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THE ROLE OF CONVERTIBLE BONDS ON STOCK DYNAMICS

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Introduction

Convertible bonds, thanks to their perfectly hybrid[1] debt-equity nature, have become an increasingly important and attractive instrument in financial markets. A convertible bond is a kind of security that combines features of debt and common equity in itself, allowing investors to get exposure to the company's equity upside alongside benefitting from the fixed income features of traditional bonds. Structurally, such securities are debt instruments paying periodic coupons and repaying the principal at maturity while also granting the bond holder the right to exchange the issuer's bond for a fixed number of shares in a specified conversion period and at a fixed conversion ratio. Essentially, one could see convertibles as a bond instrument with an embedded call option, the latter of which increases in value as, among other changes, the stock appreciates, and volatility increases[2].

In the United States, convertible bonds have long been used as capital-raising instruments, representing about 10% of all issued securities in the period 1982-2012[3]. However, over the past decade, convertible bonds' share of all corporate bonds has significantly fluctuated, strongly reflecting changes in market conditions. From a low of roughly 23% in 2017 to peaks of around 60% in 2016, 2023, and 2024, this proportion has largely changed, showing a dynamic market environment impacted by macroeconomic factors. The trough reached in 2017 can, for instance, be attributed to low volatility, moderate equity valuations, and very low interest rates, which made traditional bonds more attractive capital-raising instruments. Since 2018, however, the preference for convertibles by US companies has been supported by higher equity valuations, increased market volatility, and, more recently, the strongly restrictive stance of the Federal Reserve. This resurgence is reflected in the 2024 market data, with issuances amounting to around 60% of all corporate bonds': $108.7 billion of convertible bonds issued – a 119.5% increase

[1]Lewis et al. (1999) [66]

[2]As will be more clearly defined later on, the conversion feature of a convertible bond is to be priced using the traditional Black-Scholes-Merton [11] model for derivatives.

[3]Duca et al. (2012)[29]

compared to the pre-Covid issuance levels of 2019[4].

In the Euro area, the convertible bond market has also expanded significantly, albeit only in the most recent period. Indeed, issuance rose sharply in 2024 relative to 2019 (+93%), reaching €11.6 billion in issuances[5]. However, before 2013, convertible bonds were not widely used by European companies, with issued amounts being negligible until sharply increasing to around €4 billion in 2013 – a probable rebound effect following the sovereign-debt crisis. Supporting this hypothesis, issuance dropped again significantly between 2015 and 2017. Since 2018, issuance has risen steadily, supported by high equity valuations during 2019-2022 and a strongly restrictive monetary policy that encouraged the substitution between traditional and convertible bonds. As of August 10th, 2025, over €12 billion of convertible bonds have already been issued, marking a record high.

Overall, recent trends in both the US and Euro area convertible bond markets can be linked to the recent challenging macroeconomic environment, characterized by a global pandemic followed by ongoing wars in Europe and the Middle East. This has caused inflation to spike after a protracted period of low values and to be accompanied by extensive expansionary monetary policy. The consequent higher interest rate environment has thus pushed companies to move from capital-raising activities defined by the possibility of raising debt at extremely low rates to other funding options such as convertible bonds.

The European market for convertibles has thus seen the most changes in recent years. However, with inflation declining and foreseeably undershooting the target in 2026[6], and the consequent European Central Bank's deposit rate stabilising at the 2% neutral rate and making the cost of debt fall, European issuers may now turn back to traditional bonds, causing the convertibles trend to lose some of its momentum. Given this potential near-term shift and limited quality data, a detailed analysis of the European market will be addressed in future research.

By contrast, on the other side of the Atlantic, the US economy has shown

[4]Source Refinitiv. Please note that Convertibles methodology was updated in Dec 2024 and historical data has been revised. This includes all corporate debt, MTNs and Yankee bonds, but excludes all issues with maturities of one year or less

[5]Source Refinitiv

[6]European Central Bank, June 2025, *Eurosystem staff macroeconomic projections for the euro area.* Note that the ECB's macroeconomic projections currently foresee a 1.4% HICP in the 1Q 2026. This projection, however, reflects a baseline scenario assuming 10% tariffs. Despite the recently announced higher US tariff rate at 15%, a further downward revision of inflation projections is not to be expected. In fact, under the severe tariffs scenario which implies effective US tariff rate at 28%, the estimated deviation from baseline is only around -0.1 percentage points.

resilience, with the jobs market remaining strong, consumption staying high, possible inflationary impacts of tariffs, and a subsequent high-for-long Fed interest rate stance[7]. Accordingly, convertibles may remain a key financing instrument for US companies in an environment where the Fed is expected to cut rates gradually in the coming times.

