



Assessing the impact of operating lease capitalization with dynamic Monte Carlo simulation[☆]

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ABSTRACT

The European Commission has recently adopted a new accounting standard for leases that will be implemented in 2019, which requires operating lease contracts to be included in the balance sheet, affecting key ratios, leverage and profitability. We simulate the impact of IFRS 16 using Monte Carlo method, which incorporates the uncertainty of the future value of variables when making predictions. Unlike prior studies based on historical data, our study considers a five-year forecast horizon and, more importantly, contemplates several probable scenarios. Based on the STOXX All Europe 100, our results confirm that, in 2019, liability maturity, liquidity and return on assets will decrease, leverage and return on equity will increase, but the figures do not change substantially after 2019. The results of this dynamic approach are consistent across the five scenarios considered; however, the impact of IFRS 16 is smoothed under the strategy of reducing the life of lease contracts.

1. Introduction

The European Commission (EC) endorsement process of International Financial Reporting Standard (IFRS) 16, *Leases*, was terminated at the end of 2017; hence, European firms will have to apply it to record lease transactions in 2019. In brief, IFRS 16 requires all leases to be included as assets and liabilities on the balance sheet. This study belongs to the relevant stream of literature that looks at the economic consequences of accounting standards (Brüggemann, Hitz, & Sellhorn, 2013; Daske, Hail, Leuz, & Verdi, 2013; De George, Li, & Shivakumar, 2016; Doukakis, 2014, among others) and analyzes the potential impact of the adoption of IFRS 16 using a dynamic approach that goes beyond the one used in prior related studies. A recent study referred to European Union (EU) Regulated Markets estimated that the amount of off-balance liabilities in the nonfinancial sectors in 2015 was approximately €574 billion, representing 15% of the total debt (Europe Economics, 2017); the capitalization of these liabilities will have an impact on leverage and profitability ratios, as several academic and professional studies referring to specific years and countries have demonstrated. Those figures help explain the reluctance of companies toward the adoption of such a standard.

As Labro (2015) highlights, despite their potential usefulness, simulation methods are not commonly used methods in accounting

research. Thus, because we use a simulation approach, this study is unique and potentially more realistic than studies based on historical data. More precisely, we simulate the impact of IFRS 16 using the Monte Carlo method, which enables the consideration of complex but reasonable systems and the generation of predictions (e.g., Balakrishnan & Penno, 2014). By incorporating the uncertainty of the future values of variables that affect the results, this methodology helps address research questions when data are not available, as with the question at hand: What will be the impact of IFRS 16? Furthermore, this methodology allows the impact of possible changes in the behavior of firms to be simulated. This approach has been frequently used in other related fields, such as finance and economics (e.g., Boyle, Broadie, & Glasserman, 1997; Detemple, Garcia, & Rindisbacher, 2005; Mody, Taylor, & Kim, 2001; Pastor & Peraita, 2016; Reher & Wilfling, 2014; Varas & Walker, 2011), but it has been ignored in accounting literature.

The currently used standards, i.e., International Accounting Standard (IAS) 17 and its United States (US) counterpart, require firms to distinguish between operating and finance (or capital) leases, and only the latter are included on the balance sheet. Therefore, operating leases remain part of off-balance financing, and information about future lease payments is disclosed only in the notes to the financial statements. In general, the classification is viewed as complex and subjective. A US report concluded that, in 2003, approximately 63% of

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listed companies reported operating leases, while only 22% reported finance leases (SEC, 2005), suggesting companies were structuring financial transactions to avoid the recognition of debts on the balance sheet. In 2006, the International Accounting Standards Board (IASB) and the US Financial Accounting Standards Board (FASB) added to their agendas a joint project on lease accounting. Ten years later, both standard-setting boards have issued their own standards that require recognition of all leases on the balance sheet, although they maintain some differences. Following due process, the IASB will develop a postimplementation analysis two years after its implementation. We believe this paper could be especially useful for such a purpose because the methodology used provides a more realistic view of the impact of the new standard than previous as-if studies that only capitalize the off-balance information in the year under study.

Based on the STOXX All Europe 100, we provide an as-if analysis that allows the financial position and performance of firms affected by the accounting change in the year of implementation (i.e., 2019) to be estimated; however, different from other studies, we consider a five-year horizon in which we contemplate several scenarios. Our results confirm that leverage ratios increase, liability maturity and liquidity decrease, and the impact on profitability varies; in addition, these results are rather consistent among the five scenarios considered. We argue that, in addition to policy-makers and academics, this study could be useful for managers because it suggests that reducing the life of all leases minimizes the impact of the new standard.

Our study contributes to the literature in several ways. First, unlike other studies, this study not only examines a specific year but also adopts a dynamic approach and considers a five-year horizon starting with the year the standard is implemented. Second, this study contemplates several likely scenarios, which enables the consideration of managerial changes in the way companies will structure contracts to limit the impact of IFRS 16. Third, the methodological approach is not limited to capitalizing the lease debt and calculating the average result of a historical sample, as it simulates millions of companies and consistently approximates the expected change on the balance debt of the total population of firms.

Following this introduction, the next section is devoted to a literature review. The third section discusses methodology, including the sample and the research method. Section 4 contains the results and discussion. Finally, we summarize the main conclusions.

2. Literature review

The capitalization of lease contracts has always been subject to controversy. In the 1960s, Nelson (1963) showed that financial ratios were negatively affected by their capitalization. Imhoff and Thomas (1988) found a decrease in finance leases versus operating leases after the requirement to capitalize finance leases was imposed in the US. Later papers focused on operating leases and, based on information in the notes, estimated the as-if figures.

The constructive capitalization method developed by Imhoff, Lipe, and Wright (1991), which is probably the most sophisticated method for estimating assets and liabilities, requires a number of hypotheses to be applied to determine the minimum lease payments, the remaining useful life (i.e., the time assets will be in use in the company), the tax rate, and the discount rate. This method has been used in various contexts, such as in the US by Mulford and Gram (2007) and Duke, Hsieh, and Su (2009), in the United Kingdom (UK) by Beattie, Edwards, and Goodacre (1998) and Goodacre (2003), in New Zealand by Bennett and Bradbury (2003), in Canada by Durocher (2008), in Germany by Fülbier, Silva, and Pferdehirt (2008), in Spain by Fitó, Moya, and Orgaz (2013), Barral, Cordobés, and Ramírez (2014)—who also consider the UK—and Giner and Pardo (2017), and in Australia by Wong and Joshi (2015). In a very recent paper, Morales-Díaz and Zamora-Ramírez (2018) examine the European setting and employ a different version of the constructive approach. Additionally, as Imhoff et al. (1991) and

Imhoff, Lipe, and Wright (1997), some recent papers follow the case study methodology. Thus, Öztürk and Serçemeli (2016) consider a Turkish airline company; similarly, Joubert, Garvie, and Parle (2017) analyze two Australian companies in that sector and one in the telecommunications industry, and Arrozio, Gonzales, and Silva (2016) consider several companies in the Brazilian market.

