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The Impact of the Disclosed R & D Expenditure on the Value Relevance of the Accounting Information: Evidence from Greek Listed Firms

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Abstract: Although many empirical studies have focused on R & D performance models for markets globally, the available financial information for R & D expenditure is limited. In other words, can we assume that the reported accounting information for R & D investment is adequate and valuable? This study empirically investigates the effect of R & D reported information on the value relevance of the accounting information of firms' financial statements. Specifically, using Ohlson's equation, it is examined whether changes in stock prices are explained better when R & D factors are included in models, in conjunction with changes in book value and abnormal earnings. We focus on listed firms on the Athens Stock Exchange in order to explore whether R & D expenses are value relevant, in a market which has been affected for a long period by the global economic crisis of 2007. In our findings, we observe that the reported R & D expenses do not have any significant influence on the investors' choices, in contrast to expectations based on the prior literature. Moreover, the panel data analysis employed in the paper overcomes common methodological problems (such as autocorrelation, multicollinearity, and heteroscedasticity) and allows the estimation of unbiased and efficient estimators.

Keywords: value relevance; book value; abnormal earnings; R & D; panel data

1. Introduction

The quotes "all things are flowing", "nothing endures but change", and "nothing stays still" are attributed to Heraclitus of Ephesus (ca. 544–483 BC), who is thought to be the first influential philosopher of change. His theory is that processes of change are important, not the states of rest [1]. However, change and transformation can be accomplished only through innovation. Innovation is inseparably connected to development. Drucker (1985) characterized innovation as a special entrepreneurship tool which contributes to the creation of wealth [2] and Gartner (1990) noted that innovation is one of the factors that constitute the nature of entrepreneurship [3]. Marx (1887) interpreted innovation as the result of companies' attempts to increase their profits [4]. In other words, companies undertake innovation initiatives in the expectation that it will generate a competitive advantage and, thus, significant income from new products and processes.

Subsequently, the term research and development (R & D) is widely linked to innovation. On the one hand, R & D refers to the activities companies undertake to innovate and introduce new products

and services. On the other hand, in previous studies, innovation has been recognized as a competitive advantage of firms. As a company gains a competitive advantage by performing in some way that rivals cannot easily replicate, R & D allows that company to remain ahead of its competition. Schumpeter (1934) described how large corporations leave smaller competitors behind through a circular process of positive feedback between innovation and the financing of R & D [5].

The EU, having recognized that innovative firms develop more strategic and organizational skills than non-innovation oriented firms, has formed a specific agenda, underlining the need to invest in research and innovation, by ensuring essential public investment, supporting EU Member States to maximize their R & D expenditure, stimulating private investment, providing a simpler regulatory framework, and supporting innovation procurement [6].

R & D funding is globally examined. The total global expenditure on R & D in 2017 was USD2.2 trillion and continues to grow at a rate of 3.6% per year. The world leader is the U.S., which spends approximately 2.8% of the country's GDP on R & D, while China ranks second, spending almost 1.95% of GDP. Germany is the European leader, spending almost 2.8% of its GDP on R & D. Globally, Greece ranked 51st in 2017, having spent USD 1.83 billion (almost 0.6% of GDP). This is an unexpectedly promising outcome, considering that by 2017 Greece had suffered a severe economic recession for eight consecutive years [7].

According to Hirschey et al. (1985), several reasons explain the differences between a firm's market value and the historical value reported in accounting financial statements [8]. A significant reason is that financial statements are limited to those items that meet the present-day recognition criteria employed by the accounting profession. Thus, potentially relevant items, such as R & D investments, are not reported on balance sheets due to the fact that they do not meet the qualitative criterion of reliability. However, the purpose of financial reports is to provide investors with the information they need to make the best allocation of their investment resources. Indeed, in prior literature, Kalantonis (2011) found evidence that firms' innovative activity affected their performance and, at the same time, was a crucial criterion for investors' decision making [9].

Moreover, Lev et al. (2016) [10] noted that reported financial information has largely lost its relevance. They also proposed that a different accounting treatment of long-term investments in intangibles–such as innovation investments–could improve the value relevance of financial reports. The term "value relevance" reflects the ability of the reported accounting information to explain and summarize the market value of companies (Amir et al., 1993) [11]. Increased relevance means that investors' decisions are based more on the reported accounting information and therefore financial reports become more useful for their users, who can make investment decisions based on reliable and audited information. More effective investment decisions are more necessary during crisis periods.

In this study we explore the effect of R & D disclosed information in firms' financial reports on the value relevance of the reported accounting information. We also investigate the adequateness of the R & D reported financial and non-financial information. Since previous studies have mainly examined the consequences of the lack of reported innovative expenses for the value relevance of accounting information, we contribute to the literature by exploring the effect of the reported financial and non-financial information for the R & D activity of firms, on their annual reports. We focus on both the periods before and during the crisis in order to determine the effect of crisis. This is also a novelty of our study. The examined financial statements in this study are drawn from the listed firms on the Athens Stock Exchange.

It should be noted that the Greek economy has been strongly affected by the financial crisis since 2010. Although a small number of other countries (for example Portugal, Italy and Spain) were also affected by the economic crisis in 2008, the case of Greece is totally different. The crisis in Greece has endured for almost 10 years and can be separated into a number of phases: (i) April 2010—memorandum with International Monetary Fund (IMF), European Central bank (ECB), and European Commission; (ii) June 2015—capital controls; (iii) July 2015—new memorandum with the addition of the European

Stability Mechanism; and (iv) termination of the memorandum and beginning of probation. Moreover, intense political instability prevailed in the country as six legislative elections (October 2009, May 2012, June 2012, January 2015, September 2015, and July 2019) and a referendum (July 2015) took place during the decade of crisis. In no other country did so many events take place that dramatically transformed the entrepreneurial, business, economic, and social environments. In contrast, Cyprus accepted a memorandum in 2013, but in 2015 the first signs of recovery were evident.

Using financial data of the firms listed on the Athens Stock Exchange, we search for significant differences between the value relevance of R & D expenditure compared to the market values. Comparing our findings with those of prior relevant literature, we discuss how the market evaluates the R & D orientation within the framework of the recent Greek financial crisis.

