Credit risk identification in leveraged loans market using mediation analysis

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Abstract

The growth of the leveraged loans market has received a significant attention from the competent Authorities over the last few years, with a growing concern for the deterioration of creditworthiness. In our original sample, which combines financial and instrument-specific data, we propose a new approach through mediation analysis to identify the credit risk and the causal relationships between the variables considered. This approach, which is applied for the first time in the financial framework, allows us to decompose the effect of the covariates on the default into direct and indirect effects, which is particularly useful for better understanding the role of the covenant-lite agreement granted by the lenders.

Key Words: leveraged finance; syndacated loans; credit risk modeling; causal inference; mediation analysis.

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1 Introduction

Over the past decade an expansionary monetary policy, liquidity injections and reduction of interest rates increased investments in markets that try to achieve higher returns. One of the markets most affected by these policies is certainly the leveraged loans market. A syndacated loan is characterized by a syndacate of lenders which jointly finance a highly indebted borrower and with the aim of financing particular operations, such as refinancing, mergers, acquisitions (Bruche et al., 2017). The deal is previously promoted and managed by a single lender (or a small group of lenders) who coordinates the syndicate, as arranger. The loan is then syndacated to other banks or istitutional investors for the conclusion of the syndacation process, after which it moves to the secondary market, made up of institutional investors. Financial covenants are tipically included to monitor and test the performance of the borrower, and these allow the lenders to have a warning system if the company is failing to meet the financial performance, projected before the conclusion of the senior facility agreement (Achleitner et al., 2012). If a breach occurs, this will constitute an event of default, giving lenders the opportunity to take remedial action against obligors and to enforce the guarantees and collateral of the loan. In particular, Roberts and Sufi (2009) find that technical defaults lead to a reduction of the leverage, while Nini et al. (2009) affirm that violations are associated with declines in investment spending.

Despite the frequent use of this agreement, and the evidence of the importance of including them (DeFond and Jiambalvo, 1994; Dichev and Skinner, 2002; Franz et al., 2014), recently in the syndacated loan market, financial covenants are increasingly less frequent due to the presence of the so-called covenant-lite loans, a loan agreement that has fewer financial covenants than those that are included when we talk about traditional financial covenants (Becker and Ivashina, 2016). The growth of this type of loan stopped temporarily in 2007 with the financial crisis, but soon in 2008-2009 this type was reconfirmed, going from around 25% in 2012 to more than 80% as of December 2019 (S&P Global Market Intelligence, 2022).

Bank regulators have expressed concerns about the growth of this type of loan, due to the decline in the role of banks in monitoring and avoiding an increase in the borrower's credit risk. For this reason the Federal Reserve in March 2013 published the update "Interagency Guidance on Leveraged Lending", as well as the ECB with the "Guidance on leveraged transactions", published in May 2017. In an interview held in October 2018, Janet Yellen expressed her concerns about the significant growth of covenant-lite loans. She warned "If we have a downturn in the economy, there are a lot of firms that will go bankrupt, I think, because of this debt. It would probably worsen a downturn." The European Central Bank (2018) in the Financial Stability Review of November 2018 adds that "the leveraged loan markets continue expand between compressed spreads and weakened underwriting standards".

According to the European Banking Authority (2020), US issuance reached Eur 919.2bn in 2019 while European were Eur 162.3bn. Covid-19 at the beginning of 2020 stopped the issuance of new loans, which reached Eur 404bn for the US market and Eur 66bn for the European one. In the new issuance of loans, the European Central Bank (2018) notes that covenant-lites are the most widespread, practically becoming a market standard. The European Central Bank (2018) also notes that newly originated leveraged loans with debt to EBITDA higher than 6x are becoming common despite the fact that the credit quality of borrowers has declined.

Regarding the investor market, when we talk about leveraged loans we have to distinguish between real leveraged loans and Collateralized Loan Obligations (CLOs), i.e. asset-backed securities issued by a Special Purpose Vehicle, which acquires a portfolio of leveraged loans originated by banks and which it finances through an issuance of senior and mezzanine tranches and equity (Peristiani and Santos, 2019). The distinction between leveraged loans and CLOs is crucial when we look at the investor market, precisely because banks or other financial institutions can be present in both structures. Banks have the largest direct exposure to leveraged loans and CLOs and the greatest concentration, as reported by Fitch (2019), occurs precisely for global systemically important banks (G-SIBs). According to supervisory data (Financial Stability Board, 2019), banks in EU, Japan, UK and US have a direct exposure of US$1.368tn as of December 2019. Of this amount, 57% is held by US banks, 25% by EU banks, 10% by JP banks and 8,8% by UK banks. Banks also have a direct exposure to third-party CLOs for US$207bn (28% of CLOs outstanding).