This current macroeconomic background – combined with the US market's size, liquidity, data availability, and deeper historical records – makes the American convertibles market not only more suited, but also more strategically significant for the purposes of this study.

Furthermore, while convertible bonds have received substantial interest from investors and market players in recent years, academic literature has focused on pricing, issuance underpricing, and capital structure implications: a rather small collection of topics, indicating that the subject may still be investigated further.

This narrow scope diversification has left numerous features understudied – or even unstudied – including how the performance of the issuing company's underlying stock is affected by conversion events of convertible bonds. In general, the market reaction to conversion events – which can involve several aspects such as dilution effects, changes in leverage, and investor sentiment – is only partially studied.

Moreover, conversion events depend on specific contractual elements like settlement procedures, call provisions, and conversion ratios, which vary over time and from issuer to issuer. These elements, combined with market conditions, could influence the strength and duration of stock price reactions when approaching conversion periods. For example, the increasing popularity of cash-settlement clauses changes the usual process of stock issuance upon conversion, influencing how arbitrageurs and other market players adjust their portfolios, possibly shaping short-term market dynamics.

Furthermore, investors' decisions regarding the timing and strategy of exercising conversion rights often involve similar considerations across market participants,which can lead to a "consensus" on whether and when to convert. Particularly, bond holders must carefully weigh the possible advantages of an early conversion (e.g., realizing gains from appreciating stocks) against the opportunity cost of not benefiting from the convertible fixed income features. This balancing exercise, carried out by many market participants with possibly similar objectives, may amplify the stock market impact of approaching convertibles' maturity.

For these reasons, this thesis will concentrate on the US convertible bonds market and its links with the underlying stock market, with a particular focus

[7]This thesis was written in the beginning of August 2025.

on how conversion events affect the performance and behaviour of issuing companies' shares.

The following work will be organised into seven chapters. Chapter 1 provides an overview on features, key value drivers, and main pricing techniques of convertible bonds. It also discusses the reasons behind convertible bonds' issuance by companies, alongside the benefits and drawbacks faced by investors. Chapter 2 offers a detailed review of the existing literature. While Chapter 3 formulates the research hypotheses, Chapter 4 explains the data sources and sample construction. The event-study methodology is described in Chapter 5, and the empirical examination of conversion events and their effects on stock prices is presented in Chapter 6. The latest two chapters, Chapters 7 and 8, present possible improvements, implications for issuers, offer suggestions for further research, thus concluding the study.

Chapter 1

Introducing convertible bonds

To give context to the empirical analysis presented in the following chapters, it is essential to first introduce some foundational aspects of convertible bonds (*CBs*). Indeed, this chapter provides the theoretical and practical concepts necessary to interpret market reactions, abnormal returns and factors influencing firms' financing decisions through convertibles.

1.1 Definition, hybrid nature, issuer and investor perspectives

As their name suggests, convertible bonds are debt financial instruments which can be converted – at the option of the investor – into ordinary shares of the CB-issuing company. This attached right – by allowing investors to gain access to the upside equity participation – makes the security more attractive to investors and it is sometimes referred to as an "equity kicker" or even a "sweetener". Convertible bonds belong to a broader family of hybrid securities, combining characteristics of both debt and equity. They can be thought of as a portfolio of a traditional straight bond and a call option on the issuer's stock. Following this logic, the value of a convertible bond can be considered as the sum of the straight bond value and the value of an embedded stock call option. Particularly, this option grants its holder the right – either at maturity or at pre-specified dates – to choose between the principal repayment of the bond or the conversion of the security into a fixed number of shares. In other words, upon conversion, the convertible bond is extinguished, and the former bond holder may become a stockholder[1]. This

[1] In the case of physically settled and combination settled convertible bonds. For further information on settlement kinds, please refer to section 1.6.2.

feature is crucial, as it represents the key distinction between a convertible bond and a warrant.[2]

