold statistical significance. The adjusted R^2 value demonstrates that 82.2% of the dependent variable in the companies' model can be accounted for by the defined independent variables. Likewise, the households' model reveals about 89.1% of the NPL ratio of individuals.

Regarding the companies' model in the Azores, GDP shows statistical significance, unlike the findings in the studies of Bucur and Dragomirescu (2014), Kailirai and Scheicher (2002), Poudel (2013), and Aver (2008). The established relationship between the mentioned variable and the NPL ratio was positive, contrary to the results obtained by Bonfim (2006) and Makri et al. (2014). This occurrence may have various reasons, such as the dependent variable being the NPL ratio and not their number. In a scenario of economic growth, financial institutions may have less severe criteria for granting credit, leading to more loans granted and overdue, increasing the ratio between them.

The remaining macroeconomic factors, namely inflation rate and the unemployment rate, are not statistically significant. In the case of inflation rate, the result is consistent with the studies of Makri et al. (2014) and Aver (2008). Studies that included the unemployment rate in their models all found the variable to be statistically significant, namely Kailirai and Scheicher (2002), Bucur and Dragomirescu (2014), and Makri et al. (2014), verifying that the unemployment rate contributes positively to credit risk, while Aver (2008) found the opposite relationship. A reason that may have contributed to the mentioned insignificance could be the studied time horizon.

An increase in the Azorean corporations' BV results in a decrease in the NPL ratio of corporations, and vice versa. The result obtained for the mentioned variable is supported by Barbosa and Pinho (2017), considering that the indicator refers to the income obtained by entities through sales and services provided by them, and more income is associated with a lower probability of default on their responsibilities.

The percentage of Azorean corporations with negative net income shows a negative relationship with the dependent variable of the model, contrary to the expected sign based on the study by Zarai and Baazaoui (2013). A possible explanation for the observed occurrence is that in a scenario where there is a higher number of corporations with negative financial results, financial institutions may be more cautious when granting credit. This incident could lead to a reduced number of NPL relative to the number of loans granted, as corporations with negative NI would have more difficulty accessing bank credit.

In the households' model, GDP, inflation, and employed population did not show statistical significance, so their parameters have no interpretation within the regression. Several factors may explain this event, including the time horizon of the collected data, which may not have been large enough to observe the influence of these factors on the model.

The *amii* was the only independent variable in this model that proved to be statistically significant, with a negative influence on the NPL ratio of individuals

in the Azores. The observed parameter is supported by Agarwal et al. (2010), which also found that an increase in the variable in question leads to a decrease in the probability of bank default, and vice versa.

It is expected that an increase in credit risk due to the mentioned factors would directly and negatively impact the profitability of financial institutions. This impact results not only from the consequences of credit recovery but also from the decrease in the credit granting and the need to rely on more severe criteria to finance both corporations and individuals. Both cases may face difficulties in meeting their debt service obligations, either due to insufficient cash-flows or a reduction in their income. Consequently, both corporations and individuals would have reduced access to bank credit, either due to expected financial difficulties or the more severe criteria of financial institutions, aiming to mitigate credit risk.

The main constraints encountered in this study relate to data collection, where some of the variables used were restricted to the temporal horizon for which data are available. This factor led to, for example, the analysis of only an 8-year period in the households' model, contrary to the 13 years of the companies' model. Additionally, the available data did not allow the inclusion of other indicators in the regressions that could make both models more consistent.

Therefore, for future research, it would be important to expand the temporal horizon of the models under study, especially for households. Furthermore, it would be interesting to study the reason for the negative relationship found between GDP and the NPL ratio of corporations, to understand the behavior of bank loans in periods of economic growth or recession. The same can be verified for the percentage of corporations with negative NI.

Additionally, a way to complement this study would be to include other variables that may explain the NPL ratios, including financial ratios or other macroeconomic variables, such as private consumption in the Azores. Finally, it would also be relevant to extend the conducted research to other ultra-peripheral regions to perceive if the behavior of variables is similar to that of the Azores.

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