The leveraged loans market has grown significantly in the last decade, supported by the search for yield by investors in a context of expansionary monetary policies. The vulnerabilities associated with this growth include: weaker credit quality of borrowers, an higher concentration of lenders within a lender type, looser underwriting standars (covenant-lite), liquidity risk and systemic risk due to the interconnectedness in the financial system (Financial Stability Board, 2019). Since the COVID-19 outbreak the credit markets have deteriorated strongly (Newton et al., 2020). As reported by the European Central Bank (2020), both the high yield and leveraged loan markets experienced market declines close to two-thirds of the falls incurred during the global financial crisis, with marked consequences also on the liquidity of these instruments with exceptionally high bid-ask spreads. As a result, the rating agencies have reviewed the creditworthiness of these instruments, carrying out various downgrades.

The COVID-19 shock has exposed risky credit markets to a combination of increased borrower leverage and weaker earnings. In addition, the deterioration in credit quality for leveraged loans has been pronounced in the last few years, with the consequence of a deterioration also on the CLOs market. However, the CLOs we find now on the market present less leverage than those common during the financial crisis, and this is an important note as leverage was one of the key elements that had amplified the effects of the crisis (European Central Bank, 2020). In this context, lenders are strongly exposed to credit risk and the event of default could impact the capital adequacy ratios and increase the risk of capital shorfall (Bruche et al., 2020). In particular banks, part of the syndacation pool, are mostly exposed to credit risk due to the direct exposure to leveraged loans and CLOs.

In this paper we focus on the leveraged loans market, preliminary we analyze the default rate of these instruments and the factors that influenced it during the recent COVID-19 pandemic. In particular, we are committed to understand the role of a specific non-financial variable, the covenant-lite agreement. We make use of mediation analysis (VanderWeele, 2015) to investigate causal relationships in order to understand if the covenant-lite agreement can play a role as mediator variables, i.e. which mediate the effect of a covariate X on the outcome Y (default) through the decomposition of causal relationships between variables into direct and indirect effects. This approach also allows us to deepen the causal framework and to quantify the direct and indirect effects (Doretti et al., 2021) assuming that there is an intervention on the value of the covariate X, and to understand if the indirect effect that passes through the mediator variable is significant and how much it affects with respect to the direct effect.

To the best of our knowledge, this is the first time the credit risk associated with covenant-lite leveraged loans has been identified, and that instrument-specific information is used within the credit risk model. In addition, it is the first time that mediation analysis has been applied for credit risk estimation. It is a methodology already used in the medical and psychological fields, which can offer useful decompositions of causal relationships in defining the factors able to influence the default of loans.

Overall, our paper relates to two different strands of literature. It relates to the theoretical literature on syndacated loans for understanding the role of covenant-lite in contributing to the credit risk of loans (Sufi, 2007; Achleitner et al., 2012; Franz et al., 2014; Becker and Ivashina, 2016; Bruche et al., 2020). Our paper is also related to the literature on credit risk modeling (Lando, 2009; Thomas et al., 2017), proposing for the first time mediation analysis as an alternative to the various approaches already widely used in the financial field. For this purpose, we will make use of panel data from 2013 to 2019 concerning the compositions of the S&P European Leveraged Loan index. In particular, the data relating to the instruments present in the index were integrated with the financial information of the borrower, to obtain a unique and original dataset that combined various sources of information for this market. Furthermore, information on defaults occurred in 2020 and the first three months of 2021 was added to the dataset, to obtain the variable response that was used in our models. The paper proceeds as follows. In section 2 we present the background and technical insights for the leveraged loans market and a focus on the distinction between traditional financial covenants and covenant-lite loans. Section 3 lays out testable hypotheses. Data used in this paper are described in Section 4 with summary statistics for our sample of leveraged loans and for the concentration of these instruments in each country. In Section 5 we describe the methodology and finally Section 6 concludes and draws policy implications.

2 Background

It should be noted that there is no univocal definition of leveraged loan, which is often quite different when comparing that provided by the supervisory authorities with that provided by the main data providers. In general, the European Banking Authority (2017) reports the following characteristics:

- debt to EBITDA ratio of four times (or higher);
- credit rating below BBB, i.e. non-investment grade;
- loan purpose to finance an acquisition/merger or for refinancing the borrower;
- private equity firm acting as sponsor of the operation;
- high initial spread at issuance.

In addition, S&P Global Market Intelligence (2022) defines as "leveraged" a loan if it is rated BB+ or lower or if it is not rated (or rated BBB- or higher) but has a spread over LIBOR/EURIBOR of 125bps or higher and is secured by a first or second lien. The leveraged loans are usually provided through a syndacation process where there is an arranger bank which acts to promote the syndacation of the loan where lenders contract with a borrower, based on a common document that defines the obligations that must be fulfilled by the syndacate members (Lim et al., 2014).

