Determinants of R&D Value Reporting Bias: An Empirical Study in the EU

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Abstract

This study investigates the determinants of R&D value reporting bias in technology sector entities from six EU countries, including Germany and France, using data from 188 entities between 2006 and 2023. The research employs a mixed-method approach, including Pearson correlations, mixed model regressions, and binary logistic regressions, to analyse the relationships between financial leverage ratios, earnings per share, and the performance of intangible assets. The findings indicate significant correlations between financial structure metrics and the Net Present Value (NPV) ratios of intangible assets, suggesting that higher debt levels relative to assets enhance the performance of internally generated intangibles, while increased debt-to-equity and debt-to-capital ratios have a negative impact. Additionally, the study reveals the influence of regional factors and auditor rank on financial performance, emphasizing the complex interplay between financial metrics and the valuation of intangible assets. These insights contribute to understanding earnings management behaviours and provide practical implications for financial management in R&D-intensive entities.

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Introduction

This article delves into the potential earnings management strategies adopted by managers to enhance the financial stance of R&D intensive entities. As highlighted by various authors, the literature indicates potential biases in R&D reporting. These biases often stem from intentions such as earnings management, misleading representation to stakeholders, securing personal financial gains for managers, or even postponing punitive actions against them (Dinh et al., 2015a; Clausen & Hirth, 2016).

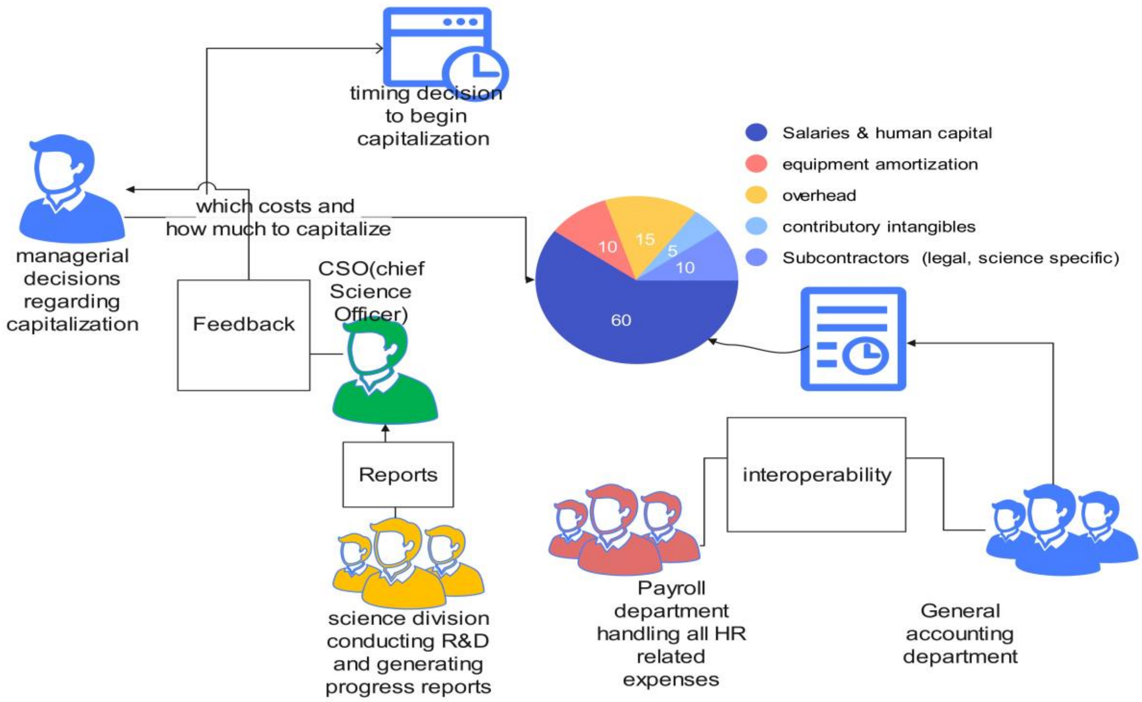
One of the most ambiguous managerial decisions in this context is the capitalisation of development costs. These costs are based on the uncertain estimation of the future economic benefits tied to an intangible asset. There are instances, like the Theranos scandal, that hint at such practices, even if indirectly. The SEC's (2018) report on Theranos alluded to manipulated earnings and false financial performance declarations (Carreyrou, 2018). It's worth noting that such practices aren't confined to private entities like Theranos; public companies, with more stringent disclosure requirements, might also be swayed by the incentives of earnings management.

Capitalisation decisions are intricate and multi-dimensional. Managers must first determine when the criteria for capitalization are met. This pivotal decision marks the transition from research to the development phase of an intangible asset, indicating a high likelihood (>50%) of future economic benefits (IASB, 2022). Following this, managers decide which expense categories are eligible for capitalisation and the proportion of these expenses to be capitalised.

Hunter et al. (2012) shed light on the challenges of segregating expenses tied to different intangibles. Their study with Australian firms revealed that less than 40% of interviewed managers segregated expenses for various intangible types. This underlines the potential for inaccurate or overlapping expenses in capitalisation records. The process demands robust internal controls, information systems, and operational management. Pinpointing specific costs, like salaries or equipment amortization related to a particular intangible, can be complex. However, contemporary IT tools offer solutions to attribute workforce hours and equipment to individual intangible asset development projects. Nonetheless, the decision to initiate the development phase remains largely subjective, influenced by managerial behaviour and incentives, which are harder to quantify.

Figure1 illustrates the complexity of the information flow that the management needs to administrate.

Figure 1
Managerial Decisions and Information Flows



Source: Author's own projection based Hunter et al., 2012

Clearly, the issue of expenditure segregation and expenditure size per capitalised internally generated asset is a matter of internal controls and information systems but also operations management. Every intangible should have a separate ledger registry entry during capitalisation. The difficult part is to identify the portion of the salaries, or equipment amortization attributed to the development of a specific intangible asset (Hunter et al.,2012). These however, are matters that can be solved with the help of modern information technology tools which could assist in attributing workforce hours and equipment on each specific intangible assets' development project. Dinh et al. (2019), point out another aspect of managerial behaviour, that of under investment in regulatory regimes where capitalisation is not permitted.

This article proposes that capitalisation decisions can be informed by the entity's capital structure and metrics such as earnings per share. The empirical research will cover technology sector entities from six EU countries, including Germany and France, EU's two largest economies in terms of gross nominal GDP (Statista, 2024b). Gatchev et al. (2009) found correlations between financing sources and intangible investments. Entities seemed more inclined to raise equity for internal intangible asset investments, especially R&D. This preference for equity financing for R&D, which inherently has higher information asymmetry, can be attributed to the elevated contracting costs associated with debt issuance. As a contrast, their sample consisted of entities using USGAAP, Gatchev et al. (2009) also indicated that the purchased capitalised intangible assets were used as collateral in order to decrease the debt issuance costs. This advantage of capitalisation is presented by Clausen and Hirth (2016), who state that although intangible intensity is associated with more equity and less leverage, patents are an exception because there is evidence that they can be used as collateral; also they serve as an indication of successful R&D in the past. Classic investment theory would suggest that investors on equity are more risk oriented, whereas debt is a more conservative and risk averse investment and treasury bills or government bonds are considered risk free (Vasiliou & Iriotis, 2009).

Higher risks means demand for higher rewards by investors. In this context, equity provides dividend and capital gains from the potential positive price swings. On the other hand equity can go to 0 if the entity fails; additionally dividend distribution is uncertain both in size and time horizon. Also, common equity provides governance options to shareholders, and this is significant for majority equity holders. Alternatively, liabilities take priority in bankruptcy proceedings usually, where they can be backed by assets used as collateral and have stable terms regarding the repayment of the loan, so the repayment is not subject to the entity's earnings or financial success, although in case of financial distress the terms could be renegotiated (Vasiliou & Iriotis, 2009).

The hypothesis presented in this paper posits that there is a significant correlation between the independent variables (e.g., debt/equity, debt/assets, debt/capital, and EPS earnings per share) and the dependent variable (various NPV ratio variants). Specifically, it is hypothesized that for every year x, the net present value (NPV) calculated using cash flows over a rolling five-year period should consistently exceed the capitalized value of the internally generated intangible assets or total intangible assets, always excluding goodwill. This relationship suggests that, values of independent variables, indicating better or worse financial health and performance, would correspond to higher or lower NPV ratios.

The rationale behind this hypothesis is that a consistent performance where the NPV exceeds the capitalized value indicates that the intangible assets are generating sufficient operational cash flows to justify their presence and amount size on the balance sheet. Conversely, if the NPV does not meet or exceed the capitalized value, it may suggest either earnings management or a misjudgment in the initial capitalisation decision. The effectiveness and accuracy of this capitalisation are expressed through the NPV to capitalised value ratio; the higher this ratio is above 1, the more the intangible assets outperform their capitalised value. This analysis aims to determine whether the financial metrics (independent variables) can reliably predict the economic performance of these intangible assets (dependent variable), thus validating their capitalisation.

The hypotheses will be put to the test by conducting a series of tests using SPSS (IBM Corp., 2017). These tests include Pearson correlations, mixed model linear regression tests and Binary Logistic Regressions using dummy versions of the dependent variables. Key independent variables for this study include leverage ratios like debt/equity, debt/assets, debt/capital, earnings per share, and categorical nominal variables such as domicile country development rank (Higher GDP per capita/lower GDP per capita) and auditor rank (Big 4 or other). Various ratio metrics will act as the dependent variables. The overarching aim is to uncover the determinants of biased R&D value reporting, echoing the methodologies outlined by Dinh et al. (2015b).

A critical aspect of this analysis is the use of a rolling five-year period to calculate the net present value (NPV) of operational cash flows attributable to the intangible assets. This method, inspired by techniques used in technical analysis according to Murphy (1999), specifically simple moving averages, allows for a dynamic and continuous assessment of the intangible asset's performance over time. By calculating the NPV for each year using the subsequent five years of operational cash flows, this approach aims to capture the ongoing contribution of the intangible asset to the firm's financial performance.