The remainder of the paper is structured as follows. In the following section we explore the research literature and state the research hypothesis. In Section 3 we describe the research methodology. In Section 4 we present the results of the data analysis. The discussion of our findings then follows, and the final section includes the conclusion, the limitations of the research, and future research suggestions.

2. Materials and Methods

2.1. Different Approaches of Measuring R & D Intensity

Examining prior and recent literature, we detected research studies that explored the relationship between innovation or R & D outcomes and the market or financial performance of firms. Nevertheless, other studies investigated the effect of R & D expenditure on firms' value (either book or market value) and their profitability. The findings of these studies were not consistent. As determinant factors of the variability of their results, we recognized the economic status and environment, the type of the studied firms, the conceptual and regulatory approach to the innovation or R & D outcome and investments, and the fact that R & D investments were treated differently in different countries depending on the adopted accounting standards. We categorized these studies according to their approach to R & D measurement and their view of the effects on firms' value or financial performance.

2.1.1. The Non-Monetary Approach

Geroski et al. (1993) evaluated the effects of producing a major innovation on corporate profitability and the differences in profitability between innovators and non-innovators. The study examined the introduction of specific innovations by observing UK manufacturing firms during the period 1972–1983 and showed that the number of innovations produced by a firm has a positive effect on its profitability [12]. Sood et al. (2009) investigated how stock markets react to each event in an innovation project using a sample consisting of U.S. listed firms and collected announcements from 1977 to 2006. Results showed that total market returns to an innovation project were substantially greater than the returns to an average event [13]. Hall et al. (2005) explored the usefulness of patent citations as a measure of the "importance" of a firm's patents [14]. Using patents and citations for 1963–1995, they noted that each citation significantly affected market value, with an extra citation per patent boosting market value by 3%. Szutowski (2016) examined long- and short-term effects of innovation announcements on the market value of the equity of tourism enterprises listed on the 32 most important stock exchanges in the European Union, released during the period of February 2011–February 2016. The study found evidence for positive, statistically significant changes in the market value of the equity of tourism enterprises [15].

2.1.2. The Monetary Approach

In this approach, which is the most commonly used approach by researchers, the R & D intensity is measured as an expenditure, that is, a monetary amount that is either expensed or capitalized. The need for such a distinction has been created because there are two different accounting treatments of R & D expenditure: such an expenditure can either be recorded as an expense in the year it is made, or it can be capitalized and recorded as an asset (under defined conditions and only for development costs, not research costs). By 2005 each country had applied its own rules. Since then, the International Financial Reporting Standards (IFRS) have been implemented, which partly allow capitalization of R & D, but only for development costs and if certain criteria are met. At the same time, many countries apply the Generally Accepted Accounting Principles (GAAP), which differ from the IFRS in their treatment of R & D expenditure (ASC 730) [16]. Under this treatment, R & D costs are recognized as an expense, as they are incurred, since any future economic benefit arising from the development of a given asset is uncertain. In the literature references listed in the remainder of this paper, R & D intensity is measured as an expenditure that is either expensed or capitalized. [17]

A significant amount of recent and relevant literature on the subject of the different accounting approaches of R & D expenditure exists. Gong et al. (2016) investigated whether the nature of differences between national GAAP and IFRS is associated with differential changes in the value relevance of R & D expenses after the adoption of IFRS, using a difference-in-differences study on a sample of public companies in eight European countries and Australia, which covers pre-IFRS and post-IFRS periods during 1997–2012 [18]. They found that the value relevance of R & D expenses declines after IFRS adoption in countries that previously mandated immediate expensing or allowed optional capitalization of R & D costs. On the contrary, they found no change in the value relevance of R & D expenses for countries that switched from the mandatory capitalization rule to IFRS. Chen et al. (2017), having focused on the relevance of voluntary disclosures in a sample of Israeli high-technology and science-based firms, showed that capitalized development costs are highly significant in relation to stock prices [19].

Cazavan-Jeny et al. (2006) tested the value relevance of R & D reporting in a sample of French firms over a 10-year period (1993–2002) and noted that capitalized R & D was significantly negatively associated with stock prices and returns. The authors concluded that this negative coefficient on capitalized R & D implied that investors were concerned with R & D capitalization and reacted negatively to it [20].

2.2. How Does R & D Expenditure Affect the Different Dimensions of Firms' Benchmarks?

2.2.1. R & D Expenditure and Enterprise Performance or Profitability

A large number of surveys are devoted to the way in which R & D intensity impacts an enterprise's performance. Cazavan-Jeny et al. (2011), using a sample of French listed firms for the period 1992–2001, found that firms which capitalized R & D expenditures spend less on R & D and were smaller and poorer performers than those who expensed R & D, showing that the decision to capitalize R & D expenditures is generally associated with a negative impact on future performance. They also showed that when firms both capitalized and expensed R & D expenditures, the expensed portion exhibited a strong negative relationship with future performance [21]. Based on a sample consisting of Australian companies from 1991 to 2001, Chan et al. (2007) suggested that firms with higher R & D intensity perform better, regardless of the accounting method used. Evidence was also found that firms which expense R & D outperform those which capitalize R & D [22]. Cinceraa et al. (2014) examined the sources of Europe's lagging R & D performance relative to the US for the period 2000–2011, and found that young firms in the US succeeded in realizing significantly higher rates of return on R & D compared to their older counterparts, including in high-tech sectors, while European firms failed to generate significant rates of return [23]. Vanderpal et al. (2015) highlighted the nature of the relationship between R & D expense and companies' profitability, having studied firms for a long

period, from 1979 to 2013, and obtained evidence supporting a positive relationship between R & D expense and companies' profitability indicators [24]. R & D expense indicators proved to be positively correlated with the profitability of companies (revenues, net income, equity, and Return on Equity). Martin (2015) examined the issue of effectiveness of business innovation and R & D efforts in Polish manufacturing companies, covering the period from 2000 to 2009 [25]. He suggested that positive effects of business R & D are mostly associated with specific time-invariant individual characteristics of business units. Finally, in the most recent study, Turlington et al. (2019), using a sample of firms in the automotive industry in the US and Europe for the period 2006–2016, noted that R & D expenses under U.S. GAAP will be expected to be higher (and income lower) compared to IFRS, as long as absolute R & D costs are growing over time [26]. When growth in R & D investment slows, the R & D expense recorded under U.S. GAAP will begin to approximate the IFRS R & D amounts, since current R & D costs will be closely related to the research expense plus the amortized portion of prior development costs. They also noted that the overall effect on ROE from capitalizing development costs under IFRS is also ambiguous, as the methodology effects both numerator and denominator amounts.