The syndacation process starts with the request of the borrower to the lender through a mandate or it is initiated by the sponsor (usually a private equity house) for making leveraged transactions (acquisitions). Afterwards the sponsor appoints other financial institutions to act as arrangers of the leveraged transaction (Sufi, 2007). The lender (or a group of lenders) who acts as arranger of the syndacation compose the syndacate, defining conditions and purposes of the operation (Lim et al., 2014). The arrangers (or co-arrangers) provide an initial agreement of the characteristics of the loan, then find other lenders to partecipate in the loan. Tipically one of the lenders assume the role of agent, which is considered the point of contact of the syndacate, monitors the compliance of the agreement, records all the notices coming from the lenders and acts as payment agent of the operations (interests, repayments and other required payments). Since loans are usually secured, a lender from the syndacate acts as security agent to hold the security used as collateral.

The financial covenants tipically included in leveraged loan transactions may include:

- leverage covenant: it indicates the level of debt against other accounts such as cash flow statement, Eincome statement and balance sheet. The most commonly used by market analysts and investors are: Debt-to-EBITDA ratio, Debt-to-Assets ratio and Debt-to-Equity ratio;
- current-ratio covenant: it require that the borrower mantain a minimum ration of current assets to current liabilities;

- coverage covenant: it compares the cashflow generated by the borrower with the aggregate of its debt, requiring the borrowing to mantain a certain level of cash flow or earning relative to expenses and debt;
- tangible-net-worth (TNW) covenant: it is specified a minimum level of TNW, often compared with the net income;
- maximum-capital-expenditures covenant: it requires that the borrower limit capital expenditure (for purchases of property etc.) to a pre-fixed amount.

Covenant-lite loan is a loan agreement that has fewer covenants than those that are included when we talk about traditional covenants (Becker and Ivashina, 2016). The birth of this type of loan is certainly due to the growth of private equity a few years before the financial crisis, at a time when bank syndicates competed with each other to offer more advantageous terms to borrowers.

We can consider this type as the one prevalent in the market, and focus on the meaning of the absence of covenant-lite in new loans.

Covenant-lite loans are usually considered more risky, due to the absence of restrictions typically included in traditional ones, referring to the maintenance of loan-to-value, leverage and EBITDA ratios. Demiroglu and James (2010) investigate the determinants of financial covenant thresholds in bank loans, trying to explore whether the thresholds are likely to be informative. The thresholds set by the banks can certainly provide information on the riskiness of the loan, considering that in the due diligence phase non-public information are available, but there are no studies in the literature on the covenant-lite loan and if this is informative with respect to traditional covenants. Maintaining certain restrictions can certainly be an effective alert in identifying borrower stress situations, and can provide the lender with tools to predict the event of default or deterioration of the loan in advance. However, considering the prevalence of the covenant-lite type in the market, the presence of traditional covenants should be considered as risky for the loan. When bank syndicates are trying to offer more flexible terms and conditions for the loan, the inclusion of covenants during the syndication process could be associated with the verification of a riskier operation. This assumption obviously depends on the correct identification of the risks in the due diligence phase on the loan, but there is an extensive literature which defines banks as screeners who almost always reduce information asymmetries (Diamond, 1991).
It therefore becomes essential to control the risks in the loan underwriting phase, and to consider not only the factors that come from the financial statements, but also those defined by the syndicate.

3 Testable hypothesis

As we have already reported, bank regulators have expressed various concerns in recent years regarding the growth of the covenant-lite loans market. These concerns have in common the assumption of greater riskiness of this type of loan due to the absence of restrictions that allow greater control of the borrower and an ability to intervene. The Financial Stability Board (2019) also noted that newly issued levereged loans are generally characterized by ever-decreasing credit quality, and therefore the covenant-lite loans from this point of view could contribute to the increase of this risk. However, considering that in recent years this type has become the most widespread in the market, it becomes difficult to hypothesize a greater riskiness for covenant-lites when they are now the most frequent, effectively becoming the market standard.

For this reason it becomes essential to assess the credit risk of leveraged loans without assuming a greater contribution to the risk of the covenant-lite ones. This also allows us to assess whether this agreement actually reduces or increases the probability of default.

Through the mediation analysis (VanderWeele, 2015), and therefore the decomposition of causal relationships into direct and indirect effects, it is possible to assess two hypotheses.

Hypothesis 1. The covenant-lite absence is due to the ability of the lenders to identify a greater risk. This hypothesis would be confirmed if the presence of the covenant-lite were explained by variables that summarize the riskiness of the loan, e.g. a significant positive effect of the profitability variables. This result would highlight the ability of banks to act as screeners who almost always reduce information asymmetries (Diamond, 1991) and would leads us to a second testable hypothesis.

Hypothesis 2. All other conditions being equal, there is a significant negative effect of the covenant-lite variable on the default event, i.e. the presence of the covenant-lite decreases the probability of default also after conditioning on all other covariates. The higher flexibility of the covenant-lite brings less financial burden to companies.

If Hypothesis 1 and Hypothesis 2 are true, then it is possible to decompose the effect of the covariate (in our case the ROA) on the probability of default into a direct effect and an indirect effect that is mediated by the covenant-lite variable.