Despite the varied periods, countries, and industries in the studies, the general conclusion is that leverage and profitability ratios are affected but that differences exist between companies and industries, with retail sectors being the most affected. Due to its negative impact on ratios, preparers strongly lobbied against the capitalization of operating leases during the due process of standard preparation, suggesting managerial changes could take place after implementation.

This ex ante approach to evaluate the impact of the accounting change has also been adopted in some recent professional studies. PwC's (2016) study considers 3199 listed firms that use IFRS, and concludes that, in the EU, the median increase in debt will be approximately 21%. The debt ratio (i.e., total debt divided by EBITDA) will increase from 1.55 to 1.78, while solvency (i.e., net income plus depreciation divided by total liabilities) will decrease from 46% to 41.6%. The study thus confirms important industry differences. Additionally, EFRAG published a study that considered the impact on a sample of large listed entities with the largest operating lease commitments in the European Economic Area (EFRAG, 2016). The simulated lease liability represents 4% of debt (with the energy sector being the most affected at 26%); however, when the financial industry is excluded, that percentage increases to 16%. Based on a sample of 1022 firms that use IFRS (of which, 348 are European), the IASB effects analysis concludes that the average increase in liabilities will be \$1661.8 billion, which is approximately 5.4% of total assets; additionally, in the airline, retailer, travel and leisure industries, this percentage increases up to 20% (IASB, 2016). The underlying question that drives this type of research is the extent to which the incorporation of new liabilities in financial statements may have economic consequences that affect market prices, debt, and remuneration contracts, among others.

In a report published by Deloitte (2011), 284 executives were surveyed to assess the potential impact of the proposed revisions to lease accounting. The general opinion was that the new treatment will have a material impact on key financial ratios, with 68% believing that the leverage ratio will increase and > 40% believing that financing would be more difficult to obtain. In addition, 49% believed that return on assets would be affected.

Leaving aside other explanations for leases, it has been suggested that the volume of operating leases has grown due to existing accounting standards, while finance leases have continued to decrease. In other words, firms design ad hoc contracts to avoid capitalization (Beatty, Liao, & Weber, 2010; Bryan, Lilien, & Martin, 2010; Dechow, Ge, Larson, & Sloan, 2011; Duke et al., 2009; Imhoff & Thomas, 1988), which can be seen as an attempt to distort their financial statements (SEC, 2005). Abdel-Khalik (1981) was probably the first author to state that firms opt for operating leases to avoid the violation of restrictive debt covenants; this statement has been documented later as well (Beneish & Press, 1993; Franz, Hassabelnaby, & Lobo, 2014; Nikolaev, 2010). Nevertheless, Demerjian (2011) and Paik, van der Laan Smith, Lee, and Yoon (2015) sustain that off-balance liabilities are considered when establishing covenants. Along these lines, Europe Economics (2017) concludes that market users seem to consider operating lease liabilities in their current decision-making.

Within this context, companies might change their financing to use operating leases at a lower extent or to modify future and even current contracts to minimize the impact of the new rules; the new standard could have unintended economic consequences (Brüggenmann et al., 2013; Wiczynska, 2015). Different from previous studies, we consider these potential managerial changes in our empirical analysis by referring to the impact of IFRS 16 in Europe.

3. Methodology

3.1. Sample and financial ratios

The sample comprises the companies included in the STOXX All Europe 100 index at the beginning of 2016. This index includes the 100 largest companies in Europe; as is common in the literature, financial and insurance companies have been excluded (26 firms). Data have been obtained from the ORBIS database and notes to the financial statements; in particular, information about future minimum lease payments has been manually collected. According to IAS 17, lessees must provide the following information in the notes: *i*) payments due the year after reporting, *ii*) payments due in the period two to five years after reporting, and *iii*) payments due after five years. Because two companies do not report on future operating lease obligations, complete information is limited to 72 companies. Data are recorded for the period from 2011 to 2015. The final sample comprises 357 observations because, for one company, only two years are available. Given that not all firms prepare the information in the same currency, the historical exchange rate at each closing date (European Central Bank) has been used to convert all currencies into euros.

To appreciate the impact of the accounting change, we have selected five financial ratios that capture dimensions of firm performance and financial position and that have been used in previous studies (Fitó et al., 2013; Giner & Pardo, 2017).

$$\text{Leverage} = \frac{\text{Total Liabilities}}{\text{Total Assets}} \tag{1}$$

$$\text{Liability maturity} = \frac{\text{Current Liabilities}}{\text{Total Liabilities}} \tag{2}$$

$$\text{Liquidity} = \frac{\text{Current Assets}}{\text{Current Liabilities}} \tag{3}$$

$$\text{ROA} = \frac{\text{EBIT}}{\text{Average Total Assets}} \tag{4}$$

$$\text{ROE} = \frac{\text{Net Income}}{\text{Average Equity}} \tag{5}$$

Ratios (1) and (2) are related to the firm's financial structure; ratio (3) analyzes the capacity of companies to deal with their short-term liabilities; and ratios (4) and (5) measure firm performance, either from the total firm perspective, ROA (return on assets, where EBIT is earnings before interest and taxes), or from the shareholders' perspective, ROE (return on equity).

Table 1 summarizes the sample descriptive statistics of the variables under study and some relevant size variables. The average firm has a market capitalization of approximately €49 billion, €64 billion in total assets, and €43 billion in net sales, which is not surprising because the

Table 1
Descriptive statistics of the sample.