2.2.2. R & D Expenditure and Enterprise's Market Value

A large number of studies have examined how capital markets interpret the information about R & D expenditures disclosed by companies, and these studies mostly find a positive relationship. Lev et al. (1996) addressed the issues of reliability, objectivity, and value-relevance of R & D capitalization by studying US manufacturing companies from 1975 to 1991 and documented the existence of a systematic mispricing of the shares of R & D–intensive companies, or compensation for an extra market risk factor associated with R & D, as they found a significant inter-temporal association between firms' R & D capital and subsequent stock returns [27]. Chambers (2002) searched for differences between the mispricing and risk explanations for R & D-related excess returns in a sample of all NYSE-, ASE-, and NASDAQ-traded firms over the period 1979–1998 and provided convincing evidence of a positive association between the level of R & D investment and post-investment excess stock returns. He proved that the pattern of increasing excess returns to R & D-intensity was associated with risk characteristics of R & D oriented firms [28]. Han et al. (2004) investigated the value-relevance of R & D expenditures of Korean firms from 1988 to 1998, and showed that R & D expenditures were positively associated with stock price [29]. They found a stronger association for the portion of R & D expenditures that was capitalized, rather than expensed. Investors also appeared to interpret fully expensed R & D expenditures as being positive for net present value, however, they suggested that these expenditures should also be capitalized. In a similar study, Ho et al. (2005), using a sample of U.S. firms for an over 40-year period from 1962 to 2001, investigated whether the future share price returns of a firm were positively related to a firm's R & D intensity and showed that R & D investment creates value for firms over one-year and three-year horizons [30]. Ike et al. (2010), using a sample of US firms for the years 1990 through 2007, studied the association between an investment in R & D and market value [31]. They found that the valuation of R & D investment can be linked to a company's market capitalization, in a linear relationship, as investors assess the value relevance of a firm. Başgoze et al. (2013) tested the ability of R & D investment intensity to explain future stock returns, using a sample of enterprises listed on the Istanbul Stock Exchange (ISE) from 2006 to 2010 [32]. Consistent with Lev et al. (1996) and Ike et al. (2010), they showed a linear and statistically significant positive relationship between annual stock returns and R & D investment intensity.

Other studies have contrasting findings to those already mentioned. Chan et al. (1999) investigated whether the stock market appropriately accounts for firms' expenditures on R & D by relating R & D spending to subsequent stock price performance using a sample consisting of all domestic firms listed on the NYSE, AMEX and NASDAQ exchanges from 1975 to 1995. Their evidence did not support a direct link between R & D spending and future stock returns, as the average return over all firms engaged in R & D activity did not differ markedly from that of firms who did not undertake R & D [33]. Callen et al. (2004) found very weak empirical support for the value relevance of R & D expenditures

when they investigated a sample selected from the period 1962 to 1996. The study showed that R & D investment significantly affected firm valuation for only 25% of the sample firms [34]. In addition, Sofronas et al. (2019) investigated the relationship between the R & D expenditures and the market value of European companies that reported their annual R & D expenditures consecutively for the years from 2002 to 2012. The study found weak evidence in support of the hypothesis that R & D expenditure positively affects the firm's market value, as well as weak evidence that economic events can disrupt the connection of R & D programs with the market value of firms [35].

In addition, other studies support the view that R & D investments affect profitable and loss-making firms in different ways. Kim et al. (2008) investigated whether there is a non-linear relationship between R & D investments and firm value, using Chinese listed firms between 2005 and 2013 [36]. They showed that R & D investments have an inverted U-shaped relationship with firm value, which indicates that as R & D investments increase, firm value increases to a certain level and then decreases. Franzen et al. (2009) examined whether the valuation relevance of R & D had already been documented for loss-making firms, and extended to profitable firms, by investigating the role of R & D expense in a residual-income based valuation framework across levels of profitability [37]. R & D expense in this study was found to be positively associated with stock prices for loss-making firms and negatively associated with stock prices for profitable firms. In a more recent study, Tsoligkas et al. (2011) examined whether R & D reported assets and expenses were value relevant after the adoption of IFRS in 2005 and searched for any size-related valuation consequences of R & D after IFRS mandatory implementation [38]. They used a sample of UK FTSE listed firms for the years 2006 to 2008. They found evidence to support the view that the capitalized and expensed portions of R & D expenditure are positively and negatively value relevant, respectively, in the UK, after 2005. The hypothesis that there are differences in the valuation of UK companies after the mandatory implementation of IFRS was partially supported with regard to R & D reporting because the expensed portion of R & D was consistently negatively value relevant only for large firms. They finally found that the capitalized portion of R & D was significantly positively related to market value, suggesting that the market perceived these items as successful projects with future economic benefits. In contrast, R & D expenses were significantly negatively related to market values under IFRS, supporting the proposition that they reflected no future economic benefits and thus they should be expensed.