From the perspective of the issuer, convertible bonds can be an attractive capital-raising technique when compared to their traditional counterparties. They allow firms to issue debt-like instruments at a lower coupon rate versus straight bonds, while deferring equity issuance until more favourable circumstances occur. In this way, convertibles serve to limit the immediate dilutive impact of stock issuance on existing equity, which is negatively perceived by the current shareholders of the firm. This characteristic makes convertible bonds especially appealing for companies expecting growth or stock appreciation, because it enables them to manage their capital structure in a much more flexible manner. Beyond these benefits, convertible bonds may also play a role in corporate governance. Convertible bonds, in fact, contribute to the reduction of the well-known agency costs originating from the principal-agent relationship between company management and traditional bond holders. This happens because the conversion right aligns – at least partially – the bond holders' interests to the equity holders' ones: an alignment which contributes to the reduction of conflicts between stakeholder, thus resulting in better management monitoring. In this sense, convertible bonds serve not only as a capital-raising instrument, but also as a strategic tool against conflicts of interest.

1.2 Conversion features

Turning to valuation, the value of a convertible bond depends on several factors. Being a debt instrument, it is influenced by coupon rate, maturity, default risk (reflecting the issuer's underlying asset risk and bond provisions) and prevailing interest rate levels. However, in the case of convertibles, call provisions – customary in many bond indentures – are especially important as they could be used to force the conversion into stocks once the stock price exceeds the bond's principal repayment. In addition, the value of convertibles is determined by conversion features, which in turn reflect the issuing firm characteristics such as risk profile, capital structure, payout policy, call policy, conversion clauses, and current stock price. The conversion features of a convertible bond include the *conversion ratio*, defining the number of shares that can be obtained by the bond holder by converting a single bond, and the *conversion price*, the nominal amount that must be exchanged at the

[2] In the case of convertible bonds, the conversion eliminates the debt instrument, whereas in warrants the bond is left in place while also providing a separate equity option. Barone (2004) [8]

time of conversion to acquire one share of stock[3].

In equilibrium, the prices of convertible bonds should be such as to remove any arbitrage opportunities for both long and short investors, assuming that bond holders follow optimum conversion methods and issuers use optimal calling policies[4]. This means that the price of a convertible bond should be at least equal to that of the shares in which it can be converted into, or to the straight bond value.

The first benchmark, which can be seen as the value of the convertible "as a stock", is called *conversion value*. It describes the dollar amount that the bond holder would obtain by immediately exercising the attached option.

$$\text{Conversion value} = \text{conversion ratio} \cdot \text{market value of stock.}$$

Because the bond also offers fixed-income payments and seniority in the capital structure, the investor must pay more than the conversion value when purchasing stock exposure through a convertible bond. The second benchmark, the convertible's value "as a straight bond" is the *parity price*[5]. This is the convertible market price that would result in a zero-payoff for the investor if they were to buy the security and convert it immediately at prevailing market price. Mathematically:

$$\text{Parity price} = \frac{\text{Value of convertible security}}{\text{Conversion ratio}}$$

In practice, the value of the convertible bond must always be higher than the parity price as, unlike a traditional bond, it has an embedded – and valuable even when the bond is not currently "in the money" – option allowing the investor to convert the bond into shares. As a result, the lower bound of the convertible price is either the conversion value or the parity price. For instance, if the parity price were to be higher than the convertible price, an arbitrage opportunity would arise and investors could buy the bond, convert it, and sell the shares at a profit until such an opportunity were to be eliminated. To analyse convertible bonds in greater detail, introducing three additional tools could be useful: *premium*, *percent premium* and *break-even yield advantage*. The premium, defined as the difference between the current bond price and the parity price, captures the additional value of the CB due to the embedded stock option.

$$\text{Premium (points)} = \text{Current market bond price - Parity price}$$

[3]This is basically the effective price to be paid per share upon conversion.

[4]Brennan and Schwartz (1980)[13].

[5]The parity price is also sometimes referred to as the market conversion price.

Additionally, the percent premium expresses this relationship in percentage terms:

$$\text{Percent premium} = \frac{\text{Value of convertible security}}{\text{Conversion ratio}} \cdot 100$$

This percentage can then be used to quickly analyse the current behaviour of the convertible bond. A high percent premium indicates that the convertible is expensive compared to the traditional bond, thus the bond's straight value is above the conversion value. This in turn means that the convertible will behave more as a bond and will be more sensitive to interest rates. Conversely, a relatively low percent premium suggests that the conversion value is higher than the straight bond value meaning the convertible behaviour resembles more an equity security.