4 Data

The original and unique dataset used is the merger of two different data sources: the compositions and information on the individual instruments were provided by S&P Dow Jones Index and we subsequently associated the financial data for each loan through Orbis (Bureau Van Dijk). Our initial S&P sample contains the compositions of the S&P European Leveraged Loan Index from 2013 to 2019, considering 2280 leveraged loans. For the purpose of our work we focused on the compositions at 31 December 2019, to assess the impact of the COVID-19 pandemic during 2020 and the beginning of 2021.

Starting from this sample, the defaults have been verified from 1 January 2020 to 31 March 2021, adding to the initial dataset a binary variable with value 1 if the loan defaulted, 0 otherwise.

The initial information on the S&P compositions concerns in particular the following characteristics: country of domicile, currency, BICS sector, loan type, loan signing date, loan maturity, use of proseeds, loan tranche size, call option, covenant-lite agreement, index floor, loan issue status, loan payment rank, coupon, loan base index at close, loan spread at close, initial Fitch rating, initial Moody's rating, initial S&P rating, Fitch rating as of 31 December 2019, Moody's rating as of 31 December 2019, and S&P rating as of 31 December 2019.

By *country of domicile* we mean the country in which the borrower has its registered office, which does not always coincide with the country where the company mainly operates. By comparing the data relating to the *country of domicile* with those relating to the *tranche size*, it is possible to obtain the size of the European leveraged loans market for each country, as shown in table 1.

Table 1: Leveraged loans market size for *country of domicile*.

	Domicile	Amount in mil. EUR (31/12/19)
1	GB	32977.29
2	LU	30718.06
3	FR	29948.07
4	NL	27950.27
5	US	25383.96
6	DE	21461.60
7	SE	7952.00
8	ES	6231.48
9	DK	4802.00
10	FI	2460.00
11	IE	2000.06
12	JE	1516.41
13	NO	1245.00
14	GI	1125.00
15	AT	980.00
16	BE	967.00
17	CA	850.00
18	IT	605.00
19	CH	543.00
20	MT	275.00
	Total	199991.19

Loan type simply specifies whether there is a PIK term loan or is simply a term loan, while *loan payment rank* specifies seniority.

Use of proceeds means the purpose for which the main operation was born, which can be summarized in acquisition, refinancing, general corporate purposes or other secondary purposes. Table 2 crosses the data on the size of the loan regarding the *country of domicile* and the *use of proceeds*.

Table 2: Leveraged loans market size by purpose and *country of domicile*.

Domicile	Acquisition	General purposes	Other	Refinance	Tot.
FR	16606.32	229.74		13112.00	29948.07
NL	15000.17	197.26		12752.85	27950.27
GB	13545.66	389.06	975.16	18067.41	32977.29
LU	12298.79	585.00	1680.33	16153.95	30718.06
US	10825.80	555.00	820.00	13183.15	25383.96
DE	6328.94		705.00	14427.66	21461.60
ES	4505.78	85.00		1640.70	6231.48
SE	3019.00			4933.00	7952.00
DK	2902.00			1900.00	4802.00
IE	1712.76			287.30	2000.06
JE	1516.42			1516.41	
AT	980.00				980.00
CA	850.00				850.00
CH	543.00				543.00
BE	417.00			550.00	967.00
MT	275.00				275.00
IT	250.00			355.00	605.00
FI			1700.00	760.00	2460.00
GI				1125.00	1125.00
NO				1245.00	1245.00
Total	91576.62	2041.06	5880.48	100493.02	199991.19

By comparing the size of this market in each country for types of operation, it is possible to understand whether companies in that country are investing more in acquisitions or in refinancing the debt. For instance, in table 2 for France and the Netherlands it is possible to observe a prevalence of leveraged loans which have the purpose of acquisition or merger. The use of leverage loans has an important role in order to support the growth process of firms. Given the importance of the firm size and the related economies of scale in the competitive landscape, this could be food for thought for countries at the end of the ranking.

The *loan tranche size* specifies the size of the specific tranche of the loan upon issue, which can obviously differ from the outstanding amount recorded subsequently.

The *call option* is a binary variable specifying with 1 a loan agreement that allows the lender to ask to be repaid at any time, 0 otherwise.

The binary variable *covenant-lite* specifies with 1 the agreement, with 0 the presence of traditional financial covenants. In our sample, about 81% of the loans are covenant-lite, confirming what is reported in the literature in the previous paragraph regarding the fact that this type has become a market standard.

The *loan coupon* (which is floating) specifies the interest rate of the loan, which can be obtained through the sum of the *loan index floor* and the *loan spread*.

Starting from the initial rating available, preferring in the order S&P, Moody's and Fitch, the rating at the end of 2019 was added to the dataset in order to construct a binary variable for identifying the predictivity of the rating that takes value 1 if there has been a downgrade and 0 otherwise.