2.3. How Does Market Value Relate to Accounting Data and R & D Information?

Ball et al. (1968) and Beaver (1968) demonstrated the association between abnormal returns and stock prices in the months before and after the dates of earning announcements [39,40]. Then, Hirschey et al. (1985) identified several reasons for the differences between the stock market value and the historical value reported in accounting financial statements [8]. One major reason is that financial statements are limited to those items that meet the present-day recognition criteria employed by the accounting profession. Thus, potentially relevant items such as R & D are not reported on balance sheets because they do not meet the qualitative criterion of reliability. We have already mentioned prior research studies which examined the value relevance of R & D disclosure to the stock market and these studies mostly find a positive relationship between them. Lev et al. (1996) studied the value-relevance of R & D capitalization among US manufacturing companies from 1975 to 1991 found a significantly positive association between firms' R & D capital and subsequent stock returns [27]. Similarly, Han et al. (2004) investigated the value-relevance of R & D expenditures of Korean firms from 1988 to 1998, and found a positive association between R & D expenditures and stock prices [29]. Ike et al. (2010), using a sample of US firms for the years 1990 through 2007, also found a positive, linear relationship between an investment in R & D and market value as investors assessed the value relevance of a firm. Nonetheless, other studies had contrary findings as their evidence did not support a direct link between R & D spending and future stock returns. For example, Callen et al. (2004) found very weak empirical support for the value relevance of R & D expenditures [34]. Finally, studies also exist with mixed findings. For example, Kim et al. (2008) proved an inverted U-shaped relationship

between R & D investments and firm value for firms with high growth opportunities, in contrast to firms with low growth opportunities, whose relationship has a plain U-shaped pattern [36]. This corresponds to the study of Franzen et al. (2009), in which R & D expense was shown to be positively associated with stock prices for loss-making firms and negatively associated with stock prices for profitable firms. In addition, the study of Tsoligkas et al. (2011) suggested that the capitalized portion of R & D was significantly positively related to market values, in contrast to the R & D expenses, which were significantly negatively related to market values [38].

2.4. The Crisis Effect

Sofronas et al. (2019), while investigating whether the European economic crisis of 2008 negatively affected the impact of innovation expenditures on the market value of a firm, found weak evidence that such economic events can disrupt the connection of R & D programs with the market value of firms [35]. Ike et al. (2010), among other hypotheses, also investigated how the effect of a global economic disruption, such as 9/11, would negatively affect R & D investment–firm value association. In contrast to Sofronas et al., they proved that disruptive economic events such as 9/11 do impact the scope and effectiveness of R & D investment on firm value.

Hardouvelis et al. (2016) found that the extended period of the economic crisis in Greece has some unique features [41]. Firstly, prior to the crisis little attention was paid to its clear warning signs and pre-existing economic imbalances, despite the fact that such indications had been in place since at least 2006, because the pre-crisis environment was one of rising living standards. Then, crisis consequences developed suddenly in October 2009, when the country's on-going fiscal deficit was discovered to be three times greater than the forecast made a few months earlier, shocking the Eurogroup, rating agencies, and, clearly, markets. Next, the size of the fiscal multiplier was underestimated and labor market reforms were given priority over product market reforms. This had the consequence of worsening the recession, as product prices did not adjust downward immediately, and the drop in nominal wages was translated into a bigger drop in real incomes and domestic aggregate demand. Thereafter, the domestic Greek banks, which had not been affected by the earlier international crisis, saw their capital base completely wiped out when a debt haircut eventually took place in February 2012 and outstanding government bonds and loans were swapped for new bonds. At the end of 2014, when the economy was picking up momentum, the new government who came to power focused on a possible nominal debt haircut. In 2015, three elections were called and a faction supporting Grexit was formed. The population gradually withdrew about EUR 45 bn from banks, accounting for 25% of deposits. Economic sentiment fell drastically, the flow of new investments stopped, and the economy froze. Finally, capital controls were put in place in late June 2015 to prevent further deposit drainage, thus dealing another blow to the private sector and exports. As a result, a third recapitalization of banks took place.

2.5. Hypothesis Statement and Methodology Approach

The main purpose of this research study is to explore the effect of R & D expenditure disclosure on the value relevance of the reported accounting information in the financial statements. Previous and more recent studies, such as these of Franzen et al. (2009), Han et al. (2004), Ike et al. (2010), and Başgoze et al. (2013) [29,31,32,37], focused on the relationship between the R & D expenses and market value of firms. Furthermore, similar studies of Lev et al. (1996) and Tsoligkas et al. (2011) [27,38] investigated the value relevance of R & D investments' capitalization. In addition to these studies, Sofronas et al. (2019) [35] investigated if the relationship between R & D programs and firm value could be affected by an economic crisis.

It is commonly accepted that R & D activity is a key factor for innovation development. Investors are interested in innovative investments, expecting more future benefits from them. Nevertheless, it is important for investors to base their investment choices on reliable information. For that purpose, audited accounting information could be the most appropriate reported information for investors,

under the assumption that the disclosed information for the firms' R & D expenditure—in their financial reports—is adequate for investors' decision making. If we accept this assumption, we would expect a significant positive effect of R & D expenditures on the value relevance of financial statements. In other words, the lack of a significant change in value relevance by including R & D in the value relevance equation could be a red flag for the adequacy of accounting information for investors who react positively to firms' R & D orientation.

Many of the previous studies have been influenced by Ohlson's model for the value relevance of accounting information. Ohlson (1995) noted that the value of a firm is equal to the sum of the book value of its equity and the present value of its expected abnormal earnings [42]. Thus, Ohlson's (1995) value relevance model related the stock price to the book value of common equity per share, abnormal earnings per share, and other information. However, Ohlson's model also admits additional information beyond the above accounting metrics, as some value-relevant factors may affect future expected earnings as opposed to current earnings; in other words, accounting measurements incorporate some value-relevant events only after a time delay.

Adopting Ohlson's value relevance equation, in this study we insert additional variables for R & D expenses, R & D disclosure, and economic crises, and we test the following research hypotheses:

Hypothesis 1. *Book value and abnormal earnings are value relevant to market value.*

Hypothesis 2. *A crisis is a determinant factor for the value relevance of the disclosed accounting information.*

Hypothesis 3. *R & D intensity improves the value relevance of the reported accounting information.*

Hypothesis 4. *R & D disclosure effects on the value relevance of the reported accounting information.*

Hypothesis 5. *A crisis affects the value relevance of the accounting information of the firms which disclose information for their R & D activity in their financial reports.*

In this study, we test the significance of the above inserted variables for R & D and crises, and their effect on the value relevance of financial reported information, in order to capture the effect of this additional information, beyond the book value of equity and the present value of expected abnormal earnings.