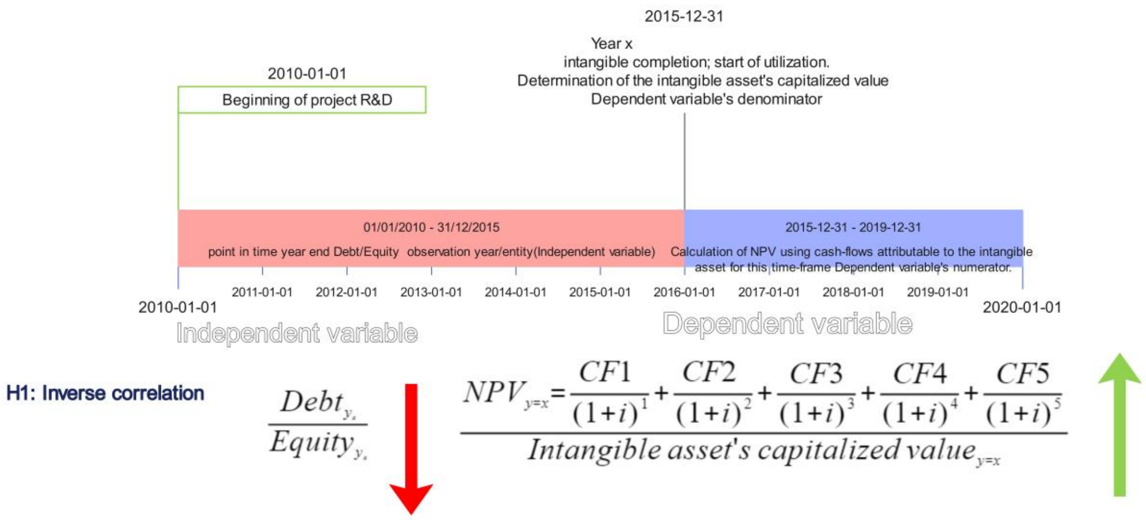
The choice of a five-year time frame is grounded in literature, legal frameworks, and WIPO statistics, all suggesting that the maximum benefits from an intangible asset are typically realised within its initial five years of use (Gong & Wang, 2016; Chan et al., 2001). According to correspondence with WIPO officers the maximum lifetime of a patent is 20 years, but renewal fees are required after year five, and by year 13, less than half of the patents are renewed, indicating the diminishing value of older patents (M. Parker, personal communication April 29, 2021).

Methodology

Description of the Proposed Model and the Variables

The proposed model comprises ratios, where leverage ratios at the end of year x serve as the independent variables. The dependent variable is the ratio of the net present value (NPV) of the operational cash flows over a five-year period, attributed to the specific intangible asset, divided by its capitalized value. The operational cash flows are weighted to reflect the contribution of specific intangible asset configurations, such as (a) internally generated intangibles excluding goodwill, (b) total intangibles (internally generated plus acquired) excluding goodwill, and (c) all assets representing the totality of operational cash flows. The independent variable is representing the intensity of pressure applied on management by outstanding debt and perhaps even the financial health of the entity more broadly and from a leverage perspective more specifically. The dependent variable measures the value generated by the intangible assets at year x from a five year period in comparison with the capitalized value at year x. Figure 2 illustrates the relationship between the two variables under the hypothesis of inverse correlation.

Figure 2
Project Timeline and Variables



Source: Author's own projection

As illustrated in Figure 2, the model presents several key weaknesses and limitations in its implementation. The most significant challenge is determining the starting year, or "year 0," which marks the beginning of the asset's exploitation. A progressive year-by-year calculation helps mitigate this weakness by providing annual snapshots of the intangible assets' performance. However, this method falls short in tracking the performance of individual intangible assets.

It is essential to have a sufficient number of annual periods as a runway for the model, specifically at least five years, to accurately calculate the related net present value (NPV) at the end of each year x. The independent variable, calculated at a specific point in time, poses fewer issues.

Similar challenges were noted by Dinh et al. (2019), where the lack of clarity regarding the initialisation of an intangible asset's use was highlighted. The model used here always makes use of the remaining intangible asset value at the end of year x, assuming the asset is already in use. This assumption is based on the fact that the assets are being amortised on the balance sheet, as confirmed by content analysis. This involves assuming that most development activities have concluded and the assets are not near their end of life by year x. However, during the five-year use period, additions might alter the intangible assets' value. Measuring the impact of these additions is difficult, thus the necessity of the earlier assumptions.

This approach is not ideal or the most reliable, but practical constraints dictate its use. The progressive calculation of the variable year by year aims to track the generated cash flows as accurately as possible. Given that intangible assets, such as software, are often enhanced with additions and upgrades, the model attempts to account for these changes through annual "snapshots." While it cannot precisely attribute these additions to the operational intangible assets, this method mitigates the impact by capturing a progressive view of the assets' performance.

Another limitation of the model is the difficulty in associating the internally generated intangible asset with the correct amount of annual operational cash flows for each of the five years, including the end of year 0. Specifically, isolating the internally generated intangible asset from other contributory assets poses a significant challenge, as does accounting for annual additions to the same intangible asset. Consequently, two types of synergies must be considered: synergies with other assets and synergies from improvements made to the same assets on an annual basis, or both simultaneously. This task is highly complex, given that even the management of the entities often struggles to accurately match the intangible assets' inputs and outputs (Hunter et al., 2012).

To address this issue, the model explores two potential pathways. The first pathway is similar to the premium profit method described by the International Valuation Standards Council (IVSC, 2021). The second pathway involves an adjusted weighted operational cash flow method, which uses the ratio of the annual capitalized value of intangible assets (excluding goodwill) to the total value of non-current assets (excluding goodwill) as a contribution coefficient. Despite these approaches, it is still uncertain that the effects of contributory intangible assets will be entirely excluded.

Therefore, the model includes four variations of the dependent variable. These variations gradually increase the operational cash flows through growing contribution coefficients used in the NPV calculations to incrementally capture the synergies. By doing so, the model aims to represent the minimum value generated solely by the internally generated intangible assets in comparison to the maximum value generated by the entity utilizing all its assets, benchmarked against the value of intangible assets, either internally generated or in total (internally and acquired), always excluding goodwill. This approach acknowledges the inherent difficulty in reliably measuring and isolating synergies, providing a spectrum of values to better understand the intangible assets' contributions.

The first method will not be applied and implemented in the model due to practical implications, although it could be used for specific case studies of entities. This method can be implemented by deducting the operational cash flow of year 0, which is representative of the without scenario, from the operational cash flows of each next year of the five year time-frame, which are representative of the with scenario. Thus the operational cash flows are modified as follows:

Cash flow end of year 1: $Cf_1 - Cf_0 = CF_{inty1}$,

Cash flow end of year 2: $Cf_2 - Cf_0 = CF_{inty2}$,

Cash flow end of year 3: $Cf_3 - Cf_0 = CF_{inty3}$,

Cash flow end of year 4: $Cf_4 - Cf_0 = CF_{inty4}$,

Cash flow end of year 5: $Cf_5 - Cf_0 = CF_{inty5}$.

Where Cf_n the operational cash flow at year 0<n≤5 and $CF_{intyn}$the cash flow attributed to the intangible at year 0<n≤5; $Cf_0$is the without the intangible operational cash flow. This method faces challenges when operational cash flows are negative and also the without value is almost impossible to determine in entities that are public and belong in R&D intensive technology sectors. There is not enough data to practically isolate the effect of specific intangible assets on the operational cash flows. Some specific entities, very few with a small range of products and services and very detailed management reports could be used in a separate case study using this method.

The second method's adjusted operational cash flows are calculated using a form of contribution coefficient calculated like this:

Cash-flow end of year 0: $CF_{Internal0} = \frac{internallygeneratedassets\prime value_{y0} excl.gw}{noncurrentassetvalue - goodwill_{y0}} * opCF_0$,

Cash-flow end of year 1: $CF_{Internal1} = \frac{internallygeneratedassets\prime value_{y1} excl.gw}{noncurrentassetvalue - goodwill_{y1}} * opCF_1$,

Cash-flow end of year 2:$CF_{Internal2} = \frac{internallygeneratedassets\prime value_{y2} excl.gw}{noncurrentassetvalue - goodwill_{y2}} * opCF_2$,

Cash-flow end of year 3:$CF_{Internal3} = \frac{internallygeneratedassets\prime value_{y3} excl.gw}{noncurrentassetvalue - goodwill_{y3}} * opCF_3$,

Cash-flow end of year 4:$CF_{Internal4} = \frac{internallygeneratedassets\prime value_{y4} excl.gw}{noncurrentassetvalue - goodwill_{y4}} * opCF_4$,.

Where $\frac{internallygeneratedintangibleassets\prime value_{yn} excl.gw}{noncurrentassetvalue - goodwill_{yn}} * opCF_n$ is the internally generated intangible assets' value excluding goodwill at the end of year 0≤n≤4 over the total non-current assets' value minus Goodwill at the end of year 0≤n≤4 multiplied by the operational cash flow at the end of year 0≤n≤4. This results in $CF_{Internaln}$which is the operational cash flow attributed to the internally generated intangible assets designated as INTERNAL from now on at the end of year 0≤n≤4; similar ratios have been used as variables by Ciftci & Darrough (2015), namely$\frac{RandD_{yn}}{totalassets_{yn}}$; while Ji (2018) used the book value of intangible assets per share in a regression. The current assets have been excluded from the calculation since their use is for liquidity purposes and their value is reclaimed within one year according to Ginoglou et al. (2005). The contribution coefficient is inspired by the asset weighting methodologies employed in Exchange Traded Products (ETPs) and closed-end funds. This method takes into account more the effect of time on the productivity of the intangible asset compared to the total assets, because as time passes amortization reduces the values of the numerator and the denominator. However, it poses two weaknesses. Firstly, a major addition of internally generated intangibles at any point within the five-year range will cause the operational cash flows of that year to be overstated relative to the actual impact of the internally generated intangible assets for the entity, particularly at the end of year 0.