Lastly, the (yield) *advantage* is a measure of the income advantage from holding the convertible bond with respect to converting it into stocks. This advantage is the difference between the straight bond yield against the dividend yield of the underlying stock. Therefore, a positive advantage indicates a higher bond "carry"[6]. In other words, ceteris paribus, the higher the yield advantage, the quicker the investor is repaid for the premium paid for downside protection.

To measure the time required for a positive yield advantage to repay the premium paid[7], one can compute the *break-even yield advantage*. This measure allows for an easy comparison between the benefit due to the yield advantage and the premium paid to obtain it. [8]

Break-even yield advantage is computed as follows:

$$\text{Breakeven yield advantage} = \frac{\frac{\text{Premium (points)}}{\text{Bond price}}}{\text{Current yield advantage}}$$

1.3 Valuation of convertible bonds

According to Ingersoll (1976) [53] [9], in the basic case in which the convertible bond does not include an early-redemption clause and the conversion option

[6]In the bond field, the so-called carry refers to the fixed-income the investor gets from holding the bond. It is basically the coupon income.

[7]Beware that the break-even yield advantage does not account for the time value of money, thus providing investors with a rough measure which is still very useful for convertible bonds' evaluation

[8]See also Fabozzi and Mann (2010) [37]

[9]The model presented by Ingersoll in 1976 is an extension of Merton's (1974)[79] model. Please refer to the Appendix for additional details.

can only be exercised at maturity, the CB's value can be broken down into its straight debt and equity option components. In such a framework, the standard Black-Scholes formula for European derivatives can then be used to evaluate CBs.

Consider a convertible bond which gives the investor, at maturity T, the right to either receive the fixed income debt repayment at nominal value X or to convert the CB into newly issued stocks corresponding to the α [10] portion of the issuer's common equity. We also assume that shares and convertible bonds are the only issuing firm's liabilities and the value of the firm is V.

Since a CB can be viewed as a portfolio consisting of a straight bond and a call option on equity, we can express its payoff at T as:

$$D_T = B_T + C_T$$

where B_T is the payoff of the straight bond component and C_T is the payoff of the embedded call option.

The straight bond component of the convertible is given by:

$$B_T = \min\left[V_T, X\right]$$

that is the minimum between the principal repayment of the debt and the remaining company value V_T in case of issuing company default. This allows for credit risk to be taken in consideration in the convertibles evaluation, as ignoring it may result in overvaluing the coupons and principal of the bond.

The equity option component payoff is:

$$C_T = \max\left[\alpha V_T - X, 0\right]$$

where the bond face value X is to be seen as strike price of a call option on a stock with value αV_T.

Combining the two components, it is possible to rewrite the convertible bond payoff as:

$$D_T = \min\left[V_T, X\right] + \max\left[\alpha V_T - X, 0\right]$$

Under the standard assumptions of the Black-Scholes model, we can now apply Black-Scholes formula [11], which allows us to evaluate the CB as the sum of a risk-free bond and a European call option on a fraction on the company's equity [12]:

[10] α is also referred to as the dilution factor

[11] Please refer to the Appendix for additional details on Black-Scholes model

[12] See also Barone (2004)[8]

$$D(V, X, T, \alpha, \sigma^2, r) = B(V, X, T, \sigma^2, r) + C(\alpha V, X, T, \sigma^2, r)$$

By looking at the above, it is possible to see that the value of the convertible bond is influenced by the following six factors:

- **Issuing firm value** V: an increase in the firm's value raises the potential reward from both the straight bond component (default risk drops) and the equity conversion option (raising αV), thus making the convertible bond more valuable overall.

- **Bond face value** X **(and "strike price" for the call)**: a higher face value increases the payoff of the straight bond component. However, as the strike price increases, the conversion becomes less probable and the value of the call component drops.

- **Maturity** T: a longer maturity makes the value of the embedded equity option increase as there is a longer time for the option to become in-the-money. However, bonds with longer maturities face greater credit risk, which in turn can reduce the value of the straight bond component.

- **Dilution factor** α: a greater α raises the bond holder's share of the company's stock upon conversion, thus positively affecting the value of the equity option component.