3. Methodology

3.1. Aims and Scope

The main scope of this paper is to explore the effect of the disclosure of R & D expenses on the value relevance of financial reports. For this purpose, we studied the relevant literature and classified it according to the approach of R & D measurement and the type of the effect of R & D expenditure on firms' value. Next, we selected our sample. All listed firms of the Athens Stock Exchange were included in our sample, excluding financial institutions, banks, and investment and insurance firms, due to the fact that their financial reports have different structures and therefore they are not comparable. Based on the previous literature we stated our hypotheses and defined our variables (dependent, explanatory, and dummy). In this study, we adopted Olson's model, which has been validated in previous studies for valuing firm equity. To avoid problems of endogeneity and autocorrelation in the error terms, we applied panel data regression. Moreover, panel data regression is an appropriate approach for the estimation of microdynamic and macrodynamic effects. Analysis and discussion of data follow, before conclusions, limitations, and further research proposals are stated in the last section of this research.

3.2. Model

The sample consists of all the listed firms on the Athens Stock Exchange. We examined the disclosed accounting information of those firms since 2005, when they adopted IFRS. According to the IFRS framework, R & D activity is discriminated in two phases [43]. Research is the first phase. However, any intangible asset coming from the research activity can be recognized as an expense. Development is the second phase. An intangible asset arising during the phase of development can be recognized only if it meets specific requirements, such as future benefit generation and availability for sale or use. In this paper we focus on the reported R & D expenses. Specifically, R & D expenses divided by Total Assets constitute the R & D intensity, which is specified as one of the added variables in Ohlson's equation.

Ohlson determined the relationship of a firm's market value with accounting variables under three assumptions:

i. The market value of the firm is equal to the present value of all expected future dividends (PVED), assuming non-stochastic interest rates.
ii. A clean surplus relationship is imposed to define the present year book value, which equals the previous year book value plus earnings minus dividends.
iii. Linear information dynamics (which explains the time series behavior of abnormal earnings), establishes a linkage between a firm's intrinsic value and current information [42].

More specifically, the algebraic model can be represented as follows:

$$MV_t = a0 + a_1 \times Bt + a_2 \times AE_t + b_3 \times OI_t + e_i$$

where:

MVt: market value, Bt: book value, AEt: abnormal earnings, OIt: additional information.

In order to test our hypotheses, we formed the following equations:

$$MVS_{it+1} = b_0 + b_1 \times BVS_{it} + b_2 \times AES_{it} + e_{it} \quad (1)$$

$$MVS_{it+1} = b_0 + b_1 \times BVS_{it} + b_2 \times AES_{it} + b_5 \times CRISIS_{it} + e_{it} \quad (2)$$

$$MVS_{\mathbf{it+1}} = b_{\mathbf{0}} + b_{\mathbf{1}} \times BVS_{\mathbf{it}} + b_{\mathbf{2}} \times AES_{\mathbf{it}} + d_{\mathbf{t}} + e_{\mathbf{it}} \quad (3)$$

$$MVS_{it+1} = b_0 + b_1 \times BVS_{it} + b_2 \times AES_{it} + b_3 \times RDE_{it} + e_{it} \quad (4)$$

$$MVS_{\mathbf{it+1}} = b_{\mathbf{0}} + b_{\mathbf{1}} \times BVS_{\mathbf{it}} + b_{\mathbf{2}} \times AES_{\mathbf{it}} + b_{\mathbf{3}} \times RDE_{\mathbf{it}} + b_{\mathbf{5}} \times CRISIS_{\mathbf{it}} + e_{\mathbf{it}} \quad (5)$$

$$MVS_{\mathbf{it+1}} = b_{\mathbf{0}} + b_{\mathbf{1}} \times BVS_{\mathbf{it}} + b_{\mathbf{2}} \times AES_{\mathbf{it}} + b_{\mathbf{3}} \times RDE_{\mathbf{it}} + d_{\mathbf{t}} + e_{\mathbf{it}} \quad (6)$$

$$MVS_{\mathbf{it+1}} = b_{\mathbf{0}} + b_{\mathbf{1}} \times BVS_{\mathbf{it}} + b_{\mathbf{2}} \times AES_{\mathbf{it}} + b_{\mathbf{4}} \times DISCLOSE_{\mathbf{it}} + e_{\mathbf{it}} \quad (7)$$

$$MVS_{\mathbf{it+1}} = b_{\mathbf{0}} + b_{\mathbf{1}} \times BVS_{\mathbf{it}} + b_{\mathbf{2}} \times AES_{\mathbf{it}} + b_{\mathbf{4}} \times DISCLOSE_{\mathbf{it}} + b_{\mathbf{5}} \times CRISIS_{\mathbf{it}} + e_{\mathbf{it}} \quad (8)$$

$$MVS_{\mathbf{it+1}} = b_{\mathbf{0}} + b_{\mathbf{1}} \times BVS_{\mathbf{it}} + b_{\mathbf{2}} \times AES_{\mathbf{it}} + b_{\mathbf{4}} \times DISCLOSE_{\mathbf{it}} + d_t + e_{\mathbf{it}} \quad (9)$$

Specifically, the variables of the equations can be stated as follows:

Dependent Variable	
MVS_{it+1}	Market Value per Share defined as the share price the first day of next year's (t + 1) April.
Independent Variables	
BVS_{it}	Book Value per Share measured as the total common stockholders' equity less the preferred stock, divided by the number of common shares of the company at 31/12 each year.
AES_{it}	Abnormal Earnings per Share at 31/12 defined as the actual earnings per share of current year results (ES_{it}) minus the normal earnings, where normal earnings can be defined as the multiplication of previous year-end book value per share (BVSit-1) and the cost of capital of the firm. As the cost of capital we choose to apply Damodaran's country risk (CR) AESit: $ES_{it} - (CR \times BVS_{it-1})$
RDE_{it}	R & D expenses divided by total assets 31/12
$DISCLOSE_{it}$	Dummy variable indicating whether a firm discloses its R & D expenses or not
$CRISIS_{it}$	Dummy variable of time dividing the study period into two subperiods 2006–2009 and 2010–2017
eit	error

3.3. Methodological Approach

Examining the quantitative methods of the previous studies of value relevance, we observe that researchers have already used time series data and cross-sectional data, and that they have also implemented pooled time-series and cross-sectional regressions [44].