From information on loans, data were integrated with annual balance sheet information from Orbis (Bureau Van Dijk). In particular, the following variables were extracted from 2013 to 2019: EBITDA, EBIT, ROA, ROE, ROC, profit margin, gross margin, current ratio, total debt, total assets, current liabilities, cash flow, net income, debt on EBITDA and debt on assets ratios. In the model used to identify credit risk, the financial variables used were taken as at 31 December 2019.

However, the variables available for the previous years were used to construct another variable used in our models, i.e. the value of the indicator at the time the loan started. To do this, the values of the financial indicators of the previous year with respect to the year specified in the variable *loan signing date* were taken for each loan. These variables are fundamental in our model to verify the predictivity of the values available to the banks' management when the loan was granted and also to verify the incidence of these, for instance in the decision to grant or not the covenant-lite agreement.

5 Methods

In this paragraph we illustrate the procedure and methodologies used to gauge how much the effect of the covariate X (e.g. ROA) on the probability of default Y is due to the mediating effect of the covenant-lite M via mediation analysis. From the eighties mediation analysis increases in popularity also among social scientists, in particular psychological sciences (Judd and Kenny, 1981; Baron and Kenny, 1986; MacKinnon et al., 2007), and recently have been applied to medicine and biostatistics (Bind et al., 2016). However, they are yet to become in use in the financial world.

In its simplest form, we assume a data generating mechanism where X causes the Mediator M and M and X together cause Y. A graphical representation of these assumptions is in Figure 1. The purpose of the mediation analysis is to quantify the effect of an external intervention to set, possibly contrary to fact, the value of X to two possible values: a value $x^\star$, usually considered as a reference value, and a second value x. The aim of mediation is to decompose the total effect of this intervention into the direct and the indirect effect, the second one mediated by M. Let $Y(x)$ and $M(x)$ the value that Y and M would take if X is externally set to x. Let $Y(x, m)$ the value that Y would take if x is set to x and M is set to m.

We then define the *total effect* which expresses the difference between the expected value of the potential outcomes under the two different states:

$$TE_{x,x^\star} = E[Y(x) - Y(x^\star)] \tag{1}$$

The *total* causal effect can then be decomposed into two effects: *pure natural direct effect* (PNDE) and *total natural indirect effect* (TNIE).

The *pure natural direct effect* describes the expected difference between potential outcomes by moving X from $x^\star$ to x, keeping the mediator at the value that it would have if the X is kept at the level $x^\star$:

$$PNDE_{x,x^\star} = E[Y(x, M(x^\star)) - Y(x^\star, M(x^\star))] \tag{2}$$

The *total natural indirect effect* describes the expected difference between potential outcomes if X had been set to x, but the mediator would be free to vary to its natural level:

$$TNIE_{x,x^\star} = E[Y(x, M(x)) - Y(x, M(x^\star))] \tag{3}$$

In addition, one should consider the *controlled direct effect*, i.e. the expected difference between potential outcomes by moving X from $x^\star$ to x, while holding the mediator constant to a specific level:

$$CDE_{x,x^\star} = E[Y(x, m^\star) - Y(x^\star, m^\star)] \tag{4}$$

In order to identify the effects defined as above, to obtain unbiased estimates and infer conclusion from real data, we need several assumptions.

- Temporal ordering assumption: it is necessary to assume that events follow a temporal sequence;

- Consistency assumption: when the population is exposed to the treatment $X = x$, then the potential outcome $Y(x)$ equals the observed outcome Y for that population, i.e. $P(Y(x) = y \mid X = x) = P(Y = y \mid X = x)$.

We further assume there exists a set of observable confounders C (possibly empty), such that, after conditional on C the following assumptions hold:

$$Y(x,m) \perp\!\!\!\perp X \mid C \tag{5a}$$
$$Y(x,m) \perp\!\!\!\perp W \mid X, C \tag{5b}$$
$$Y(x,m) \perp\!\!\!\perp X \mid C \tag{5c}$$
$$Y(x,m) \perp\!\!\!\perp M(x^\star) \mid C \tag{5d}$$

where the notation $Z \perp\!\!\!\perp W \mid U$ is used to denote that the random variables Z and W are conditionally independent after conditioning in U. In words, these assumptions imply that the unobserved factors influencing each random variables (i.e. the residuals of a structural equation model) are independent. See Pearl (2014) for an explantion that links the above assumptions to the linear structural equation models. A discussion in literaure on the use of counterfactuals in causal analysis can be found in Robins and Greenland (1992), Dawid (2000), Pearl (2000), Rubin (2000).

In the context of linear model, the decomposition of the total effects hinges on the work of Cochran (1938). Cochran's formula decomposes the marginal regression coefficient of Y on X into the sum of products of pathway-specific regression parameters, starting from the two following equations:

$$Y = \beta_0 + \beta_X X + \beta_M M + \epsilon_Y \tag{6a}$$
$$M = \gamma_0 + \gamma_X X + \epsilon_M \tag{6b}$$

where linear least square assumptions are satisfied for each equation and ϵ_Y and ϵ_m are indipendent.