For example, consider if the internally generated intangible assets' value excluding goodwill over non-current assets' value excluding goodwill is $\frac{internallygeneratedintangibleassets'value_{yn}excl.gw}{non-currentassetvalue-goodwill_{yn}} = \frac{1mil}{3mil}$ from years' 0 to 3 with minor fluctuations and suddenly at the end of year 4 it becomes $\frac{internallygeneratedintangibleassets'value_{yn}}{non-currentassetvalue-goodwill_{yn}} = \frac{3mil}{5mil}$. This sudden increase will cause the operational cash flow attributed to the internally generated intangible assets for the end of year 4 to be miscalculated and overstated. The method will eventually balance out in the next snapshot, correcting the distortion when the coefficient reaches the end of year 4 from year 0 at this specific example. Furthermore, if a major addition of internally generated intangibles occurs, the coefficient will partially compensate due to an equal increase in the denominator, namely the total non-current assets' value minus goodwill.

Secondly, this method assumes that the productivity of any asset's monetary unit is equivalent across all asset types. In other words, it assumes that €1 of buildings is as productive as €1 of equipment or intangible assets, which may not always be true. Additionally, important assets that interact with intangibles, such as human resources, do not appear on the balance sheet.

An asset’s cost or value is not necessarily a true indicator of its productivity (Sarmaniotis, 2000). Factors such as management, effectiveness, and efficiency also play crucial roles in determining an asset’s productivity. However, for the purpose of this model, we assume that these factors remain constant (ceteris paribus) across entities and from year to year. These assumptions are necessary to isolate as much as possible the contribution of intangible assets to the entities’ financial performance without overstating or understating their impact.

As previously mentioned, to address this issue and provide a basis for comparison, variations of the relevant cash flows will be calculated. These variations will be used to adjust the dependent variable in order to observe the synergies and contributions among assets and their impact on the model. The second variation will consider both internally generated and acquired intangibles as a single cash-generating unit. To achieve this, the relevant contribution coefficients and cash flow calculations will be modified as follows:

$$CF_{Totaln} = \frac{acquiredintangibleassets'value_{yn} + internallygeneratedassets'value_{yn} - goodwill}{non-currentassetvalue_{yn} - goodwill_{yn}} * opCF_n$$

where at the corresponding ending year the cash flows are calculated as follows

$$CF_{Total0} = \frac{acquiredintangibleassets'value_{y0} + internallygeneratedassets'value_{y0} - goodwill_{y0}}{non - currentassetvalue_{y0} - goodwill_{y0}} * opCF_0$$

$$CF_{Total1} = \frac{acquiredintangibleassets'value_{y1} + internallygeneratedassets'value_{y1} - goodwill_{y1}}{non - currentassetvalue_{y1} - goodwill_{y1}} * opCF_1$$

$$CF_{Total2} = \frac{acquiredintangibleassets'value_{y2} + internallygeneratedassets'value_{y2} - goodwill_{y2}}{non - currentassetvalue_{y2} - goodwill_{y2}} * opCF_2$$

$$CF_{Total3} = \frac{acquiredintangibleassets'value_{y3} + internallygeneratedassets'value_{y3} - goodwill_{y3}}{non - currentassetvalue_{y3} - goodwill_{y3}} * opCF_3$$

$$CF_{Total4} = \frac{acquiredintangibleassets'value_{y4} + internallygeneratedassets'value_{y4} - goodwill_{y4}}{non - currentassetvalue_{y4} - goodwill_{y4}} * opCF_4$$

For each of the five years the calculation represents the acquired intangible assets' plus internally generated intangible assets' value minus goodwill at year ending 0≤n≤4 over the total non-current assets' value minus Goodwill at year ending 0≤n≤4 multiplied by the operational cash flow at year ending 0≤n≤4 resulting in CF_{Totaln}which is the operational cash flow attributed to the cash generating unit of acquired and internally generated intangible assets designated as Total from now on at year ending 0≤n≤4. The last cash flow calculation variation is using the operational cash flows deriving from the maximum effort of the entity and it acts as the maximum value benchmark; it is expressed like this $operationalCF_n = CF_{MAXEFFORTn}$. The cash flows at each year ending 0≤n≤4 will result as follows:

Cash-flow end of year 0: $operationalCF_0 = CF_{MAXEFFORT0}$

Cash-flow end of year 1: $operationalCF_1 = CF_{MAXEFFORT1}$

Cash-flow end of year 2: $operationalCF_2 = CF_{MAXEFFORT2}$

Cash-flow end of year 3:$operationalCF_3 = CF_{MAXEFFORT3}$

Cash-flow end of year 4:$operationalCF_4 = CF_{MAXEFFORT4}$

The contribution coefficient here equals to 1; in this variation, the net present value calculated using the maximum effort cash flows represents the maximum possible net present value generated by the entity using all the assets at its disposal. The Net present value designated as Maxeffort will be used for dual comparison, once over the internally generated intangible assets' value minus goodwill at year ending 0 to indicate if the maximum net present value recovers the capitalized amount of internally generated assets. As well as, over the acquired intangible assets' plus

internally generated intangible assets' value minus goodwill at year ending 0 to indicate if the maximum net present value recovers the Total value of intangible assets. This will result in the creation of two additional dependent variables. As such the dependent variable variations will be as follows:
Dependent variable variant 1: NPV attributed to internally generated intangible assets excluding goodwill over their value.

$$InternalNPVratio = \frac{NPV_{y=x} = \frac{CF_{internal0}}{(1+i)^1} + \frac{CF_{internal1}}{(1+i)^2} + \frac{CF_{internal2}}{(1+i)^3} + \frac{CF_{internal3}}{(1+i)^4} + \frac{CF_{internal4}}{(1+i)^5}}{InternallyGeneratedIntangibleAssets'Capitalizedvalue_{y=x} - goodwill_{y=x}}$$

Dependent variable variant 2: NPV attributed to internally generated assets and acquired intangible assets excluding goodwill over their value.

$$TotalNPVratio = \frac{NPV_{y=x} = \frac{CF_{Total0}}{(1+i)^1} + \frac{CF_{Total1}}{(1+i)^2} + \frac{CF_{Total2}}{(1+i)^3} + \frac{CF_{Total3}}{(1+i)^4} + \frac{CF_{Total4}}{(1+i)^5}}{acquiredintangibleassets'value_{y=x} + internallygeneratedassets'value_{y=x} - goodwill_{y=x}}$$

Dependent variable variant 3: NPV attributed to all the assets of the entity over the value of internally generated intangible assets excluding goodwill.

$$MaxEffortInternalratio = \frac{NPV_{y=x} = \frac{CF_{maxeffort0}}{(1+i)^1} + \frac{CF_{Maxeffort1}}{(1+i)^2} + \frac{CF_{Maxeffort2}}{(1+i)^3} + \frac{CF_{Maceffort3}}{(1+i)^4} + \frac{CF_{Maxeffort4}}{(1+i)^5}}{InternallyGeneratedIntangibleAssets'Capitalizedvalue_{y=x} - goodwill_{y=x}}$$

Dependent variable variant 4: NPV attributed to all the assets of the entity over the value of internally generated intangible assets excluding goodwill.

$$MaxEffortTotalratio = \frac{NPV_{y=x} = \frac{CF_{Maxeffort0}}{(1+i)^1} + \frac{CF_{Maxeffort1}}{(1+i)^2} + \frac{CF_{Maxeffort2}}{(1+i)^3} + \frac{CF_{Maceffort3}}{(1+i)^4} + \frac{CF_{Maxeffort4}}{(1+i)^5}}{acquiredintangibleassets'value_{y=x} + internallygeneratedassets'value_{y=x} - goodwill_{y=x}}$$

The discount rate used in the NPV component calculations of all dependent variables will be the Weighted Average Cost of Capital (WACC) for each corresponding entity, as provided by Refinitiv (2023) and Alphaspread (2024). Given the high-risk nature of the technology R&D intensive sector to which the sample entities belong, the cost of capital is significant. The average WACC for the entities included in this study is 8.52%. Although WACC can fluctuate over time, for practical reasons, the most recent WACC data has been used, as data prior to 2019 is extremely scarce.

The next step will be to present all the variables, the independent variables are not complex, they comprise mostly of leverage ratios and so their presentation will be brief and due to their simplicity, their calculation will not be detailed.

Table 1, illustrates all the variables according to their measure type and their designation as either independent or dependent:

Table 1
Variable Presentation per Type and Measure

Variable name	Type (dependent or independent)	measure
DEBTTOEQUITY	Independent	scale(continuous)
DEBTTOEQUITYVER2	Independent	scale(continuous)
COUNTRY	Independent	nominal (categorical)
DEVELOPMENT	Independent	nominal (categorical)
AUDITORANK	Independent	nominal (categorical)
ENTITY	Independent	nominal (categorical- attribute)
ActualYearstart	Independent	scale(continuous-attribute)
DEBTTOASSETS	Independent	scale(continuous)
DEBTTOCAPITAL	Independent	scale(continuous)
EPS (Earnings Per Share)	Independent	scale(continuous)
InternalNPVRatio	Dependent	scale(continuous)
TotalNPVRatio	Dependent	scale(continuous)
MaxEffortInternalRatio	Dependent	scale(continuous)
MaxEffortTotalRatio	Dependent	scale(continuous)
Dummy_transformations dependent		
Dummy_InternalNPVRatio	dependent	nominal (binary)
Dummy_MaxEffortInternalRatio	dependent	nominal (binary)
Dummy_TotalNPVRatio	dependent	nominal (binary)
Dummy_MaxEffortTotalRatio	dependent	nominal (binary)
Special (modified) version independent		
Winsorised_EPS (Earnings Per Share)	independent	scale(continuous)

Source: Author's own projection

In this analysis, leverage ratios have been employed as independent variables. These ratios include debt/equity, debt/assets, and debt/capital, sourced from the financial summaries of the entities as provided by Refinitiv (2023). Another significant independent variable taken into account is the EPS (Earnings Per Share). The EPS variable has been winsorised in order to exclude outliers. It's noteworthy that while the data from Refinitiv was comprehensive, there were certain gaps in the reported figures.