As we have the same 139 cross-sectional units surveyed over a 12-year period, we have balanced panel data. Thus, according to the literature, we adopted panel data analysis by applying a linear regression model. Following this procedure, we avoid the methodological problems of the time-series analysis and the cross-section methods, which often fail to detect the dynamic factors that may affect the dependent variable. In addition, panel data analysis has a number of advantages because it not only provides efficient and unbiased estimators, but also provides a larger number of degrees of freedom available for the estimation, and allows the researcher to overcome the restrictive assumptions of the linear regression model [45].

According to Baltagi (2005) [46], the main difference between time series or cross section regression models and a panel regression model is that the panel regression model has a double subscript on its variables. In the case of our data this would be interpreted as follows:

$$Y_{it} = a + bX_{it} + u_{it,}\ i = 1, \ldots, N \text{ and } t = 1, \ldots, T \quad (10)$$

where i represents the 139 firms of our sample and t represents the 12 years within the period 2006–2017. Consequently, i reflects the cross-section dimension and t reflects the time series dimension of the model. In addition, X_{it} represents the it observation of the five explanatory variables of our equation. In other words, we included the variables X1, X2, and X3 in our model. Thus, our panel data equation becomes:

$$Y_{it} = a + b_1 \times X1_{it} + b2 \times X2_{it} + b3 \times X3_{it} + u_{it} \quad (11)$$

Adopting Baltagi's point of view for error terms in the panel data, we assume that there is a one-way error term, which is uncorrelated with the explanatory variables (Hsiao (2003) [47]) and can be expressed according to Baltagi as follows:

$$U_{it} = \mu_{it} + \nu_{it} \quad (12)$$

The unobservable individual specific effect, which is reflected in μ_{it} and ν_{it}, interprets the usual disturbance in the regression equation. In our specific model—which is based on Ohlson's equation

for the measurement of the accounting information's value relevance—the unobservable explanatory variables for the market value can be reflected in u_{it}. Hsiao (2003) stated that microdynamic and macrodynamic effects can be estimated with panel data regression analysis and this is its significant advantage [47].

An alternative approach to present the panel regression model was adopted by Karathanasis et al. (2003), who showed that Ohlson's model was superior for the equity valuation [45]. In their study they presented the following approach:

$$Y_{it} = a + \mu_{it} + \lambda_{it} + \sum_{\kappa=1}^{3} (b_\kappa \times X_{\kappa it}) + \varepsilon_{it} \quad (13)$$

In this model Y_{it} denotes the dependent value for cross section i at time t and $X_{\kappa it}$ denotes the independent (explanatory) variables, which in our research are the book value per share (BVS_{it}), the abnormal earnings per share (AES_{it}), and the R & D expenses divided by total assets (RDEit). Our dependent variable is market value per share (MVS_{it+1}). In this model, μ_i expresses the unobserved cross section effect, λ_t the unobserved time effect, and ε_{it} the remaining non-observed error. We must note that in order to apply Equation (13) we have to assume that either μ_i and λ_i are both fixed or that they are random.

Based on theory and prior literature, we expect a positive and statistically significant effect of both of Ohlson's independent variables (Book Value and Abnormal Earnings on the Market Value). However contradictory findings have been detected in previous studies regarding the effect of the R & D and crises on firms' value.

3.4. Data and Descriptives

Our sample consists of 139 firms listed on the Athens Stock Exchange for the period 2006–2017, as the IFRS were adopted in Greece in 2005. Accounting data were collected from firms' annual balance sheets and financial statements. Stock prices were retrieved from internet [48]. To be included in the sample, necessary accounting and market data must have been available. In addition, the sample was confined to firms with December fiscal year-ends. Banks, financial, assurance, and real estate companies was excluded. The exact sample size was 1668 total observations. The market value of common stock (MV_{it+1}) was as of the first day of April in year t + 1. This allows a 3-month filing period for year t financial statements, to ensure that market value is measured after the release of the information.

In order to explore the impact of financial crisis on the value relevance of accounting information for firms which disclose their R & D expenses, we divided the financial data into two periods. The cut-off year for the division of the two subperiods is 2010. In 2010, the Greek economy began financial probation of the EU and the IMF. Therefore, we considered the period from 2010 to 2017 as the crisis period and the period from 2006 to 2009 as the pre-crisis period for the Greek economy.

Descriptive statistics of the equation's variables are presented in Table 1. We observe that the Greek listed firms spend annually, on average, 0.2% of their total asset value for their R & D activities. Since the mean, minimum, and maximum values of R & D intensity were not significantly charged after the beginning of the Greek economy probation period, we could consider that the crisis did not affect the R & D intensity of the Greek listed firms. However, 28.24% of the firms disclosed information for their R & D expenses in their annual financial reports.

Table 1. Descriptive statistics.

	Mean	Median	St. Deviation	Min.	Max
MVS_{t+1}	4.1079	1.0450	15.6100	0.0060	286.0000
BVS_{it}	3.3504	1.5405	11.3500	−15.7550	261.6800
AES_{it}	−0.0193	−0.1012	4.6583	−12.9500	138.7900
RDE_{it} total	0.0026	0.0000	0.0087	0.0000	0.0858
RDE_{it} before	0.0028	0.0000	0.0099	0.0000	0.0858
RDE_{it} during	0.0025	0.0000	0.0081	0.0000	0.07846

4. Results and Discussion

This study attempts to explore the impact of R & D reported expenses on the value relevance of accounting information. Previous similar studies used Ohlson's equation to measure the value relevance of financial statements. The main two components introduced by Ohlson to measure the relevance are the book value and the abnormal earnings. Both can be noted as independent variables of the regression equation. Indeed, the market value is the dependent variable of Ohlson's model for the measurement of value relevance.