	Mean	Median	St. dev.
Market capitalization	48,945.176	36,592.587	35,912.966
Total assets	63,864.232	37,986.590	57,393.664
Net sales	43,380.060	25,961.051	60,665.407
Leverage	0.595	0.595	0.155
Liability maturity	0.485	0.469	0.169
Liquidity	1.259	1.125	0.542
ROA	0.093	0.081	0.067
ROE	0.146	0.141	0.493

Note: Market capitalization, total assets, and net sales are in millions of €; leverage is measured by total liabilities/total assets; liability maturity is measured by current liabilities/total liabilities; liquidity is measured by current assets/current liabilities; ROA is measured by EBIT/average total assets; ROE is measured by net income/average equity; and number of observations is 357.

sample includes the largest listed firms in Europe. Furthermore, these firms are very profitable, with an average ROA of 9.3% and an average ROE of 14.6%. The leverage ratio is approximately 0.6, and liabilities are divided into current and noncurrent nearly equally. The financial position is strong, as the average liquidity ratio is larger than 1.

3.2. Capitalization model

We use the constructive capitalization model to reflect the impact of operating leases on the balance sheet, as this method is the one most frequently used in the literature (Barral et al., 2014; Beattie et al., 1998; Bennett & Bradbury, 2003; Duke et al., 2009; Durocher, 2008; Fitó et al., 2013; Fülbier et al., 2008; Giner & Pardo, 2017; Goodacre, 2003; Mulford & Gram, 2007; Wong & Joshi, 2015). Different from other, simpler, heuristic methods (such as the factor method), this model considers operating leases as finance leases at the time of their inception and produces decreasing lease payments, which is consistent with having several contracts with different lengths, as usually occurs. The factor method, which basically consists of multiplying the current lease expense by a multiplier, has been used in the academic literature to confirm other results only (e.g., Fülbier et al., 2008; Giner & Pardo, 2017) but is frequently used by rating agencies such as Moody's and Standard and Poor's. Although the figures obtained with the factor method could be aligned with the market, they tend to overvalue those figures resulting from the application of the accounting standard; conversely, the constructive method provides lower values for assets and liabilities.

Although, as mentioned earlier, future payment commitments are indicated in the notes to the financial statements, that information must be disaggregated to determine the present value of the annual minimum lease payments per year (*mlp*); to that end, several assumptions regarding each single operating lease contract are stated. Additionally, *mlps* must be discounted to obtain the value of liabilities and leased assets. Unlike heuristic methods, the difference between the lease asset and the liability during the lease term causes a decrease in the equity position and an adjustment of deferred taxes.

Following Imhoff et al. (1991), among others, we consider some general assumptions to apply the constructive method: *(i)* at the inception of each contract, the value of the leased asset is equal to the value of the lease liability as well as the present value of the future lease payments; *(ii)* at the end of the lease, the book values of the asset and the liability are zero; *(iii)* the straight-line method is used to amortize assets; *(iv)* all lease payments are made at year's end; *(v)* lease payments are constant over the lease term; and *(vi)* because the company is a going concern, the operating lease portfolio will be constantly renewed, and so we assume that assets are in the middle of their useful life.

Regarding lease contracts, minimum lease payments must be calculated for each year *t*, *mlp(t)*, for all lease contracts existing in year *y*. Based on sample data and given that firms do not report detailed information of *mlp(t)* for *t > 5* in the notes to the financial statements, the remaining life of lease contracts is obtained by rounding up the result attained by dividing the total future payment reported for *t > 5* by the amount at the fifth year.

Furthermore, we introduce some specific assumptions to operationalize the model. Thus, the remaining life (*RL*) of any contract is 9, which is the average *RL* of the sample under study; regarding the discount rate, as in most previous studies (Beattie et al., 1998; Bennett & Bradbury, 2003; Duke et al., 2009; Wong & Joshi, 2015), we use a fixed rate. Given that the studies by EFRAG (2016), IASB (2016), and Europe Economics (2017) refer to years included in our sample period (in particular, to 2013, 2014, and 2015) and use 5%, we use this value as well; moreover, Giner and Pardo (2017) show that results remain consistent when using company-time-specific rates instead of a 5% fixed rate. However, as a sensitivity analysis, we replicate the study with a 3% discount rate, as in EFRAG (2016) and Europe Economics (2017). Regarding the tax rate, we use the median of the effective tax

rates of the sample (i.e., 23.86%) obtained as the tax expense divided by the earnings before taxes.

Based on the established model, the liability adjustment is:

$$adjustment_L = (mlp(1) \times (1 + i)^{-1}) + (mlp(2) \times (1 + i)^{-2}) + (mlp(3) \times (1 + i)^{-3}) + \dots + (mlp(9) \times (1 + i)^{-9}) \quad (6)$$

where i is the discount rate.

The asset adjustment is:

$$adjustment_A = R \times adjustment_L \quad (7)$$

where R is:

$$R = \frac{RL}{TL} \times \frac{1 - (1 + i)^{-TL}}{1 - (1 + i)^{-RL}} \quad (8)$$

Here, RL is the remaining lifetime of the lease contract, TL is the total life of the lease contract, and $RL = 0.5 \times TL$.

The liability adjustment, net of taxes, is:

$$net_adjustment_L = adjustment_L - (adjustment_L - adjustment_A) \times t, \quad (9)$$

where t is the effective tax rate.

Based on those figures, the current and noncurrent liability adjustments and the equity adjustment are calculated as:

$$net_adjustment_{CL} = (mlp(1) \times (1 + i)^{-1}) - [(mlp(1) \times (1 + i)^{-1}) - R \times (mlp(1) \times (1 + i)^{-1})] \times t, \quad (10)$$

$$net_adjustment_{NCL} = net_adjustment_L - net_adjustment_{CL}, \quad (11)$$

$$adjustment_E = (adjustment_L - adjustment_A) \times (1 - t), \quad (12)$$

The balance sheet figures after capitalizing operating leases are:

$$CA_a = CA_o, \quad (13)$$

$$NCA_a = NCA_o + adjustment_A, \quad (14)$$

$$CL_a = CL_o + net_adjustment_{CL}, \quad (15)$$

$$NCL_a = NCL_o + net_adjustment_{NCL}, \quad (16)$$

$$E_a = E_o - adjustment_E, \quad (17)$$

where CA_o is original current assets, NCA_o is original noncurrent assets, CL_o is original current liabilities, NCL_o is original noncurrent liabilities, and E_o is original equity. After capitalization of the operating leases, CA_a is adjusted current assets, NCA_a is adjusted noncurrent assets, CL_a is adjusted current liabilities, NCL_a is adjusted noncurrent liabilities, and E_a is adjusted equity.