The DEBTTOEQUITY variable represents a modified debt-to-equity ratio. Unlike the traditional calculation, which typically focuses on creditor-related liabilities, this tailored ratio incorporates a broader range of obligations, including tax payable and accounts payable. This modification provides a more stringent measure of an entity's financial leverage, offering a more comprehensive view of its financial obligations relative to shareholders' equity.

DEBTTOEQUITYVER2 is the traditional calculation of the debt-to-equity ratio as provided by Refinitiv (2023), focusing on creditor-related liabilities.

The following variables are nominal in measure, Country, Development, Auditorank and Entity.

The COUNTRY attribute categorizes entities based on the country in which they are domiciled. This classification helps analyse the impact of geographic and economic conditions on the financial metrics being studied, offering insights into how regional factors influence financial performance.

DEVELOPMENT is a binary nominal variable that classifies entities based on whether they are domiciled in a higher GDP per capita country or a lower GDP per capita country. With values indicating Higher GDP per capita vs. Lower GDP per capita, this variable helps in understanding the economic context in which the entities operate and its influence on their financial metrics. The classification was made according to the GDP per capita information provided by Statista (2024a). The year/entities from entities domiciled in countries belonging to the top 10 were classified as higher GDP per capita, the others as Lower GDP per capita. Namely, year/entities from entities domiciled in Germany, France and Ireland were classified as higher GDP per capita; On the other hand year/entities from entities domiciled in Cyprus, Greece and Romania were classified as lower GDP per capita.

AUDITORANK is a categorical variable that ranks auditors or auditing firms into three categories: Big 4, Other, and Unknown. This ranking helps assess the impact of auditor reputation and quality on financial outcomes, providing insights into how the stature of the auditing firm influences the financial reporting of entities.

The ENTITY variable is an attribute actually that determines with which entity the case is associated. By distinguishing between individual entities, this variable allows for the analysis of entity-specific characteristics and their effects on the dependent variables.

ACTUALYEARSTART represents the specific year of the observation for each entity, for example, 2007. It is also an attribute; it indicates the year to which the data pertains, providing a temporal reference for the case and helping to track changes and trends over time.

DEBTTOASSETS represents the ratio of a company's total debt to its total assets. This ratio measures the extent to which a company's assets are financed by debt, offering insights into the company's financial structure and risk level by indicating its reliance on borrowed funds. It is retrieved from Refinitiv (2023) according to the financial summary data of each participating entity.

DEBTTOCAPITAL compares a company's total debt to its total capital (long term debt plus equity). This ratio is used to understand the proportion of capital that comes from debt, providing a perspective on the company's leverage and financial stability, and indicating how much of the company's funding is sourced through debt. It is also retrieved from Refinitiv (2023) according to the financial summary data of each participating entity.

EPS, or Earnings Per Share, measures the portion of a company's profit allocated to each outstanding share of common stock. This variable is a crucial indicator of a company's profitability and is widely used by investors to gauge financial performance

and make informed investment decisions. To improve the accuracy of the analysis, EPS has been Winsorized to minimize the effect of outliers. This process involves adjusting extreme values to reduce their impact, thereby providing a more reliable measure of central tendency. The original EPS values were retrieved from Refinitiv (2023) according to the financial summary data of each participating entity.
For the purposes of this study, the dependent variables, mentioned previously, were transformed into Dummy variable versions.

Dummy variables were created to simplify the analysis by categorizing the dependent variables into binary outcomes. The Dummy variable is set to 0 if the value of the dependent variable is less than 1 and set to 1 if the value is greater than 1. This binary classification allows for a more straightforward interpretation of whether the NPV to book value ratio exceeds the threshold of 1, indicating a potentially higher financial performance of the intangibles.

Specifically, Dummy variables were created to categorize the dependent variables into binary outcomes for a more straightforward analysis. The Dummy_InternalNPVRatio is set to 0 if the internal NPV ratio is less than 1 and 1 if it is equal to or greater than 1. Similarly, Dummy_TotalNPVRatio, Dummy_MaxEffortInternalRatio and Dummy_MaxEffortTotalRatio follow the same rule, being set to 0 if their respective ratios are less than 1 and 1 if equal to or greater than 1. These Dummy variables are nominal (binary) and help to provide a simplified interpretation of whether the NPV to book value ratio exceeds the threshold of 1, indicating a potentially higher financial performance of the intangibles.

Sample

As stated by Hunter et al. (2012), better and more detailed registration of inputs and outputs per intangible asset is required; the data scarcity is evident even in publicly traded entities. If the available data was detailed, then robust operational cash flows would be more efficiently attributed to each and every intangible asset on the balance sheet. These issues highlight the importance of the notes to the financial statements and the management's report, if available, of the sample's entities. Consequently the native language in which the financial statements are written is a decisive factor in the attempt to hand pick the data. Sometimes translations can suffer from "semantic divergence" which in the case of the notes to the financial statements might result in significant loss of information. Knowing the native language in which the financial statements are written has affected the origin of the sample's entities to some extent.

The datasets employed in this study were sourced from Eikon Refinitiv (2023), a trusted financial data platform widely recognized for its comprehensive coverage. These datasets encompass a wide array of financial information, meticulously extracted from consolidated financial statements. The dataset includes crucial financial documents such as the balance sheet, income statement, cash flow statement, and financial summary of 270 distinct entities from Germany, France, Greece, Ireland, Cyprus, and Romania. These entities actively operate within diverse sectors, specifically Software & IT services, Technology & Equipment, and Financial Technology (Fintech and Infrastructure), ensuring a focus on R&D-intensive industries with significant intangible assets on their balance sheets.

In order to ensure a robust and insightful analysis, the dataset spans a substantial time frame from the year 2006 to 2023. This time frame has been thoughtfully chosen in consideration of the implementation of International Financial Reporting Standards (IFRS), which became mandatory in most EU countries in 2006 (IASB, 2022). This alignment with international financial reporting standards ensures that the financial information presented adheres to standardised reporting practices, enhancing comparability across the entities and years under examination. A deliberate decision was made to include a minimum of five years of data to ensure statistical reliability and meaningful trend analysis.

The selected datasets serve as the foundation for a comprehensive examination of financial trends and the performance of intangible assets across the specified industries and geographic regions. However, the practical constraints of calculating Net Present Value (NPV) require a five-year runway for subsequent annual cash flows. Therefore, the year/entity observations effectively span from 2006 to 2019 to facilitate this requirement.

To calculate the NPV for a given year, "x", five subsequent annual cash flows were required. As an illustration, for the year 2019 (the last practical year/entity), cash flow data from the years 2019 through 2023 was used. This constraint meant that 2019 was the last feasible year to gather a complete set of five subsequent annual cash flows.

The foundational datasets for the research were sourced from Eikon Refinitiv (2023), a platform esteemed for its extensive and precise financial coverage. Eikon Refinitiv supplies meticulously curated information derived directly from consolidated financial statements. This dataset encompasses essential financial data, including balance sheets, income statements, cash flow statements, and financial summaries for entities from Germany, France, Greece, Ireland, Cyprus, and Romania.

While Eikon Refinitiv is abundant in numerical data, it notably lacks detailed notes to the financial statements and management's reports. These qualitative components, vital for a nuanced understanding of an entity's financial stance and the subtleties of its financial operations, are absent. Moreover, specific data gaps were observed, particularly concerning the 2023 financial reporting period. To supplement these gaps and extract qualitative details, an effort was made to cross-reference the Eikon Refinitiv data with original financial statements from the entities' official websites. This process identified original financial statements for 188 out of the initial 270 entities. This detailed content analysis not only enriched the dataset with the critical notes to the financial statements and management's reports but also filled data inconsistencies for the year 2023.

The sampling employed in this study is a form of non-probability sampling, specifically a combination of convenience sampling and purposive sampling. Convenience sampling was used due to the accessibility of financial data from Refinitiv and the entities' official websites. Purposive sampling was employed to ensure that the selected entities belonged to R&D-intensive sectors and had significant intangible assets reported on their balance sheets (Blaxter et al., 2001). Another factor influencing the selection of entities was the availability of translated financial reports in English. This linguistic facilitation was crucial, as familiar languages enabled better data extraction and ensured more accurate analysis of the financial statements. Entities with financial reports available in English were prioritized to avoid potential misinterpretations due to language barriers.

Table 2 below provides an overview of the entities and their usability after the data filtering process:

Table 2
Entities' Overview

Country	Initial Entities	Unusable-rejected	Usable
Germany	109	30	79
France	108	29	79
Greece	17	2	15
Romania	14	11	3
Cyprus	6	2	4
Ireland	16	8	8
Total	270	82	188

Source: Author's own projection

In summary, of the initial 270 entities, 188 were retained as usable after rejecting non-IFRS entities, entities without sufficient data, or those lacking intangible assets on their balance sheets. The total number of year/entity cases derived from the sample (usable in SPSS) is 1680. This equates to an average of about 8.94 year/entity cases per individual entity.

Descriptive statistics

This section presents the descriptive statistics for the variables used in the study. Descriptive statistics provide a summary of the central tendencies, dispersion, and shape of the dataset's distribution, offering insights into the basic features of the data. The analysis is divided into three main parts: independent scale variables, independent nominal variables, and dependent variables, including both their original and transformed versions. This structured approach allows for a comprehensive understanding of the dataset and sets the foundation for further statistical analysis.