By substituting the equation (6b) in equation (6a), we obtain:

$$Y = \beta_0 + \beta_X X + \beta_M(\gamma_0 + \gamma_X X + \epsilon_m) + \epsilon_Y \tag{7}$$

If the assumptions are satisfied, by marginalising over M, then:

$$Y = \beta_0^* + \beta_X^* x + \eta_Y \tag{8}$$

where $\eta_y = \beta_M \epsilon_M + \epsilon_Y$ and therefore we have:

$$\beta_0^* = \beta_0 + \beta_M \gamma_0 \tag{9a}$$
$$\beta_X^* = \beta_X + \gamma_X \beta_M \tag{9b}$$

(9c)

Notice, further, that $\beta_X^* - \beta_X = \gamma_X \beta_M$. It then follows that in this simple case in which the assumptions are satisfied and the DAG in Figure 1 contains no unobserved confounders and the set C is empty, the *causal* effects are as follows:

- Total causal effect is $\beta_X^*(x - x^\star)$;
- Controlled direct effect is $\beta_X(x - x^\star)$;
- Natural direct effect is also $\beta_X(x - x^\star)$;
- Natural indirect effect is $\gamma_X \beta_M(x - x^\star)$.

The above results are, however, limited to the simple linear models. Outside the linear case, the notion remains equal, but the parametric decomposition requires different derivations. When the dependent variable is binary, equations (6a) and (6b) must be adjusted for the logistic regression. For binary outcomes VanderWeele and Vansteelandt (2010) and Valeri and VanderWeele (2013) have defined the causal effects on the odds ratios scale, in a multiplicative fashion. As a consequence the relationship between total effect and direct and indirect effects is additive on the log odds scale. However, the work hinges on the assumption that the outcome is rare. To overcome this and other limitations, Doretti et al. (2021) have provided a parametric expression for natural direct and indirect effects. These are the parametric expressions we have used in this paper to obtain our *causal* effects, considering that we have a binary mediator and a binary response.

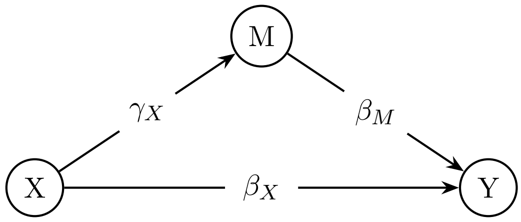

Figure 1: Mediation model.

6 Results

The purpose of this application is to see which factors impacted the default of leveraged loans during the COVID-19 pandemic, using a combination of leveraged loan data and borrower related financial data. Starting from the identification of the determinant variables, we use for the first time the mediation model applied to the estimation of credit risk with the aim to assess the role of the covenant-lite agreement and its impact on the default event. Working only on complete cases, we investigated the structure in the missing data, without evidence of any informative relationships.

Due to the imbalance of the binary response variable (default), in this work we use a Synthetic Minority Over-sampling Technique (SMOTE) Chawla et al. (2002). The idea of the SMOTE algorithm is to rebalance the dataset by introducing synthetic examples of the minority class through a smooting method to avoid overfitting. We then fit two logistic regression models on the augmented data (Lando, 2009; Crook et al., 2007). This allows us to balance the accuracy, efficiency and interpretability of the results obtained (Crone and Finlay, 2012).

The two initial logistic models are fitted including all the available confounders, (i.e. Loan Size, Loan Rank, BICS sector, EBITDA, ROA, Current Ratio, Total Debt, Use of Proceeds, as available for the logistic model for the covenant-lite and Loan Size, Spead, EBITDA, ROA, Current Ratio, Total Debt, BICS sector, Country, Loan Rank, Use of Proceeds for the logistic model of the default event). The final logistic models are obtained through Stepwise selection (Venables and Ripley, 2013) in order to minimize the AIC (Akaike Information Criterion) (Akaike, 1998). The AIC model fitting criterion is used as performance indicator to avoid overfitting by adding variables into model. This is achieved by using a penalty term as the number of variables in the model increases.

We make use of the notation of section 5 and denote by X the initial ROA, by Y the binary response loan default, by M the binary mediator covenant-lite agreement and by C the set of possible confounders included in the model. We first estimated the logistic model with covenant-lite as response and as covariates all the possible explanatory variables of this agreement, obtaining the model with the best AIC in Table 3.

Table 3: Results from the fitted logistic models for the mediator (H1).

$CovLite \sim X + C$					
	Estimate	Std. Error	t value	Pr(> |t|)	
(Intercept)	1.7469	0.2460	7.10	0.0000	***
$BICSComm.$	-2.1848	0.4946	-4.42	0.0000	***
$BICSTechn.$	-0.1721	0.4710	-0.37	0.7149	
$LoanSize$	0.6954	0.2473	2.81	0.0049	**
ROA_{init}	1.0272	0.2914	3.52	0.0004	***

We can notice the presence of the two BICS sectors with a negative effect on the probability of obtaining a covenant-lite. The Loan Size in this model shows a significant positive effect on the probability of obtaining the agreement, which could be due to the greater bargaining power of companies with larger amounts. Finally, the initial ROA has a positive effect on the probability of obtaining the covenant-lite. This demonstrates that this agreement is often granted to companies with good profitability (Hypothesis 1).