These figures are the components of (1) to (5).

3.3. The Monte Carlo method

Monte Carlo is a computational algorithm that relies on repeated random sampling (Valencia, Smith, & Ang, 2013). It approximates the expected result of the total population by simulating a large new sample based on the performance of real firms; in this way, the result is expected to be closer to the real than that obtained with the historic approach of as-if studies that capitalize only the debt on a limited sample. Every firm generated for the simulated sample derives from the application of the computational algorithm and is known as a run.

Monte Carlo simulation is conceptually very simple compared to other numerical methods and does not require specific knowledge of the form of the solution or its analytic properties. However, it is a slow computational and random numerical method, and it is affected by the distribution of the random variables simulated (Gentle, 2003). It directly simulates the underlying process of the variable of interest and then calculates the average result of the process as:

$$a_m = \frac{1}{r} \sum_{i=1}^r x_i \quad (18)$$

where a_m is the average result of the Monte Carlo method for the variable of interest a , x is the individual result of each simulated observation, and r is the number of simulations (runs). A sufficient number of runs is needed to generate meaningful and reliable results.

In this paper, we perform 11,000,000 runs because, beyond this number, the improvement in the results does not compensate for the computational cost; i.e., to achieve an additional decimal of precision in the answer requires 100 times the number of iterations. In our model, the estimated standard deviations of ratios (1) to (5) are 0.264, 0.122, 1.630, 0.148 and 0.531, respectively.

The Monte Carlo result is a consistent and unbiased estimator because it samples a probability distribution for each variable, which produces millions of possible firms and considers very low probability regions, i.e., rare firms (Glasserman, 2004). Under this method, the average obtained by the simulation process converges to the population average with a speed $\frac{b_m}{\sqrt{r}}$, where b_m is the estimated standard deviation. The estimated variance takes the following form:

$$b_m^2 = \frac{\sum_{i=1}^r (x_i - a_m)^2}{r - 1}. \quad (19)$$

The unknown expected value a lies with probability = 95% in the confidence interval:

$$\left[a_m - \frac{1.96b_m}{\sqrt{r}}, a_m + \frac{1.96b_m}{\sqrt{r}} \right], \quad (20)$$

Although the simulation time horizon spans from 2019 to 2023, 2018 is also simulated as the year of origin to provide necessary data for the first year (2019), given that ratios (4) and (5) involve averages. During the simulation period, contracts could be canceled early, others could expire (when the lifetime ends), and new contracts could be signed. Therefore, different from other studies, our study follows a dynamic approach.

The model has been written and implemented in the calculation software Wolfram Mathematica 11.0.

4. Results and discussion

4.1. Numerical results of Monte Carlo simulation

To estimate the effect of IFRS 16 on the aforementioned financial ratios, simulations of the main accounting figures for the period from 2019 to 2023 are carried out. The minimum lease payments in t for all lease contracts existing in year y ($mlp(t)_y$) are affected each year t by the annual variation $Vmlp(t)$ due to the new contracts and/or cancellations (this value can be negative if cancellations are greater than new contracts, except for $t = RL$). Thus, annual payments are $mlp(t)_y = mlp(t + 1)_{y-1} + Vmlp(t)$. However, for the first year (i.e., 2018), all minimum lease payments in years 7, 8 and 9 are equal to the payments in year 6; and, for the entire period considered, the annual variation of payments in years 7 and 8 is equal to the annual variation of payments in year 6.

The simulation procedure is as follows:

- i) Random variables are generated from the best-fit distributions (see Table 2, Panel A).
- ii) Balance sheet and lease-related variables ($mlp(t)$ and $Vmlp(t)$) are simulated from the equations in Table 2, Panel B, for 2018.
- iii) All cases in which any of the balance sheet and lease-related variables ($mlp(t)$ or $Vmlp(9)$) are negative are deleted.
- iv) For $y > 2018$, $mlps$ are simulated as follows:

Table 2
Monte Carlo simulation procedure

Panel A: Probability distributions fitted to the stochastic variables of the model			
Variable	Probability distribution	Variable	Probability distribution
CA	Mixture [{0.7627, 0.2372}], {Gamma [2.231, 5654.749], Uniform [605.88, 92570.52]}	e ₁₀	Mixture [{0.8944, 0.1055}], {Cauchy [-1.8592, 24.54376], LogNormal [5.1787, 0.7917]}
e ₁	Logistic [-136.961, 2755.486]	e ₁₁	TStudent [54.3261, 34.7809, 0.9187]
e ₂	Mixture [{0.641, 0.359}], {Normal [1759.555, 5707.5003], Normal [19163.357, 18365.317]}	e ₁₂	Mixture [{0.7301, 0.2698}], {Normal [-25.7460, 21.9772], Normal [74.1128, 203.9814]}
e ₃	Mixture [{0.845, 0.154}], {Cauchy [-2031.257, 6400.134], Gamma [4.315, 8109.457]}	e ₁₃	TStudent [-8.6267, 0.4338, 0.3711]
e ₄	TStudent [-107.331, 1120.833, 1.406]	e ₁₄	TStudent [1.8322, 4.6180, 0.778]
e ₅	Mixture [{0.219, 0.7806}], {Normal [1271.0358, 10631.1130], Normal [-314.3649, 1746.5288]}	e ₁₅	TStudent [-23.7401, 46.8783, 1.0059]
e ₆	Cauchy [3.0514, 26.1341]	e ₁₆	TStudent [-10.2339, 11.3516, 0.8417]
e ₇	TStudent [5.2188, 9.664, 0.829]	e ₁₇	Weibull [0.6795, 186.4527, -199.8973]
e ₈	Cauchy [5.6048, 15.6085]	e ₁₈	Mixture [{0.6015, 0.3984}], {Normal [-133.9709, 183.734501], Normal [202.4179, 1132.6557]}
e ₉	TStudent [4.992, 5.795, 0.839]		
Panel B: Equations of OLS regression models			
Dependent variable	OLS Equation	P-value	R ²
CL	1117.67 + (0.816546 * CA) + e ₁	0.004	0.903
NCL	3938.03 + (1.07165 * CL) + e ₂	0.000	0.643
NCA	(33.4747 * (NCL ^{0.718125})) + e ₃	0.000	0.873
E	(CA + NCA) - (CL + NCL)		
NI	573.106 + (0.109552 * E) + e ₄	0.000	0.334
EBIT	2552.22 + (0.765167 * NI) + e ₅	0.000	0.432
mlp(1)	-24.4064 + (0.0317034 * CA) + e ₁₈	0.000	0.389
mlp(2)	(0.684485 * (mlp(1) ^{0.987768})) + e ₆	0.000	0.949
mlp(3)	(0.953904 * (mlp(2) ^{0.994356})) + e ₇	0.000	0.989
mlp(4)	(0.876323 * (mlp(3) ^{1.0034})) + e ₈	0.000	0.981
mlp(5)	(0.900753 * (mlp(4) ^{1.00834})) + e ₉	0.000	0.989
mlp(6)	(0.462814 * (mlp(5) ^{1.06051})) + e ₁₀	0.000	0.737
Vmlp(1)	-80.8699 + (0.551304 * mlp(1)) + e ₁₁	0.000	0.844
Vmlp(2)	28.604 + (0.0751225 * Vmlp(1)) + e ₁₂	0.000	0.149
Vmlp(3)	8.72319 + (0.972717 * Vmlp(2)) + e ₁₃	0.000	0.771
Vmlp(4)	-1.18971 + (0.69368 * Vmlp(3)) + e ₁₄	0.000	0.767
Vmlp(5)	42.6296 + (1.30546 * Vmlp(4)) + e ₁₅	0.000	0.184
Vmlp(6)	7.90459 + (0.125027 * Vmlp(5)) + e ₁₆	0.000	0.112
Vmlp(9)	220.072 + (1.1367 * Vmlp(6)) + e ₁₇	0.000	0.098