Table 3
Descriptive Statistics of Independent Scale Variables

Statistic	Debt/equity independent	Debt/equity ver2 independent	Year of observation model start scale	Debt/Assets	Debt/Capital	Earnings per share (EPS)	Winsorized EPS
N (valid)	1615	1612	1680	1648	1633	1671	1671
Missing	65	68	0	32	47	9	9
Mean	1.65	0.55	2013.21	0.17	0.27	-4718.27	-0.97
Median	0.95	0.24	2013	0.13	0.19	0.25	0.25
Std. Deviation	5.33	2.49	3.41	0.21	0.71	149014.43	86.34
Range	135.16	62.76	13	2.45	23.46	5871060.2	2538.2
Minimum	0.04	0	2006	0	0	-5870022	-1500
Maximum	135.2	62.76	2019	2.45	23.46	1038.2	1038.20

Source: Author's own projection

The descriptive statistics presented in Table 3 above for the independent scale variables provide a comprehensive overview of their central tendencies, dispersion, and range, offering valuable insights into the financial characteristics of the entities under study. The mean debt to equity ratio is 1.647543, indicating that, on average, the entities have 1.65 units of debt for every unit of equity. This variable exhibits substantial variability, as evidenced by a high standard deviation of 5.3278293 and a range spanning from 0.0400 to 135.2000. Similarly, the alternative debt-to-equity ratio has a mean of 0.545787 and a standard deviation of 2.4942700, with values ranging from 0.0000 to 62.7624, demonstrating significant variation across the dataset.

The year of observation, representing the model start scale, spans from 2006 to 2019, with a mean year of 2013.21 and a median of 2013.00. This distribution ensures a comprehensive temporal coverage for the analysis. The debt-to-assets ratio has a mean of 0.173032 and a standard deviation of 0.2144289, with values ranging from 0.0000 to 2.4503. This indicates that some entities have no debt, while others have debt exceeding their total assets. The debt-to-capital ratio reveals a mean of 0.272344 and a standard deviation of 0.7091123, with a wide range from 0.0000 to 23.4565, highlighting significant disparities in how entities finance their capital.

Earnings per Share (EPS) show a mean of -4718.269916, reflecting large losses in some entities, and an exceptionally high standard deviation of 149014.4261695. The EPS values range dramatically from -5870022.0000 to 1038.2000, indicating extreme outliers within the dataset. After applying winsorization to mitigate the impact of these outliers, the mean EPS is -0.9659, with a standard deviation of 86.26140. The winsorized EPS values are more constrained, ranging from -1500.00 to 1038.20, compared to the original EPS values.

Table 4
Descriptive Statistics of the Independent Nominal Variable "Country"

Country	Frequency	Percent	Valid percent	Cumulative percent
GREECE	125	7.4%	7.4%	7.4%
CYPRUS	23	1.4%	1.4%	8.8%
ROMANIA	5	0.3%	0.3%	9.1%
IRELAND	34	2%	2%	11.1%
GERMANY	811	48.3%	48.3%	59.4%
FRANCE	682	40.6%	40.6%	100%
TOTAL	1680	100%	100%	

Source: Author's own projection

The frequency distribution of the COUNTRY variable reveals the geographic composition of the year/entity cases included in the study. The majority of the cases are from Germany and France, with 48.3% and 40.6% of the total sample, respectively. This significant representation from two of the largest economies in the EU underscores their prominence in the technology and R&D intensive sectors under examination.

Cases from Greece account for 7.4% of the sample, reflecting a moderate level of participation. Ireland contributes 2.0% to the dataset, which aligns with its growing influence in the technology and financial sectors. Cyprus and Romania have smaller representations, with 1.4% and 0.3% respectively, indicating a more limited presence of cases from these countries in the sample.

Overall, the distribution ensures a diverse geographic coverage, allowing for comparative analyses between year/entity cases from different EU countries. The cumulative percentage indicates that after accounting for cases from Germany and France, nearly 90% of the sample is covered. Including cases from Greece, Cyprus, Romania, and Ireland provides additional insights into how entities from various economic backgrounds and regions perform in terms of financial leverage and other key metrics.

Table 5
Descriptive Statistics of the Independent Nominal Variable "Development"

Development category	Frequency	Percent	Valid percent	Cumulative percent
HIGHER GDP/CAPITA	1527	90.9%	90.9%	90.9%
LOWER GDP/CAPITA	153	9.1%	9.1%	100%
TOTAL	1680	100%	100%	

Source: Author's own projection

The frequency distribution for the DEVELOPMENT variable categorises the year/entity cases based on the GDP per capita of the countries where the entities are domiciled. The data shows that a substantial majority, 90.9%, of the cases are from countries with higher GDP per capita. This indicates that most of the entities in the study operate in economically stronger regions, which might influence their financial leverage and performance metrics due to better access to resources and capital.

In contrast, 9.1% of the cases are from countries with lower GDP per capita. This smaller representation highlights the differences in economic environments within the EU and provides an opportunity to compare how entities from these different economic contexts perform.

This categorisation helps in understanding the economic context in which the entities operate. By comparing the financial performance and leverage metrics across these two categories, the analysis can reveal the impact of economic development on the entities' financial health. The cumulative percentage shows that once cases from higher GDP per capita countries are considered, the dataset is almost entirely covered, with the remaining 9.1% representing the lower GDP per capita countries.

Table 6
Descriptive Statistics of the Independent Nominal Variable "Auditorank"

Auditor rank	Frequency	Percent	Valid percent	Cumulative percent
BIG 4	772	46.0%	46.0%	46.0%
Other	786	46.7%	46.7%	92.8%
Unknown	122	7.3%	7.3%	100%
TOTAL	1680	100%	100%	

Source: Author's own projection

The frequency distribution for the AUDITORANK variable categorizes the year/entity cases based on the type of auditor. The data reveals that 46.0% of the cases are audited by one of the Big 4 auditing firms, which include Deloitte, PricewaterhouseCoopers (PwC), Ernst & Young (EY), and KPMG. These firms are renowned for their high standards and rigorous audit processes, often providing a higher level of assurance regarding the accuracy and reliability of financial statements.

Another 46.7% of the cases are audited by other auditing firms. This indicates a nearly equal representation of cases audited by non-Big 4 firms, which might include regional or smaller firms with varying levels of audit quality and standards.

The remaining 7.2% of the cases fall under the UNKNOWN category, where it was not possible to determine the auditor with full certainty. This category highlights the challenges in data collection and the limitations in available information for certain year/entity cases.

The distribution of auditor ranks allows for an analysis of how the type of auditor might impact financial reporting and performance metrics. Entities audited by the Big 4 are often subject to more stringent audit procedures, which could influence their reported financial health and compliance with regulatory standards. The cumulative percentage shows that after accounting for the Big 4 and other auditors, the dataset is almost fully covered, with the UNKNOWN category representing a small portion of the sample.

Table 7
Descriptive Statistics of Dependent Scale Variables

Statistic	Internal NPV Ratio	Total NPV ratio	Max Effort Internal Ratio	Max Effort Total Ratio
N (valid)	787	1652	787	1652
Missing	893	28	893	28
Mean	1.91	2.94	68.68	3.93
Median	1.06	1.37	6.71	4.20
Std. Deviation	5.26	13.80	309.59	473.02
Range	87.12	455.11	4465.01	17457.44
Minimum	-24.76	-231.04	-445.15	-16287.77
Maximum	62.36	224.07	4019.86	1169.67

Source: Author's own projection

The descriptive statistics for the scale dependent variables, which are ratios of Net Present Value (NPV) over the book value of intangibles, provide critical insights into the financial performance of the entities under study.

For the InternalNPVRatio, the mean value is 1.91, indicating that, on average, the internal NPV is about 1.91 times the book value of intangibles. However, this variable shows substantial variability with a standard deviation of 5.26. The range of values extends from -24.76 to 62.36, reflecting the outliers and variability in the dataset.

The TotalNPVRatio has a mean of 1.37, suggesting a higher average ratio compared to the internal NPV. This variable also exhibits a higher standard deviation of 13.80, indicating extreme variability. The range from -231.04 to 224.07 underscores the presence of extreme values with almost equal distance from 0.

For the MaxEffortInternalRatio, the mean is substantially higher at 68.68, with a standard deviation of 309.59. This suggests that when considering maximum effort, the internal NPV can vary widely, with values ranging from -445.15 to 4019.86. The high variability and extreme values highlight the significant fluctuations in the financial performance of intangibles under maximum effort scenarios.

Lastly, the MaxEffortTotalRatio has a mean of 3.93 and a standard deviation of 473.02. The range of values is the broadest, extending from -16287.77 to 1169.67. This extreme variability indicates that under maximum effort conditions, the total NPV can fluctuate dramatically, reflecting diverse outcomes in the entities' financial performance.

These statistics highlight the substantial variability and presence of outliers in the dataset, which will be further addressed through transformations and binary categorization in the subsequent analyses.

Table 8
Descriptive Statistics for Dependent Binary Dummy Version Variables

Statistic	Dummy Internal NPV Ratio	Dummy Max Effort Internal Ratio	Dummy Total NPV ratio	Dummy Max Effort Total Ratio
N (valid)	787	787	1655	1655
Missing	896	896	28	28
Mode	1.00	1.00	1.00	1.00
Range	1.00	1.00	1.00	1.00
Minimum	0.00	0.00	0.00	0.00
Maximum	1.00	1.00	1.00	1.00

Source: Author's own projection

The descriptive statistics for the dummy transformed dependent variables provide a binary classification of the original scale variables, where a value of 0 indicates that the scale dependent variable is less than 1, and a value of 1 indicates that it is greater than 1. This transformation simplifies the interpretation of the data by categorizing it into two distinct groups, facilitating easier comparison and analysis.