In Table 4 we report the results of the logistic model on the default as outcome.

Table 4: Results from the fitted logistic models for the outcome (H2).

$Default \sim X + M + C$					
	Estimate	Std. Error	t value	Pr(> |t|)	
(Intercept)	-5.5924	1.3358	-4.19	0.0000	***
$CovLiteY$	-2.0880	0.7034	-2.97	0.0030	**
$BICSComm.$	4.7399	1.1915	3.98	0.0001	***
$BICSTechn.$	5.5371	1.0980	5.04	0.0000	***
$LoanSize$	-2.8009	0.7050	-3.97	0.0001	***
ROA_{init}	-2.5888	0.7198	-3.60	0.0003	***
TD_{19}	1.7827	0.4729	3.77	0.0002	***
$EBITDA_{19}$	-1.1678	0.3020	-3.87	0.0001	***
CR_{19}	-3.7254	1.4777	-2.52	0.0117	*

The significant variables include the covenant-lite agreement with a negative effect on the probability of default (Hypothesis 2). Since this effect holds for all other covariates being equal, it is probably due to the flexibility of covenant-lite and lower financial burden, contrary to the possibility to have "higher than usual losses in an economic downturn" for this type of loan (European Central Bank, 2019).

As for the BICS Communications and Technologies sectors, we can note that these instead have a positive effect on the probability of default, compared to the other sectors. Loan Size with a negative effect highlights a greater probability of default for borrowers who use leveraged loans for smaller amounts. For what concerns the financial variables, we can note that the initial ROA, EBITDA 19 and Current Ratio 19 have a negative effect on the response, as opposed to Total Debt 19 with a positive effect.

The causal mediation setting that we want to assess is the one shown in Figure 2. We want to decompose the total effect of the initial ROA on the default into the direct one and the indirect one passing through the covenant-lite, as this anaysis shows that the agreement could be granted on the basis of profitability.

It is possible to note that in Table 3 and Table 4 all the estimated coefficients are statistically significant, thus including those related to the mediation pathways $X \to M \to Y$ and $X \to Y$. The effect related to the pathway $X \to M$ is positive, the one related to $M \to Y$ is negative and the one related to $X \to Y$ is negative. Overall we therefore have both an indirect and a direct negative effect, whereas the initial ROA increases the probability of getting a covenant-lite which in turn decreases the probability of defaulting. In addition, the coefficients related to the pathway $X \to M \to Y$ are not so small compared to that of pathway $X \to Y$, suggesting that the direct effect is not the

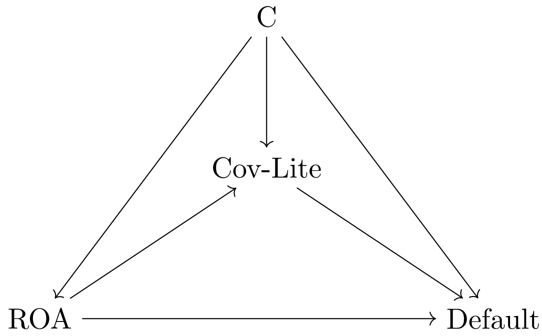

Figure 2: Causal mediation setting for Initial ROA as exposure

dominant component of the total effect.

We estimated the causal effects based on the parametric expression provided by (Doretti et al., 2021), which is applied to the case of binary mediator and binary response.

In Table 5 we report the estimated total, direct and indirect effect, on the log odds scale, if $x^\star$ is equal to the average amount of the initial ROA in the sample (3.77) and $x = x^\star + 1$, i.e. when the ROA is one point higher than the observed average value. The effects refers to loans with average Total Debt, average EBITDA and average Current ratio and different levels of the BICS Sector and Loan Size covariates. The table also reports the standard errors and 95% confidence intervals, built using the delta method (Oehlert, 1992). All the 95% confidence intervals for the direct, indirect and total effects are quite far from 0, showing that all effects are significant.