Notes: CA is current assets, NCA is noncurrent assets, CL is current liabilities, NCL is noncurrent liabilities, and E is equity. Regarding lease payments, we define *mlp*(*t*)_{*y*} as the minimum lease payments in time *t* for all the lease contracts existing in year *y* and *Vmlp*(*t*) as its annual variation (*mlp*(*t*)_{*y*} = *mlp*(*t* + 1)_{*y*} - 1 + *Vmlp*(*t*)).

$$\begin{aligned}
 mlp(1)_y &= mlp(2)_{y-1} + Vmlp(1), mlp(2)_y = mlp(3)_{y-1} + Vmlp(2), \dots, \\
 mlp(8)_y &= mlp(9)_{y-1} + Vmlp(8), mlp(9)_y = Vmlp(9).
 \end{aligned}
 \tag{21}$$

- v) The constructive capitalization model (i.e., expressions (6) to (17)) is applied to the simulated data.
- vi) Financial ratios (i.e., expressions (1) to (5)) are calculated for each year and for the simulated data before and after the capitalization model is applied.
- vii) To approximate the behavior of our sample for any EU-listed firm, when applying the Monte Carlo method, we limit the simulated sample to an interval that spans the mean plus/minus three standard deviations with data from all listed companies in the EU. Thus, no cases are generated in which the following restrictions are not met: -10 ≤ ROA ≤ 10, -25 ≤ ROE ≤ 25, liquidity ≤ 52, and leverage ≤ 0.989.
- viii) We calculate the arithmetic mean of each ratio for each year and for the simulated data before (IAS 17) and after the capitalization model (IFRS 16) is applied.

From the sample data, we model the accounting figures, the balance sheet groupings (i.e., noncurrent assets, current assets, equity, non-current liabilities, and current liabilities), EBIT, and net income, as well as *mlp*(*t*)_{*y*} and *Vmlp*(*t*). To that end, we use simple linear regression with an ordinary least squares (OLS) approach (see Table 2, Panel B). Using a trial-and-error approach, we set current assets (CA) as the origin

variable because it provides the best fitting results. Note that, in this type of analysis, the R² of the regressions is not especially relevant because the error term of the regression model is the one that acquires special importance, enabling the generation of random variables for every simulated firm (King, Tomz, & Wittenberg, 2000).

Logarithms are taken when errors present heteroscedasticity. However, the hypothesis of error normality does not need to be satisfied, as the stochastic disturbances are simulated according to a probability distribution with high goodness of fit.

All stochastic variables (CA and OLS regression errors) are fitted to a probability distribution. Only nonsignificant different distributions (*p*-value > 0.05), according to Pearson's Chi Square or Cramer-von Mises values are selected. Those aforementioned methods test the null hypothesis that the distribution of the sample data and the proposed theoretical distribution are coincident. We check the five best-fit distributions for each stochastic variable. When two or more theoretical distributions are not significantly different from the distribution of the sample data, we select the distribution with the minimum Akaike Information Criterion (AIC).

After identifying the underlying distributions of the data, distribution parameters are estimated via random sampling with replacement (bootstrap) to ensure the robustness and stability of the estimations (Mitchell & Stafford, 2000; Simar & Wilson, 2000). The distributions fitted to the stochastic variables of the model, as well as the main parameters of the fitting, are presented in Table 2, Panel A.

Table 3, Panel A, includes the simulated ratios and their variations,

Table 3
Evolution of the ratios under the simulated scenarios.

Panel A: Base scenario (ratios and variation)											
Year	Leverage		Liability maturity		Liquidity		ROA		ROE		Var.
	2019–2023 ^a	Var.	2019–2023 ^a	Var.	2019–2023 ^a	Var.	2019–2023 ^a	Var.	2019–2023 ^a	Var.	
2019	0.6657	4.1%	0.3530	-5.3%	1.1880	-12.3%	0.0707	-6.2%	0.1304	-6.2%	4.1%
2020	0.6676	4.4%	0.3566	-4.3%	1.1805	-12.9%	0.0701	-7.0%	0.1304	-7.0%	4.2%
2021	0.6687	4.6%	0.3522	-5.5%	1.1533	-14.9%	0.0695	-7.7%	0.1304	-7.7%	4.1%
2022	0.6693	4.7%	0.3590	-3.7%	1.1587	-14.5%	0.0698	-7.3%	0.1304	-7.3%	4.1%
2023	0.6687	4.6%	0.3596	-3.5%	1.1374	-16.0%	0.0698	-7.3%	0.1304	-7.3%	4.1%