For the InternalNPVRatio Dummy Version, the mode is 1.00, indicating that the majority of the valid cases have a ratio greater than 1. This suggests that most entities have an internal NPV that exceeds the book value of their intangibles. The range, minimum, and maximum values are consistent with a binary variable, spanning from 0.00 to 1.00.

The MaxEffortInternalRatio Dummy Version also has a mode of 1.00, reflecting a similar pattern where most cases exhibit a maximum effort internal NPV ratio greater than 1. The binary nature of this variable is further confirmed by its range, minimum, and maximum values.

For the TotalNPVRatio Dummy Version, the mode is again 1.00, indicating that most cases have a total NPV ratio greater than 1. This suggests that the overall financial performance, when considering all intangible assets, generally exceeds the book value of the intangibles.

Lastly, the MaxEffortTotalRatio Dummy Version follows the same trend, with a mode of 1.00, highlighting that the majority of cases have a maximum effort total NPV ratio greater than 1. This indicates that, under maximum effort scenarios, the total NPV typically surpasses the book value of the intangibles.

These dummy variables provide a simplified yet powerful way to analyse the data, enabling straightforward comparisons between entities with different levels of financial performance relative to their intangible assets. The presence of missing values, particularly for the InternalNPVRatio and MaxEffortInternalRatio dummy versions, should be noted, as it may impact the overall analysis.

Table 9
Frequency Distribution for Dummy InternalNPVRatio

Dummy Internal NPV Ratio	Frequency	Percent	Valid Percent	Cumulative Percent
0.00	376	22.4%	47.8%	47.8%
1.00	411	24.5%	52.2%	100%
Total (Valid)	787	46.8%	100%	
Missing (System)	893	53.2%		
Total	1680	100%		

Source: Author's own projection

The frequency distribution for the Dummy InternalNPVRatio categorizes the year/entity cases into two groups based on whether the internal NPV ratio is less than or greater than 1. Out of the 787 valid cases, 376 cases (47.8%) have an internal NPV ratio less than 1, indicated by the value 0. This implies that for nearly half of the valid cases, the internal NPV does not exceed the book value of the intangibles.

Conversely, 411 cases (52.2%) have an internal NPV ratio greater than 1, indicated by the value 1. This suggests that for the majority of the valid cases, the internal NPV surpasses the book value of the intangibles, reflecting a higher financial performance of the internal intangible assets.

It is also noteworthy that there are 893 missing cases, accounting for 53.2% of the total sample. This substantial amount of missing data may impact the robustness of the analysis and should be taken into consideration when interpreting the results. However, this is an indication of both lack of capitalisation of intangibles or inability to segregate them from the other intangibles on the balance sheet.

Table 10
Frequency Distribution for Dummy MaxEffortInternalNPVRatio

Dummy Max Effort Internal NPV Ratio	Frequency	Percent	Valid Percent	Cumulative Percent
0.00	172	10.2%	21.9%	21.9%
1.00	615	36.6%	78.1%	100%
Total (Valid)	787	46.8%	100%	
Missing (System)	893	53.2%		
Total	1680	100%		

Source: Author's own projection

The frequency distribution for the Dummy MaxEffortInternalNPVRatio categorizes the year/entity cases into two groups based on whether the maximum effort internal NPV ratio is less than or greater than 1. Out of the 787 valid cases, 172 cases (21.9%) have a maximum effort internal NPV ratio less than 1, indicated by the value 0. This suggests that in about one-fifth of the valid cases, the maximum effort internal NPV does not exceed the book value of the intangibles.

Conversely, 615 cases (78.1%) have a maximum effort internal NPV ratio greater than 1, indicated by the value 1. This indicates that for the majority of the valid cases, the maximum effort internal NPV surpasses the book value of the internally generated intangibles, reflecting a higher financial performance of the internal intangible assets under maximum effort conditions.

It is particularly troubling that in some cases, even the NPV generated by the maximum effort of the entity at specific year/entities is unable to justify the capitalised value of the intangibles. This indicates that despite the best efforts and optimal conditions, the internal NPV fails to match or exceed the book value of the intangibles, raising concerns about the valuation and performance of these assets.

Similar to the previous variable, there are 893 missing cases, accounting for 53.2% of the total sample. The presence of this substantial amount of missing data due to lack of capitalisation of intangibles or inability to segregate them from the other intangibles on the balance sheet.

Table 11
Frequency Distribution for Dummy TotalRatio

Dummy Total NPV Ratio	Frequency	Percent	Valid Percent	Cumulative Percent
0.00	700	41.7%	42.4%	42.3%
1.00	952	56.7%	57.6%	100%
Total (Valid)	1652	98.3%	100%	
Missing (System)	28	1.7%		
Total	1680	100%		

Source: Author's own projection

The frequency distribution for the Dummy TotalRatio categorizes the year/entity cases based on whether the total NPV ratio is less than or greater than 1. Out of the 1652 valid cases, 700 cases (42.4%) have a total NPV ratio less than 1, indicated by the value 0. This suggests that for a significant portion of the valid cases, the total NPV does not exceed the book value of the intangibles.

Conversely, 952 cases (57.6%) have a total NPV ratio greater than 1, indicated by the value 1. This indicates that for the majority of the valid cases, the total NPV surpasses the book value of the intangibles, reflecting a higher overall financial performance when considering all intangible assets.

Additionally, there are 28 missing cases, accounting for 1.7% of the total sample. This low number of missing values is primarily because this variable encompasses the entire value of intangibles, excluding Goodwill, as reported on the balance sheet. Unlike variables that require the segregation of internally generated intangible assets, the TotalNPVRatio considers the combined value of all intangibles. Consequently, the comprehensive nature of this variable reduces the incidence of missing data, facilitating a more robust and complete analysis.

Table 12
Frequency Distribution for Dummy MaxEffortTotalRatio

Dummy Max Effort Total NPV Ratio	Frequency	Percent	Valid Percent	Cumulative Percent
0.00	375	22.3%	22.7%	22.7%
1.00	1277	76.0%	77.3%	100%
Total (Valid)	1652	98.3%	100%	
Missing (System)	28	1.7%		
Total	1680	100%		

Source: Author's own projection

The frequency distribution for the Dummy MaxEffortTotalRatio categorizes the year/entity cases based on whether the maximum effort total NPV ratio is less than or greater than 1. Out of the 1655 valid cases, 375 cases (22.3%) have a maximum effort total NPV ratio less than 1, indicated by the value 0. This suggests that in about one-fifth of the valid cases, the total NPV generated under maximum effort conditions does not exceed the book value of the intangibles.

Conversely, 1277 cases (77.3%) have a maximum effort total NPV ratio greater than 1, indicated by the value 1. This indicates that for the vast majority of the valid cases, the total NPV under maximum effort conditions surpasses the book value of the intangibles, reflecting a higher overall financial performance when considering all assets.

It is concerning that in some cases, even under maximum effort scenarios, the NPV generated fails to justify the capitalised value of the intangibles. This highlights potential issues in the valuation and performance of these assets, suggesting that the reported book values may not always be supported by the generated NPVs, even under optimal conditions.

The missing values for the Dummy MaxEffortTotalRatio are relatively few, with only 28 out of 1680 cases (1.7%) being missing. This low number of missing values is primarily because this variable encompasses the entire value of intangibles, excluding Goodwill, as reported on the balance sheet. Unlike variables that require the segregation of internally generated intangible assets, the MaxEffortTotalRatio considers the combined value of all intangibles.

Results

This section presents the empirical results of the analysis conducted to investigate potential earnings management behavior in R&D intensive entities or overvaluation of intangible assets. Initially, correlations between key variables are explored. Following this, regressions using scale and dummy versions of the dependent variables are conducted to delve deeper into the relationships identified. This section contains the following types of statistical analysis tests:

1. Correlations. Pearson's Correlation analysis is used to measure the strength and direction of the linear relationship between two variables. This helps identify whether there is a significant association between variables and the extent of this association.

2. Mixed model linear Regressions using scale dependent variables and Binary Logistic regressions using the Dummy versions of the dependent variables. Mixed model regressions are employed to account for both fixed and random effects, providing a more nuanced understanding of the relationships between variables. This

approach is particularly useful when dealing with hierarchical or grouped data. The use of scale dependent variables allows for the examination of continuous outcomes. Binary logistic regressions, on the other hand, are used for predicting binary outcomes, such as the dummy versions of the dependent variables, which classify the data into two categories (e.g., greater than 1 or less than 1). This method is essential for understanding how different factors influence the probability of a particular outcome occurring.

This structure aims to provide a clear and logical flow to the presentation of results, facilitating a comprehensive understanding of the empirical findings and their implications.

The following table contains the correlations between the variables in scale measure.

Table 13
Correlations

Independent variable		Dependent variables			
		InternalNPVRatio	TotalNPVRatio	MaxEffortInternalRatio	MaxEffort TotalRatio
Debt/equity ver2	Pearson Correlation	-0.071	0.23	-0.021	-0.007
	Significance. (2-tailed)	0.05*	366	0.559	0.789
	N	761	1584	761	1584
Debt/Assets	Pearson Correlation	0.126	-0.036	-0.017	-0.031
	Significance. (2-tailed)	0.00**	0.143	0.630	0.216
	N	772	1620	772	1620
Debt/Capital	Pearson Correlation	-0.113	-0.017	-0.023	-0.016
	Significance. (2-tailed)	0.002**	0.486	0.522	0.525
	N	765	1605	765	1605
Winsorized EPS	Pearson Correlation	0.127	0.028	0.019	0.006
	Significance. (2-tailed)	0.000**	0.254	0.599	0.796
	N	782	1643	782	1643

Note[1]: *Statistically significant at the 0.05 level
Note[2]: **Statistically significant at the 0.01 level
Source: Author's own projection

The correlations do not account for the temporal effects and the variability of entities included in the sample, as each year/entity is treated equally. Among all the dependent variables, only the internal NPV ratio variable shows significant correlations with all the independent variables. The correlations are detailed as follows: The Pearson correlation coefficient is -0.071 for the Debt/equity ver2, indicating a weak negative correlation. The significance level is 0.050*, which is just at the threshold of statistical significance. For the Debt/Assets variable, the Pearson correlation coefficient is 0.126, indicating a weak positive correlation. The significance level is 0.000**, indicating a highly significant correlation. For Debt/Capital the Pearson correlation coefficient is -0.113, indicating a weak negative correlation. The significance level is 0.002**, indicating again a highly significant correlation. Finally, for the only non-leverage ratio, winsorized EPS; the Pearson correlation coefficient is 0.127, indicating a weak positive correlation. The significance level is 0.000**, also indicating a highly significant correlation.