Table 5: Estimates, standard errors (SEs), 95% confidence intervals (CIs) and p values of the causal log-odds ratios for the mediation scheme of Fig. 2

	Est.	SE	95%	CI	p value	Est.	SE	95%	CI	p value
	S=Comm., L=509 mil.					*S=Comm., L=609 mil.*				
$\log OR_{PNDE}$	-0.208	0.065	-0.336	-0.080	0.001	-0.216	0.066	-0.345	-0.087	0.001
$\log OR_{TNIE}$	-0.033	0.014	-0.061	-0.005	0.021	-0.034	0.014	-0.062	-0.006	0.017
$\log OR_{TE}$	-0.241	0.064	-0.367	-0.116	0.000	-0.250	0.064	-0.376	-0.124	0.000
	S=Techn., L=509 mil.					*S=Techn., L=609 mil.*				
$\log OR_{PNDE}$	-0.195	0.061	-0.316	-0.075	0.001	-0.205	0.067	-0.338	-0.073	0.002
$\log OR_{TNIE}$	-0.035	0.017	-0.068	-0.002	0.039	-0.036	0.016	-0.066	-0.005	0.021
$\log OR_{TE}$	-0.230	0.061	-0.350	-0.111	0.000	-0.241	0.066	-0.371	-0.111	0.000
	S=Other, L=509 mil.					*S=Other., L=609 mil.*				
$\log OR_{PNDE}$	-0.227	0.063	-0.351	-0.103	0.000	-0.227	0.063	-0.351	-0.103	0.000
$\log OR_{TNIE}$	-0.039	0.018	-0.075	-0.003	0.035	-0.032	0.013	-0.058	-0.006	0.017
$\log OR_{TE}$	-0.266	0.063	-0.389	-0.143	0.000	-0.259	0.062	-0.381	-0.137	0.000

By looking at Table 5 we can see that results are stable across the different covariate patterns. The estimated $\log OR_{PNDE}$ lie between -0.227 and -0.195, and all estimates of

$\log OR_{TNIE}$ lie around -0.035. Regarding the $\log OR_{TE}$, the estimates lie between -0.266 and -0.230, and represents the total marginal effect on the log-odds ratio of the default due to an increase of the inital value of the ROA from $x^\star$ to x. As expected, this increase has a begative impact on the probability of default.

In this setting, the $\log OR_{PNDE}$ expresses how much the log odds ratio of the default event decreases if the ROA goes from $x^\star$ to x, but the decision to grant the convenant-lite is taken as if the ROA were at $x^\star$. We could hypothesize a situation in which the lender decides to grant the covenant-lite as if unaware of an increase in the initial value of ROA, therefore behaving as if it were constant at $x^\star$. Therefore, considering the negative and similar effects for all six cases, an increase in ROA decreases the log-odds ratio of the default. The $\log OR_{TNIE}$ expresses the opposite case, i.e. the effect on the probability of default if the lender is informed that the inital ROA has increased from $x^\star$ to x, but in fact the inital value of the ROA value is fixed at x. This is therefore the effect that passes through the decision to grant the covenant-lite, which also in this case is negative and similar for all six patterns, and shows a decrease in the log-odds ratio of the default as the lenders review the judgment on the granting of the covenant-lite on the basis of a higher profitability of the financed company. Notice that the total natural indirect effect brings a smaller contribution than the direct effect to the total effect. However, since it is significantly different from zero, it cannot be neglected.

In general, it is possible to confirm the validity of our causal setting. Therefore, a higher initial ROA not only directly decreases the probability of default, but also indirectly decreases it with the effect that passes through the granting of the covenant-lite. The direct effect reduces it more, but the indirect effect is still a significant effect to consider. Like in every empirical study it is not easy to guarantee with certainty the absence of confounders in the model and therefore the results must in any case be interpreted with caution. Indeed, there could be some unobserved confounders of the relationship between the mediator variable covenant-lite and the probability of default, such as managerial skills of the board of the companies.

7 Discussion and conclusions

We analyze credit risk in the leveraged loan market, by investigating the role of the covenant-lite agreement that is granted by lenders during the underwriting process. For this purpose, we use the mediation analysis in order to understand if the covenant-lite agreement can play a role as mediator variable. This approach allows us to confirm that lenders do not actually grant the covenant-lite agreement if they identify greater risk. Furthermore, we identify a lower probability of default for covenant-lite loans. A possible explanation of the positive impact of the covenant-lite agreement is that it brings higher flexibility and less financial burden to companies. The use of mediation analysis also allows us to desentangle from the total effect of the initial ROA on the probability of default, the direct effect, i.e. the one not due to the lender's decision to grant a covenant-lite agreement, and the indirect one, i.e. the one transmitted through the decision to grant a covenant-lite. The significance of the direct and indirect effects confirms that a higher initial ROA not only directly decreases the probability of default, but also increases the probability of getting a covenant-lite which in turn decreases the probability of defaulting. Only the correct identification of credit risk allows us to effectively monitor those lenders with a higher concentration of risky leveraged loans. For this purpose, the use of mediation analysis for the first time applied to the identification of credit risk, lays the foundations for an alternative to the previous approaches used in this field.

This paper offers an interesting starting point for the correct identification of systemic risk in this market. To expand this work, we are working on identifying a concentration indicator of risky leveraged loans that allows us to identify those banks/lenders with greater risk exposure and potentially source of systemic risk.

However, it is not always easy to obtain data for all leveraged loans, but the consideration of public companies still allows us to reconstruct most of the market, as often the lack of data relates to private companies with less significant financed amounts.

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