Panel B: Other future scenarios (variation)															
Year	Scenario (i)		Scenario (ii)		Scenario (iii)		Scenario (iv)		ROA		ROE				
	Leverage	Liab. matur.	Liquidity	ROA	ROE	Leverage	Liab. matur.	Liquidity	ROA	ROE					
2019	-4.0%	-12.2%	-12.2%	-6.5%	4.7%	3.2%	-2.3%	-12.4%	-6.0%	3.6%	3.9%	-4.3%	-10.7%	-5.8%	4.1%
2020	-4.0%	-12.8%	-12.8%	-7.1%	4.1%	3.3%	-2.1%	-12.8%	-6.2%	2.3%	4.1%	-4.4%	-11.8%	-6.5%	4.1%
2021	-3.2%	-14.6%	-14.6%	-7.4%	3.4%	3.3%	-1.1%	-14.4%	-6.2%	2.2%	4.2%	-3.9%	-13.4%	-6.7%	3.9%
2022	-2.3%	-15.3%	-15.3%	-7.6%	2.7%	3.3%	0.1%	-15.3%	-6.2%	2.1%	4.4%	-3.9%	-13.5%	-6.9%	3.8%
2023	-0.8%	-16.6%	-16.6%	-7.5%	2.3%	3.1%	1.9%	-16.5%	-6.0%	1.9%	4.2%	-3.7%	-14.2%	-6.6%	3.7%

Percentage variation is measured with respect to the simulation results applying IAS 17 for each scenario.

^a First row presents the simulation results applying IAS 17 (before capitalization); other rows present the simulation results applying IFRS 16 (after capitalization). Var. is the percentage of variation measured with respect to data in the first row for each ratio.

assuming that the application of IFRS 16 will not affect the existing structure of operating lease contracts (base scenario). The first row shows the simulation results for each ratio applying IAS 17 (before operating lease capitalization) as the benchmark; the other rows indicate the results applying IFRS 16 per year and the changes in the ratios with respect to that benchmark. After capitalization, leverage increases by 4.1% in 2019, while liability maturity and liquidity decrease (due to the larger increase in noncurrent liabilities, compared with current ones) by 5.3% and 12.3%, respectively. As for profitability ratios, ROA decreases by 6.2%, while ROE improves by 4.1%. In general, the results are rather stable in the subsequent years, although the reduction in liquidity ratio increases along the period. We also perform a sensitivity analysis using a discount rate of 3%, which provides similar results.

These results are in line with those obtained in other studies. We believe it is useful to compare our results with the most recent papers that consider the European setting; however, given the varied ways ratios are measured, it is not always possible to make comparisons. Unfortunately, the non-academic studies do not provide comparable ratios, and only the IASB (2016) analysis indicates that the increase in total liabilities compared to total assets is 5.4%. In our study, this value is 4.8% (nontabulated data). For leverage, in the Spanish market, Fitó et al. (2013) and Giner and Pardo (2017) obtain an increase in relative terms of 5.4% and 1.28%, respectively, which is in line with our result, i.e., 4.1% (Table 3, Panel A), while in a European setting, Morales-Díaz and Zamora-Ramírez (2018) find a larger increase of 9.28%, which, as they argue, is due to the methodology they employ to estimate future lease payments. Regarding ROA, consistent with our result of -6.2% (Table 3, Panel A), Giner and Pardo (2017) and Fitó et al. (2013) find a reduction of 2.77% and 4.8%, respectively, while Morales-Díaz and Zamora-Ramírez (2018) show an increase of 3.07%. For the change in ROE, Fitó et al. (2013) and Giner and Pardo (2017) show increases of 2.1% and 0.45%, respectively, which are lower than our result of 4.1% (Table 3, Panel A). Fitó et al. (2013) and Giner and Pardo (2017) find a decrease in liquidity of 4.7% and 2.16%, respectively. In our case, this value is 12.3%.

The simulated ratios before and after capitalization are also shown in the two Panels of Fig. 1, where the dashed lines capture the new ratios due to the application of IFRS 16 (after capitalization), and the solid lines show the ratios under IAS 17 (before capitalization).

Unlike other papers, our dynamic approach provides results not only for the year of implementation of IFRS 16 but also for subsequent years, and these results confirm no major changes after the year of implementation. Furthermore, our results are obtained with a large simulated sample that includes 11 million firms that are based on the

performance of real firms. This fact implies a big difference from prior as-if studies, which include only assets and liabilities and are therefore off-balance in the reported financial statements of those companies in the study sample in the year under analysis.

4.2. Other future scenarios

In previous estimations, we assumed that the introduction of IFRS 16 will not affect the structure of operating lease contracts; however, this assumption is the basis of just one possible future scenario. It is quite likely that lessees will renegotiate existing contracts or prepare new contracts under different conditions to reduce the impact of the new standard on the financial statements. The implementation of IFRS 16 might have unintended consequences, as has occurred with other standards (Brüggemann et al., 2013). As discussed earlier, some stakeholders consider that the new standard might affect covenants or compensation bonuses with prominent employees. Thus, the affected companies might be interested in minimizing the impact of the standard.

A survey of UK users and preparers indicated that both groups believed that lease terms would become shorter if operating leases were capitalized, and some preparers argued lease finance would be less attractive (Beattie, Goodacre, & Thomson, 2006). In Deloitte's (2011) study, 40% of respondents thought the new lease standard would lead to shorter-term leases. Europe Economics (2017) concludes that lessees will be incentivized to seek solutions that minimize the value of reported operating leases. Approximately 60% of the interviewees replied they might shorten the new contracts and enter into ones with more variable payments that could be interpreted as services rather than leases (the last two options are not recognized on the balance sheet).

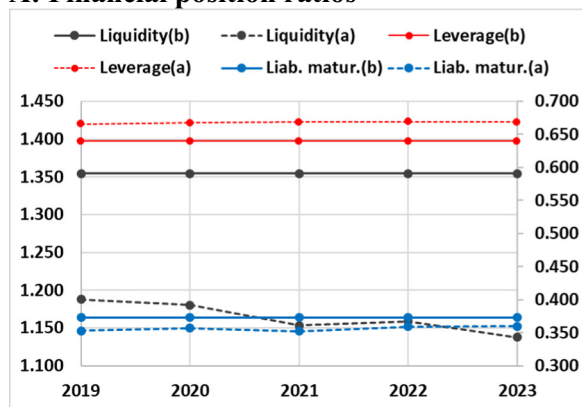
Based on those results, we consider two scenarios that predict shorter contract lives. Under the first scenario (i), we assume that lease contracts will have no payments after 5 years. Mathematically, we define $Vmlp_t(i)$, for $t \geq 5$, the amount of new contracts (in millions of euros) with remaining life t years in scenario (i), as follows:

$$Vmlp_5(i) = Vmlp(5), Vmlp_6(i) = 0, Vmlp_7(i) = 0, Vmlp_8(i) = 0, Vmlp_9(i) = 0, Vmlp_{t \geq 5}(i) \geq 0 \tag{22}$$

In scenario (i), $mlp(t)$ for $t \geq 5$ is defined in Table 4.