The quantitative approach proposed in prior and recent literature for regression analysis is an OLS regression for pooled data. We applied the F-test for fixed effects, from which we assumed that the fixed effect model is better than the pooled OLS. We also applied the Breusch–Pagan LM test for random effects, from which we assumed that the random effect model is able to deal with heterogeneity better than the pooled OLS. Then we applied the Hausman test for comparing fixed and random effects. From this test we assumed that the random effect model is able to deal with heterogeneity better than the pooled OLS. However, due to the fact that we have time-series and cross-sectional data, we also tested the results of the regression analysis for heteroscedasticity. We selected the White test, which is an appropriate test for heteroscedasticity [49]. In the results shown in Table 2 we observe that there is no significant evidence to accept the null hypothesis, which has been stated as follows: there is no heteroscedasticity when all the coefficients are equal to zero. The chi-square value obtained ($X^2 = 1618$) exceeds the critical chi-square value $p(X^2)$ at the chosen level of significance and therefore the *p*-value is approximately zero. Then, according to the findings, we cannot assume homoscedasticity and we implement WLS panel data analysis.

Table 2. White's OLS heteroscedasticity test.

Independent Variables	Coefficient	St. Deviation	t-Statistics	*p*-Value
b0	56.9886	9.3988	6.06	<0.0001 ***
BVS_{it}	−28.5945	1.8487	−15.47	<0.0001 ***
AES_{it}	−30.24	8.8765	−3.4	0.0007 ***
$sqBVS_{it}$	1.0495	0.0118	88.45	0.0000 ***
$X2X3_{it}$	−0.8522	0.1228	−6.94	<0.0001 ***
$sqAES_{it}$	0.4393	0.0635	6.91	<0.0001 ***
R-square Adjusted		0.9703		
chi-square		1618.549		

*** 1%, ** 5%, * 10% significance level.

As shown in Table 3, the book value and the abnormal earnings of the examined firms have a significant effect on their market value. The R^2 is approximately 0.40, which indicates an adequate level of relevance. Of course, this implies unexplained variability of almost 60%. As we have already mentioned, the examined period was divided into two sub-periods. The first period was before the beginning of the Greek economy's financial probation, and the second was the period during the probation. Introducing to Ohlson's equation a variable for the crisis, we observe a 5% increase in adjusted R^2. Looking at Model 2 of Table 3, we can observe, first, that the book value and the abnormal

earnings positively affect the market value, and, second, that the crisis significantly negatively affects the market value.

Table 3. Weighted least squares regression analysis.

Independent Variables	Coefficient	St. Deviation	t-Statistics	*p*-Value
Model 1				
b_0	0.4943	0.0417	11.84	<0.0001 ***
BVS_{it}	0.6535	0.0198	32.9	<0.0001 ***
AES_{it}	0.2059	0.0519	3.96	<0.0001 ***
R-square Adjusted		0.4070		
Model 2				
b_0	1.3371	0.0712	18.78	<0.0001 ***
BVS_{it}	0.6282	0.0203	30.84	<0.0001 ***
AES_{it}	0.1092	0.0501	2.17	0.0295 **
$CRISIS_{it}$	−1.1207	0.0774	−14.47	<0.0001 ***
R-square Adjusted		0.4507		
Model 3				
b_0	0.6114	0.133	4.45	<0.0001***
BVS_{it}	0.6118	0.02	30.52	<0.0001 ***
AES_{it}	0.0794	0.0481	1.65	0.0989 *
$d2006_t$	1.937	0.1852	10.46	<0.0001 ***
$d2007_t$	1.4109	0.1852	7.61	<0.0001 ***
$d2008_t$	−0.0814	0.1848	−0.44	0.6595
$d2009_t$	0.0306	0.1846	0.16	0.8681
$d2010_t$	−0.4124	0.1846	−2.23	0.0257 **
$d2011_t$	−0.7089	0.1849	−3.83	0.001 ***
$d2012_t$	−0.4093	0.1849	−2.21	0.0270 **
$d2013_t$	−0.0406	0.185	−0.21	0.8262
$d2014_t$	−0.4103	0.1846	−2.22	0.0264 **
$d2015_t$	−0.4596	0.1845	−2.49	0.0129 **
$d2016_t$	−0.3971	0.1845	−2.15	0.0315 **
R-square Adjusted		0.4825		
Model 4				
b_0	0.4865	0.0431	11.29	<0.0001 ***
BVS_{it}	0.6526	0.0198	32.81	<0.0001 ***
AES_{it}	0.2041	0.0519	3.92	<0.0001 ***
RDE_{it}	3.9956	4.5097	0.88	0.3757
R-square Adjusted		0.4056		
Model 5				
b_0	1.3302	0.0725	18.33	<0.0001 ***
BVS_{it}	0.6278	0.0204	30.76	<0.0001 ***
AES_{it}	0.1072	0.0501	2.13	0.0326 **
RDE_{it}	2.1497	4.3043	0.49	0.6175
$CRISIS_{it}$	−1.1203	0.0775	−14.45	<0.0001 ***
R-square Adjusted		0.449		
Model 6				
b0	0.6059	0.1345	4.5	<0.0001 ***
BVS_{it}	0.6125	0.0201	30.35	<0.0001 ***
AES_{it}	0.078	0.0481	1.62	0.1052
RDE_{it}	1.3561	3.9447	0.34	0.731
$d2006_t$	1.9269	0.1856	10.38	<0.0001 ***
$d2007_t$	1.411	0.1855	7.6	<0.0001 ***