It is important to note that correlation does not imply causation; however, these correlations can provide insights into the probable factors influencing these relationships (Karapistolis, 2001). Given that all the variables are ratios, the moving parts include two numerators and two denominators for each correlation. This approach allows for reasoned assumptions about how these ratios move. For instance, according to the inverse relationship between Debt/Equity ver 2 if an entity is more financed by debt instead of equity, thus the debt/equity ratio rising, it might be inferred that the internally generated intangible assets perform worse in comparison to their capitalised value. By examining these relationships, a better understanding of the dynamics at play is gained, even though the exact causal mechanisms remain to be further investigated.

Debt to assets has a significant but weak positive correlation to the internalNPV ratio which is reasonable since the denominator of both the independent and the dependent variable have an identical component which is the capitalised value of the intangible assets. The more the entities' assets, all assets, are financed by debt the better the performance of the internally generated assets. The last leverage ratio, debt to capital is negatively correlated to the dependent variable internalNPV ratio, which is reasonable since it has similar composition as the Debt/Equity ver 2 independent variable, only difference is the additional long term debt on the denominator. In summary, the correlations showed that from a capital structure point increased debt in relation to equity and capital has a negative impact on the internally generated intangible asset's performance, although weak. Increased leverage in relation to the total amount of assets has a positive impact on the internally generated intangible asset's performance. However, it is difficult to identify if the leverage affects the cash flows used to calculate the NPV attributed to the internally generated assets or if it impacts the capitalised development amounts.

The last correlated independent variable is the winsorised EPS, which is the only non-leverage ratio used as an independent variable. The correlation is positive but weak, yet in this correlation direct significant assumptions and educated guesses can be made concerning the dependent variable. Evidently, in case of extreme earnings management the EPS would rise but the correlation with the dependent variable would be negative since a large amount of development cost would be capitalised without meeting the requirements of IAS 38 causing the dependent variable's denominator to increase, while related operational cash flows would decrease thus reducing the internalNPV ratio.

In summary, the correlation analysis reveals significant relationships between the internal NPV ratio and all the independent variables, indicating that financial leverage and profitability metrics are associated with the performance of internally generated intangible assets. While these correlations provide valuable insights, it is crucial to remember that they do not establish causation. The observed relationships highlight the need for further investigation into the underlying mechanisms driving these associations. Future analyses should consider the temporal effects and variability among entities to deepen the understanding of these dynamics. Overall, these findings underscore the complex interplay between financial structures and the valuation of intangible assets in R&D-intensive entities, setting the stage for more comprehensive regression analyses.

Mixed model regressions

To further explore the relationships between the independent variables and the performance metrics of intangible assets, mixed model regressions will be conducted. This analysis will be performed separately for each of the four dependent variables: InternalNPVRatio, TotalNPVRatio, MaxEffortInternalRatio, and MaxEffortTotalRatio.

The linear mixed model is particularly well-suited for this analysis as it allows for the inclusion of both fixed effects, which are consistent across all entities, and random effects, which vary across entities. This approach accounts for the hierarchical structure of the data, where multiple observations are nested within entities over time. In this model, the entity will be set as the subject variable to account for variations between different entities, while the model year start will be treated as a repeated measure to capture the temporal effects within each entity. By incorporating these factors, the mixed model regression provides a more comprehensive understanding of the underlying dynamics and interactions between the variables, offering insights that are not apparent through simple correlation analysis. Table 14 below presents the results of the mixed model linear regressions.

Table 14
Mixed model linear regressions

Independent variable		Dependent variables			
		InternalNPVRatio	TotalNPVRatio	MaxEffortInternalRatio	MaxEffortTotalRatio
Scale continuous	Akaike's information criterion (AIC)	4329,14	12964,23	9982,27	20506,04
Debt/equity ver2	Estimate of fixed effect	-0.05	0,32	-1,20	1,21
	Significance. (2-tailed)	0.321	0.00**	0,679	0,428
Debt/Assets	Estimate of fixed effect	2,74	0,78	-3,63	-5,75
	Significance. (2-tailed)	0.00**	0,54	0,874	0,582
Debt/Capital	Estimate of fixed effect	-3,60	-5,55	6,77	-44,75
	Significance. (2-tailed)	0.000**	0.00**	0,813	0.00**
Winsorized EPS	Estimate of fixed effect	0.006	0,001	0,002	0,01
	Significance. (2-tailed)	0.000**	0,65	0,962	0,602
Nominal categorial					
Development	Estimate of fixed effect	Not applicable	Not applicable	Not applicable	Not applicable
	Significance. (2-tailed)	-	-	-	-
Country	Estimate of fixed effect	Not applicable	Not applicable	Reference Country France	Not applicable
	Significance. (2-tailed)	0,466	0,464	0.000**	0,344
Auditor rank	Estimate of fixed effect	Not applicable	Big 4 Auditors or other = higher TotalNPV ratio	Not applicable	Not applicable
	Significance. (2-tailed)	0,674	0,049*	0,335	0,355

Note[1]: *Statistically significant at the 0.05 level
Note[2]: **Statistically significant at the 0.01 level

Source: Author's own projection

In regards to the InternalNPVRatio dependent variable, the analysis indicates that among the financial metrics, the debt-to-assets ratio, debt-to-capital ratio, and Winsorized EPS are significant predictors of the InternalNPVRatio. Higher debt relative to assets and higher earnings per share are associated with better performance of internally generated intangible assets, whereas a higher debt-to-capital ratio is associated with poorer performance. These findings highlight the importance of financial structure in determining the value and performance of intangible assets in R&D-intensive entities.

Regarding the TotalNPV ratio dependent variable, the analysis shows that the auditor rank, debt-to-equity ratio (version 2), and debt-to-capital ratio are significant predictors of the TotalNPVRatio. Entities audited by higher-ranked auditors and those with higher debt-to-equity ratios tend to have higher TotalNPVRatios. Conversely, a higher debt-to-capital ratio is associated with lower TotalNPVRatios. The reference category for auditor rank is the unknown auditors, so the result is difficult to interpret accurately. Also It is controversial that debt-equity ver2 and debt-capital have adverse effects on the TotalNPV ratio given their proximity.

In reference to the Max effort internal ratio, the analysis indicates that the country of the entity is a significant predictor of the MaxEffortInternalRatio, with Germany showing a particularly strong positive effect in relation to the reference country, France. This suggests that entities in Germany are able to generate a higher max effort internal ratio compared to France which is the reference country. However, other variables such as development status, auditor rank, financial leverage ratios, and Winsorized EPS do not significantly affect the MaxEffortInternalRatio. These findings highlight the potential importance of regional factors in influencing the performance of internally generated intangible assets.

Lastly the analysis for the last dependent variable MaxEffortTotalRatio indicates that the debt-to-capital ratio is a significant predictor of the MaxEffortTotalRatio, with higher debt-to-capital ratios being associated with lower maximum asset performance over total intangible assets. These findings suggest that financial structure and regional factors can influence the overall effort applied to leveraging intangible assets. Other variables, including development status, auditor rank, debt-to-equity ratio, debt-to-assets ratio, and Winsorized EPS, do not significantly affect the MaxEffortTotalRatio in this model.

These findings underscore the importance of considering geographic and regional factors when evaluating the performance of internally generated intangible assets.

The mixed model linear regression analyses conducted across different dependent variables provide valuable insights into the factors influencing the financial performance of intangible assets in R&D-intensive entities. This comprehensive approach, which includes the analysis of both scale continuous and nominal categorical variables, offers a nuanced understanding of the relationships at play.

The results reveal significant findings for several independent variables. Specifically, the debt-to-capital ratio consistently emerges as a significant predictor across multiple models. For instance, it negatively impacts the InternalNPVRatio, TotalNPVRatio, and MaxEffortTotalRatio, showing highly significant effects ($p < 0.001$). This underscores the critical role of financial leverage in determining the performance and efficiency of intangible assets.

Debt/Assets also shows a significant positive effect on InternalNPVRatio ($p < 0.001$), suggesting that higher debt levels relative to assets can enhance the performance of internally generated intangible assets. However, its effects on other dependent variables were not significant, indicating that this relationship may be more complex and context-specific.

Winsorized EPS, as an indicator of profitability, demonstrates a significant positive effect on InternalNPVRatio ($p < 0.001$), indicating that higher earnings per share are associated with better performance of internally generated intangible assets. However, its impact on other dependent variables was not statistically significant, suggesting that profitability may not directly influence the broader measures of maximum effort over total intangible assets performance.

Country-specific effects are particularly notable for MaxEffortInternalRatio, where Germany (Country 5) shows a significant positive effect ($p < 0.001$), indicating that entities in Germany are more effective in leveraging their internally generated intangible assets compared to those in the reference country, France. This highlights the influence of regional factors and the potential advantages of the German industrial and innovation environment.

Auditor rank also plays a significant role in influencing the TotalNPVRatio, with Big 4 auditors or other high-ranking auditors associated with higher ratios ($p < 0.05$). This suggests that the quality and reputation of the auditing firm can positively impact the financial reporting and perceived value of intangible assets.