Under scenario (ii), in addition to the assumption of scenario (i), we introduce the possibility of renegotiating the remaining life of existing lease contracts. Hence, contracts that previously had a remaining life of 6, 7, 8, and 9 years will be shortened to 5 years. Thus, $mlp(t) = 0$ for $t \geq 6$, and $Vmlp_t(ii)$ for $t \geq 5$, as in expression (22) (see Table 4). Note that, as TL and RL change, Eq. (8) must be reformulated each year in

A: Financial position ratios



B: Profitability ratios

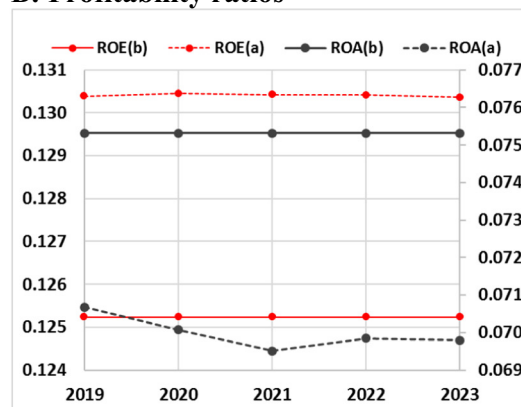


Fig. 1. Results of the Monte Carlo model from 2019 to 2023 for data (b) before and (a) after lease capitalization. Panel A: Liquidity (left axis), Leverage (right axis) and Liability maturity (right axis) ratios. Panel B: Results for financial (ROE, left axis) and economic (ROA, right axis) profitability ratios.

Table 4
Mathematical formulation of $mlp(t)$ in scenarios (i) and (ii).

Year	$mlp(5)$	$mlp(6)$	$mlp(7)$	$mlp(8)$	$mlp(9)$
Scenario (i)					
2019	$mlp(6)_{18} + Vmlp_5(i)$	$mlp(7)_{18}$	$mlp(8)_{18}$	$mlp(9)_{18}$	0
2020	$mlp(6)_{19} + Vmlp_5(i)$	$mlp(7)_{19}$	$mlp(8)_{19}$	0	0
2021	$mlp(6)_{20} + Vmlp_5(i)$	$mlp(7)_{20}$	0	0	0
2022	$mlp(6)_{21} + Vmlp_5(i)$	0	0	0	0
2023	$Vmlp_5(i)$	0	0	0	0
Scenario (ii)					
2019	$mlp(6)_{18} + Vmlp_5(i)$	0	0	0	0
2020, 2021, 2022, 2023	$Vmlp_5(i)$	0	0	0	0

scenarios (i) and (ii).

Furthermore, contract structure could change. Given that, under IFRS 16, variable lease payments are not included in the measurement of lease liability (unless they depend on an index or a rate), firms have an incentive to agree a greater proportion of this payment type in their new lease contracts. In addition, lease contracts less than twelve months are exempt from capitalization, which might cause firms to prefer such contracts. Therefore, we assume two additional scenarios: scenario (iii), in which 20% of the total amount of new contracts will be variable payments, and scenario (iv), in which additionally 20% of the new contracts will be replaced by short-term lease contracts. These scenarios are modeled as follows:

$$Vmlp_{1(iii)} = 0.8 \times Vmlp(1), Vmlp_{2(iii)} = 0.8 \times Vmlp(2), \dots, Vmlp_{9(iii)} = 0.8 \times Vmlp(9), \tag{23}$$

$$Vmlp_{1(iv)} = 0.6 \times Vmlp(1), Vmlp_{2(iv)} = 0.6 \times Vmlp(2), \dots, Vmlp_{9(iv)} = 0.6 \times Vmlp(9). \tag{24}$$

Fig. 2 exhibits the behavior of the three most representative ratios (i.e., leverage, ROA, and ROE) before (with IAS 17) and after lease capitalization for the 5 scenarios. Confidence Intervals (CIs) are calculated with expression (20), but 95% CIs are only represented for the base and (ii) scenarios to allow significant comparisons of the most extreme situations while retaining the clarity of the figure. Note that the width of the CI depends on the standard deviation of the ratio; thus, the CIs for leverage (in Panel A) are almost imperceptible.

Additionally, in Table 3, Panel B, we provide the variation (in percentage) in the five ratios under the four scenarios explained earlier. It is useful to compare these results with the simulation results attained by applying IAS 17 (first row in Table 3, Panel A) and the base scenario (other rows of that panel). Indeed, the new scenarios provide additional results. The leverage ratio increases in all scenarios (significant at 5%), although it remains below that of the base scenario. Furthermore, as Panel B of Table 3 shows, the increase in scenario (ii) is the lowest (approximately 3%), while in the other scenarios, it is approximately 4%. Note that significant differences in ROA and ROE compared with the base scenario are obtained for scenario (ii), since 95% CIs do not overlap with the CIs in the base scenario (Panels B and C in Fig. 2). Thus, with 95% certainty, the differences in ROA and ROE between the base and scenario (ii) are not due to chance and are therefore significant. Table 3, Panel B, shows that the decrease in ROA under scenario (ii), which is approximately 6.2%, is smaller than in the base scenario, in which the reduction reaches 7.7% (Table 3, Panel A), and is very similar to the reduction in scenarios (iii) and (iv). The increase in ROE under scenario (ii) is the lowest, i.e., 3.6% in the first year, but decreases gradually. However, no substantial differences are found in scenarios (iii) and (iv) with respect to the base scenario because the increase in ROE is close to 4% and 95% CIs overlap.

The liability maturity ratio decreases by 5.3% in 2019 in the base scenario; in line with the results above, scenarios (iii) and (iv) do not

provide substantial differences compared to the base scenario (with a decrease in the liability maturity ratio between 4.4% and 2.8%), while scenario (ii) suffers the smallest change, maintaining its value between 0.364 and 0.379 (unreported in the table), close to 0.372 under IAS 17 (Table 3, Panel A). However, the variations in the liquidity ratio under scenario (ii) are very similar to the variations in the base scenario. The other scenarios present differences, but we are not able to realize any pattern that explains them.