Table 3. *Cont.*

Independent Variables	Coefficient	St. Deviation	t-Statistics	*p*-Value
$d2008_t$	−0.0823	0.1852	−0.44	0.6568
$d2009_t$	0.0291	0.185	0.16	0.8747
$d2010_t$	−0.4125	0.1851	−2.23	0.260 **
$d2011_t$	−0.7113	0.1853	−3.84	0.001 ***
$d2012_t$	−0.4097	0.1853	−2.21	0.0272 **
$d2013_t$	−0.04	0.1853	−0.21	0.8291
$d2014_t$	−0.4154	0.185	−2.24	0.0249 **
$d2015_t$	−0.4632	0.1849	−2.5	0.0124 **
$d2016_t$	−0.4013	0.1849	−2.17	0.0301 **
R-square Adjusted		0.4806		
		Model 7		
b_0	0.4492	0.0452	9.92	<0.0001 ***
BVS_{it}	0.6442	0.0201	32	<0.0001 ***
AES_{it}	0.2055	0.0518	3.96	<0.0001 ***
$DISCLOSE_{it}$	0.221	0.0769	2.87	0.0041 ***
R-square Adjusted		0.4087		
		Model 8		
b_0	1.301	0.073	17.82	<0.0001 ***
BVS_{it}	0.6227	0.0204	30.47	<0.0001 ***
AES_{it}	0.1082	0.0501	2.16	0.0308 **
$DISCLOSE_{it}$	0.1888	0.0744	2.53	0.0112 **
CRISISit	−1.1487	0.0776	−14.8	<0.0001 ***
R-square Adjusted		0.4537		
		Model 9		
b_0	0.5328	0.1359	3.91	<0.0001 ***
BVS_{it}	0.6106	0.02	30.5	<0.0001 ***
AES_{it}	0.0786	0.048	1.63	0.1022
$DISCLOSE_{it}$	0.2252	0.0788	2.85	0.0043
$d2006_t$	1.9415	0.1852	10.48	<0.0001 ***
$d2007_t$	1.4201	0.1851	7.66	<0.0001 ***
$d2008_t$	−0.0699	0.1848	−0.37	0.7051
$d2009_t$	0.0397	0.1846	0.21	0.8294
$d2010_t$	−0.3981	0.1846	−2.15	0.0312 **
$d2011_t$	−0.705	0.1848	−3.81	0.001 ***
$d2012_t$	−0.4104	0.1849	−2.22	0.0266 **
$d2013_t$	−0.0425	0.1849	−0.22	0.8182
$d2014_t$	−0.4173	0.1846	−2.26	0.0239 **
$d2015_t$	−0.4641	0.1845	−2.51	0.0120 **
$d2016_t$	−0.4006	0.1844	−2.17	0.0300 **
R-square Adjusted		0.4867		

*** 1%, ** 5%, * 10% significance level.

The placement of the Greek economy under the status of financial probation occurred in May of 2010. According to our findings (Model 3, Table 3), all the years of the period 2010–2016 significantly negatively affected the market value of firms as also shown by other studies [50,51]. Different findings have been observed regarding the effect of R & D expenses on firms' market value, both prior to and under probation. Specifically, there is no evidence of a significant impact of R & D expenses on firms' market value. Furthermore, we should note that the insertion of the variable R & D expenses in Ohlson's equation had no effect on the adjusted R^2 (Model4, Table 3). Based on the above findings we cannot claim that R & D expenses are relevant to market value. On the other hand, as is shown (Model 7, Table 3), the disclosure of R & D affirms activity and significantly positively affects the market

value. Nevertheless, it does not seem to improve the fit of the model, since no significant change in adjusted R^2 is observed.

5. Concluding Remarks

This study explored the impact of the reported R & D expenditure on the value relevance of financial statements. We measured the R & D expenditure under the assumption that it is reflected in the R & D disclosed expenses. Ohlson's model was adopted for the estimation of the value relevance of the disclosed accounting information. We imported, in addition to the typical variables of Ohlson's equation, R & D intensity and R & D disclosure as independent variables in the model. The research period was divided into the "pre-crisis" and "during the crisis" periods. Two different quantitative analysis approaches were implemented in order to test our research hypotheses. Although OLS regression analysis has been used in previous studies, we applied the WLS panel data regression analysis to avoid heteroscedasticity. The implementation of this method and the fact that the research target was Greek listed firms for the period 2006–2017, which have not been analyzed in previous relevant studies, constitutes our contribution to the research literature. We must stress that the Greek economy was affected by the global crisis later than European countries. Nevertheless, the duration of the consequences of the global crisis was extremely long compared to those of other European countries.

In this research paper we documented evidence of the effects of R & D disclosed information on the value relevance of the reported financial information. We positively verified Hypothesis 1 and Hypothesis 4, and negatively verified Hypothesis 2 and Hypothesis 5, but found no verification for Hypothesis 3. Next, the basic model of Ohlson was also positively verified in our study. In addition, our results showed that R & D expenses were not value relevant to the market value, but the disclosure of R & D was positively value relevant to the market value. An interpretation of these findings is that investors are interested in firms which report their R & D activity, but the reported amount does not seem to be of interest. Another finding to be highlighted is that the financial crisis significantly negatively affected the market value of Greek listed firms. However, we did not find evidence to prove that the financial crisis was a determinant factor of value relevance. An interpretation of our findings could be that the reported R & D expenditure is not sufficiently adequate to allow investors to make investment decisions. We believe that the managers of firms are not willing to disclose more financial information than is required according to the legal and regulatory framework. In this study, we highlight the necessity of an improvement of the legal framework in the direction of an obligatory reporting of capitalized R & D information, which could be more attractive to the investors and shareholders.

The results of our investigation are in accordance with Zhao's (2002) study [52], as we both found evidence to support the view that R & D reporting has a significant effect on the association of equity price with accounting data. Concerning the fact that we found no evidence to support the view that R & D expenses are value relevant to market value, we verify previous studies, such these of Chan et al. (1999), Callen et al. (2004), and Sofronas et al. (2019) [22,34,35]. Finally, our findings are in agreement with the literature showing that investors react positively to capitalized R & D investment, while they are indifferent to, or negatively placed against, expended R & D.

It is clear that R & D input affects various factors, for example, strategic alliances and external investments, until it enhances financial performance. This is because R & D input represents a firm's willingness to invest in technology. At the same time, R & D may affect the market reputation of a firm [53–55]. Therefore, it is inevitable to create various direct and indirect paths from R & D input to financial outcomes. Nevertheless, it is not possible to measure this supplementary financial outcome, as Greek firms release little relevant information. Thus, this is a limitation of our study. We must also note that we used data of the Greek Stock Exchange and this could be another limitation in our study. Moreover, the fact that we did not expand our research to include the period before 2006 could also be a limitation of our study. This is because the financial data before 2005 were reported according to the Greek accounting standards, and not the international standards that were adopted in 2005.

Future research could be extended to all the PIGS countries. Furthermore, the fact that R & D disclosed expenditures are not relevant to market value could support further discussion with the IASB or the national boards for accounting standards.

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