Additionally, the Akaike's Information Criterion (AIC) was used to rank the models based on their quality. Among the models, the one for InternalNPVRatio had the lowest AIC value (4329.14), indicating the best fit among the tested models, followed by the MaxEffortInternalRatio (9982.27), TotalNPVRatio (12964.23) and MaxEffortTotalRatio (20506.04). This ranking suggests that the model explaining InternalNPVRatio is the most robust in terms of predictive accuracy and goodness of fit.

In summary, the analyses highlight the multifaceted nature of financial performance in R&D-intensive entities, where factors such as financial leverage, profitability, regional context, and auditor quality interplay to shape the outcomes. These findings provide a robust foundation for further research and offer practical implications for financial management and policy-making in the context of intangible assets.

Binary logistic regressions

This section introduces the binary logistic regression analyses conducted to further investigate the determinants of financial performance related to intangible assets. Binary logistic regressions are particularly well-suited for this analysis as they are designed to handle dependent variables that are categorical and binary in nature. In this case, the dummy versions of the dependent variables are used, where each variable is coded as either 0 or 1. This transformation allows the examination of the likelihood of a specific outcome occurring (i.e., whether the dependent variable exceeds a certain threshold).

The binary logistic regression approach is ideal for modelling situations where the dependent variable represents a binary decision or outcome. For instance, it can help in understanding the factors that increase the probability of an entity's Net Present Value (NPV) ratio surpassing 1, indicating a higher performance relative to its book value of intangibles. By focusing on the binary outcomes, this method simplifies the interpretation of results and highlights the key predictors driving these significant financial thresholds.

Through this analysis, the aim is to identify and quantify the impact of various independent variables, including financial ratios, country of origin, and auditor rank, on the likelihood of achieving higher performance levels. The results of these binary logistic regressions will then be compared to those obtained from the mixed model regressions to provide a comprehensive understanding of the factors influencing the financial performance of intangible assets across different modelling approaches. This comparative analysis will enhance the robustness of our findings and offer deeper insights into the dynamics at play.

Table 15
Binary Logistic Regressions

Independent variable		Dependent variables			
		Dummy InternalNPVRatio	Dummy TotalNPVRatio	Dummy MaxEffortInternalRatio	Dummy MaxEffortTotalRatio
Scale continuous	Hosner & Lemeshow test	0.118 (good fit)	0.463 (good fit)	0.012 (not good fit)	0.043 (not good fit)
	Predictability %	59.8%	59.3%	79.4%	79.7%
Debt/equity ver2	(B)	-0.074	0.004	-0.124	-0.028
	Significance. (2-tailed)	0.51	0.84	0.192	0.201
Debt/Assets	(B)	1.01	0.22	5.586	1.768
	Significance. (2-tailed)	0.069	0.516	0.004**	0.022*
Debt/Capital	(B)	-1.577	-1.197	-2.417	-0.997
	Significance. (2-tailed)	0.01**	0.00**	0.082	0.038*
Winsorized EPS	(B)	0.001	0.00	0.002	0.002
	Significance. (2-tailed)	0.105	0.657	0.042*	0.027*
Nominal categorial					
Develop-ment	(B)	Higher GDP/capita vs Lower GDP/capita (1.382)	Higher GDP/capita vs Lower GDP/capita (1.059)	Not applicable	Higher GDP/capita vs Lower GDP/capita (0.578)
	Significance. (2-tailed)	0.00**	0.00**	Not significant	0.009**
Auditor rank	(B)	Not applicable	BiG 4 (0.924) Other (1.03)	Not applicable	Not applicable
	Significance. (2-tailed)	Not significant	0.00**	Not significant	Not significant

Note[1]: *Statistically significant at the 0.05 level
Note[2]: **Statistically significant at the 0.01 level
Source: Author's own projection

The binary logistic regression results for the InternalNPVRatio Dummy version dependent variable indicate that the country development category and debt-to-capital ratio are significant predictors of the InternalNPVRatio Dummy version. Entities in higher GDP per capita countries are significantly more likely to have an InternalNPVRatio greater than 1. The debt-to-capital ratio has a negative effect, meaning higher debt to capital ratios decrease the likelihood of having an InternalNPVRatio greater than 1.

Additionally, the Hosmer and Lemeshow test, with a chi-square value of 12.817 and a significance level of 0.118, suggests that the model fits the data well ($p > 0.05$). The classification table shows that the model correctly predicts 59.8% of the cases, demonstrating a moderate ability to predict the dependent variable.

Overall, the logistic regression analysis for the TotalNPVRatio Dummy variable reveals that the country development category, debt to assets, and debt to capital ratios are significant predictors. Entities from higher GDP per capita countries are more likely to have a TotalNPVRatio Dummy value of 1, indicating a higher net present value relative to the book value of intangibles. The debt-to-capital ratio has a negative effect, meaning higher ratios decrease the likelihood of having an InternalNPVRatio greater than 1. The model's fit, as assessed by the Hosmer and Lemeshow Test, is acceptable, and its predictive power is modest.

The binary logistic regression model for the Dummy Max Effort Internal Ratio reveals insightful findings about the factors influencing the likelihood of an entity achieving a Max Effort Internal Ratio above 1. The Hosmer and Lemeshow Test returned a significance of 0.012, suggesting that the model does not fit the data reasonably well. The model's overall classification accuracy was 79.4%, which is notably high.

Among the independent variables, Debt to Assets and Winsorized EPS were found to be statistically significant predictors.

The estimated coefficient for Debt to Assets is 5.586 with a significance level of 0.004, showing a significant positive impact. This implies that a higher debt to assets ratio greatly increases the probability of achieving a Max Effort Internal Ratio above 1.

The estimated coefficient for Winsorized EPS is 0.002 with a significance level of 0.042, indicating a slight positive impact. This suggests that higher Winsorized EPS slightly increases the likelihood of achieving a Max Effort Internal Ratio above 1.

The other variables, were not statistically significant in the model.

The Hosmer and Lemeshow Test, with a chi-square value of 19.609 and a significance of 0.012, indicates that the model is not a reasonably good fit to the data.

The binary logistic regression analysis for the MaxEffort Total Ratio dummy version variable reveals significant insights into the factors influencing the likelihood of having a higher than 1 MaxEffort Total Ratio among firms. The classification table indicates that the model correctly predicts 79.7% of the cases, demonstrating strong predictive power.

The analysis identifies several key predictors:

In regards to the Country Development Category; firms in higher GDP per capita countries are significantly more likely to have a high MaxEffort Total Ratio compared to those in lower GDP per capita countries.

The Debt to Assets leverage ratio is highly significant; a higher debt-to-assets ratio significantly increases the likelihood of a high MaxEffort Total Ratio.

The Debt to Capital leverage ratio is also highly significant; firms with lower debt-to-capital ratios are markedly more likely to exhibit a high MaxEffort Total Ratio, underscoring the substantial impact of this financial metric.

Winsorized EPS is also a significant predictor; indicating that firms with greater earnings per share are more likely to achieve a high MaxEffort Total Ratio.

Other variables, such as Debt to Equity (Version 2) and auditor rank (Big 4 or Other), do not show significant effects on the likelihood of a high MaxEffort Total Ratio.

The Hosmer and Lemeshow Test shows that the model is marginally not a good fit. In conclusion, both mixed model linear regressions and binary logistic regressions offer complementary insights into the determinants of financial performance metrics. Mixed models are particularly useful for understanding the continuous relationship between variables, while binary logistic regressions are effective in elucidating the factors that significantly influence categorical outcomes. The convergence in results for key variables like Debt/Capital and Winsorized EPS underscores their robust impact across different model specifications. However, the divergence in findings for variables like Debt/Assets highlights the importance of model selection based on the nature of the dependent variable being analysed. This comprehensive approach provides a holistic understanding of the financial dynamics at play, guiding strategic financial decision-making. Both the mixed model linear regressions and binary logistic regressions consistently highlighted the significant influence of Debt/Capital and Winsorized EPS on the dependent variables in the same direction across models, indicating their robust impact across different analytical approaches.

Discussion

The empirical results of this study highlight the significant influence of financial leverage and profitability metrics on the performance of intangible assets in R&D-intensive entities. The Pearson correlation analysis revealed that the internal NPV ratio is significantly correlated with all independent variables, indicating the sensitivity of internally generated intangible assets to financial structure and earnings performance. The mixed model regression further elucidated these relationships, showing that debt-to-assets ratio, debt-to-capital ratio, and Winsorized EPS are significant predictors of the internal NPV ratio. These findings suggest that higher leverage relative to assets and higher earnings per share are associated with better performance of internally generated intangibles, while a higher debt-to-capital ratio negatively impacts their performance.

The binary logistic regression analysis provided additional insights, confirming the significant influence of debt-to-capital ratio and Winsorized EPS on the probability of achieving higher performance levels. The Hosmer and Lemeshow test indicate a good fit for Dummy InternalNPVRatio and Dummy TotalNPVRatio, with the Dummy MaxEffortInternalRatio and Dummy MaxEffortTotalRatio showing the highest predictability at 79.4% and 79.7%, respectively. These results underscore the robustness of the financial leverage and profitability metrics as determinants of intangible asset performance.

Conclusion

This study provides a comprehensive analysis of the determinants of R&D value reporting bias in EU technology sector entities, revealing significant correlations between financial leverage ratios, earnings per share, and the performance of intangible assets. The mixed model regression and binary logistic regression analyses highlight the critical role of financial structure and profitability metrics in predicting the economic performance of intangibles. The findings suggest that higher debt levels relative to assets and higher earnings per share enhance the performance of internally generated intangible assets, while increased debt-to-equity and debt-to-capital ratios have a detrimental effect.

The study also underscores the importance of regional factors and audit quality, with entities from higher GDP per capita countries and those audited by Big 4 firms demonstrating better financial performance on some metrics. These insights contribute to understanding earnings management behaviours and provide practical implications for financial management and policy-making in R&D-intensive entities. Future research should explore the causal mechanisms underlying these relationships and consider the temporal effects and variability among entities to deepen the understanding of the dynamics at play.

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