In summary, the strategy of reducing the life of all leases to 5 years, which is mainly captured by scenario (ii), minimizes the impact of IFRS 16. Indeed, one could think of another scenario in which companies stop signing operating leases. Depending on the way they finance assets, the impact on the balance sheet and related ratios would differ. Thus, if service contracts replace leases, the existing accounting figures will remain (as if IAS 17 was applied); however, if loans are obtained, the accounting figures will be close to those in the base scenario (with IFRS 16).

5. Conclusions

This paper employed Monte Carlo simulation to capture the impact of implementing the new standard on leases, IFRS 16, which forces companies to include operating leases on the balance sheet, thus increasing assets and related liabilities. Although as-if studies that try to measure the impact of capitalizing such transactions are relatively common, they have adopted a static approach and ascertain the impact in a particular year. The use of a dynamic approach can be seen as a contribution of this paper because, despite the potential usefulness of simulation methods, these methods are not common in accounting research. The method used allows the consideration of complex situations for which data are not available, as happens with the following question: How much will IFRS 16 affect the financial performance of companies? Furthermore, by incorporating the uncertainty of the future in the estimations, we can consider various future scenarios to estimate the impact of IFRS 16.

Our results support the idea that, with the exception of the year the new standard is implemented, key financial ratios will not be additionally impacted if the current structure of lease contracts is maintained. Indeed, in 2019, leverage will increase, the liability maturity and liquidity will decrease, and the impact on profitability ratios will vary. Thus, return on assets will decrease, but return on equity will increase. Moreover, our dynamic approach provides results that are rather consistent across several likely estimation scenarios, through which we consider changes in the contracts to reduce the impact of lease capitalization on the balance sheet. However, we identify significant differences under the strategy of reducing the life of all leases because this strategy will smooth the impact of the new treatment of lease contracts. In this way, we argue that this study could be useful for managers because some stakeholders might be interested in minimizing the impact of IFRS 16. In addition, we claim that this paper is relevant to policy and could be useful in the postimplementation review of the new standard that will occur in 2021.

Before concluding, we want to summarize the implications and contributions of this paper. The results are relevant not only for policymakers, as mentioned above, but also for managers, because they illustrate how several financing strategies might impact the financial position of a company. Furthermore, the new methodology adds value for academics because it offers a new perspective to be used in the accounting domain. Consequently, this paper significantly contributes to literature on the economic consequences of accounting.

This study is not without limitations, however. First, to improve the comparability of results between scenarios and narrow the simulation error, further simulations could be performed with a higher number of runs, but this improvement involves a cost-benefit tradeoff. Second, as in any estimation, this study is subject to a number of assumptions when applying both the constructive method and the Monte Carlo

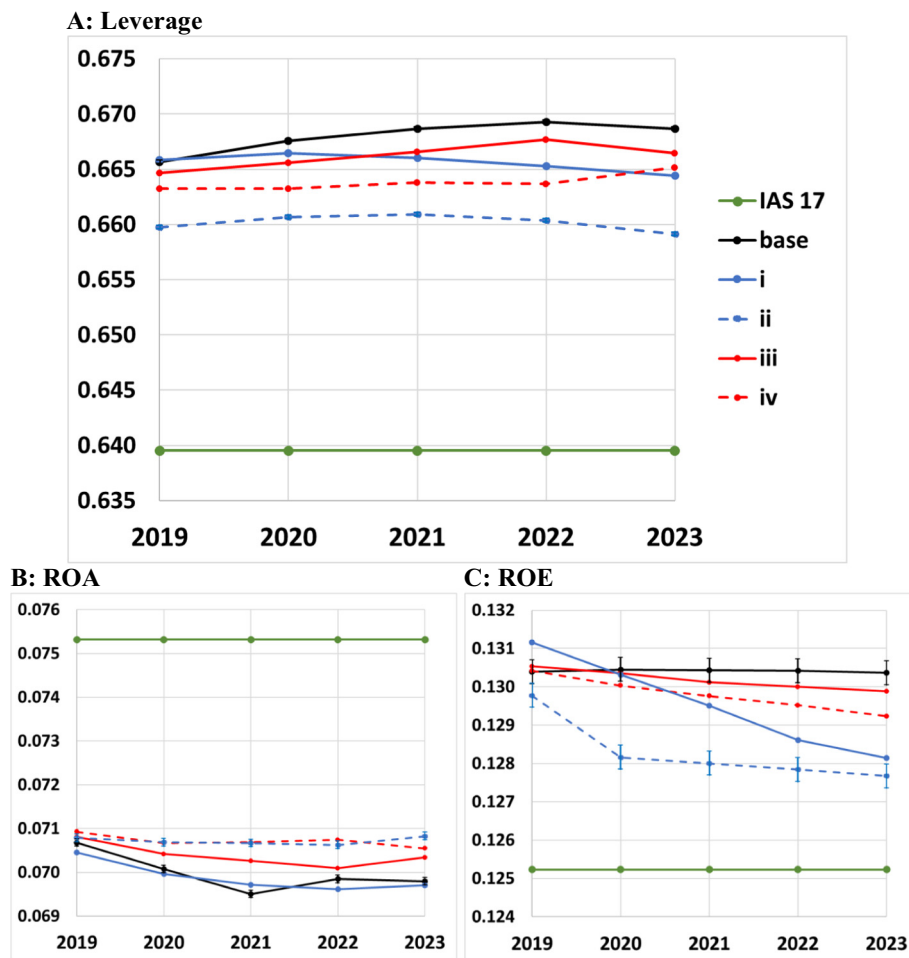


Fig. 2. Annual ratios from 2019 to 2023 before (IAS 17) and after lease capitalization for all scenarios (base, (i), (ii), (iii), and (iv)). The 95% Confidence Intervals (CIs) are represented only for base and (ii) scenarios.

Legend of Panel A applies for Panels B and C. CIs have been calculated with expression (20). Note that the width of the CI depends on the standard deviation of the ratio; thus, the CIs for leverage are almost imperceptible.

method. Finally, the study is based on a specific group of companies, i.e., those included in the STOXX All Europe 100 index, which could be seen as a limitation. Nonetheless, we believe that the results are close to those that could be obtained for similar firms in other contexts.

Declarations of interest

None.

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