- **Volatility of the underlying stock price** σ^2: stronger volatility increases the upside potential of the conversion option, making it more valuable. If it does not affect the value of the company, it only has little impact on the straight bond component.

- **Term structure of interest rates** r: the bond component's value is negatively affected by an increase in interest rates while, as implied by the Black-Scholes formula, r positively affects the call option component.

Equivalently to the above formulation, the convertible payoff at T can be written to highlight the dual nature of the security which combines the downside protection (captured by the minimum function) together with the potential upside exposure to equity (captured by the maximum function).

$$D_T = \min\left[V_T, \max(\alpha V_T, X)\right]$$

The above is the Ingersoll's (1976)[53] model: it provides us with an easy tool for the evaluation of convertible bonds, and it can be applied for securities with no-early redemption clauses. In real markets, however, CBs can be callable, meaning that the issuer has the right to buy the securities back at certain dates and at pre-specified prices. When the issue is called, the CB's holder has to either accept the debt repayment or exercise the embedded conversion right. Hence, the call feature is typically used by issuers to induce investors to convert their bonds early. Ingersoll (1976) [53] also allowed for an extension of its own model by defining the optimal call strategy for the issuer exercise of its call option. That is, the optimal call happens when the cost of calling the bond is equal to the cost of not calling it or, in other words, when the call price set by the issuer is lower than the conversion value.

$$\alpha V \geq X$$

According to this, the breakeven for the issuer occurs when the value of the issuing company reaches the threshold

$$\bar{V}(t) = \frac{X}{\alpha}.$$

A callable convertible payoff at call ($t < T$) or at maturity ($t = T$) can thus be written as:

$$D_t = \begin{cases} \min\left[V_t, \max(\alpha V_t, X_t)\right], & \text{if } V_t < \bar{V}(t) \text{ (no call)}, \\ \max(\alpha V_t, X_t), & \text{if } V_t \geq \bar{V}(t) \text{ (call)}. \end{cases}$$

Another widely used approach to evaluate convertible bonds, favoured for its simplicity, is based on modelling the price of the underlying stock using a binomial tree. Binomial tree models, which were first introduced by Cox et al. (1979) [23] for the valuation of stock options, can also be extended to convertible bonds. These models – like the ones proposed by Milanov et al. (2012)[81], Ammannet et al. (2001)[4] and Spiegeleer et al. (2011)[93] – are especially useful as they allow several factors to be included in the model so as to capture specific features of the convertible bond. For example, in addition to the regular stock price and interest rates, one could include credit spreads.

A common implementation proposed by Hull (2022) [51] assumes that the stock price follows a Brownian motion, with the addition of short-term default risk. For every short period Δt, a $(1 - e^{-\lambda \Delta t})$ [13] default probability is computed. In case the default event occurs, the stock price will drop to

[13] λ is the so-called hazard rate, defined as the probability that the issuer defaults between period t and t+1, conditionally on no-default events happening before t.

zero in the following period and the recovery value will be paid to the bond holder.

This binomial tree is built so that, at every node, there is a p_u probability of an u increase in the price, a p_d probability of a downward movement of size d, and a probability $1 - e^{-\lambda \Delta t}$ that the issuer defaults, resulting in the stock price being zeroed.

This approach then requires the calculation of the value of the convertible bond at each node, until the value of the final node is determined. This involves assuming that the bond is not converted at any intermediate node and adding the present value of future coupon payments on the bond at each node[14].

In a broader sense, convertible bond pricing models are not only valuable instruments for analyses but are of great importance for the structuring of investment strategies such as arbitrage and hedging. They are also relevant for determining the appropriate issue price of newly issued convertibles. Beyond the models already discussed above, a wide range of alternative frameworks exist in the literature. A detailed description of these, however, is beyond the scope of this discussion.

1.4 Corporate issuance: why firms issue convertible bonds

Companies are commonly believed to issue convertible bonds due to the *debt-like but at a lower rate* feature of these securities. This indeed can be especially reasonable for firms characterized by high-risk and/or high-growth which – logically and traditionally – face higher borrowing costs as well as difficulties in going public and issuing equity instruments to raise capital. However, the topic of why companies issue convertible bonds has been greatly studied, with most capital-structure-choice theories historically being formulated from the perspective of the issuing company. Most of the available literature that studies the matter can be divided into four main theories.

According to the theory proposed by Stein (1992)[94], companies may issue convertible bonds as they see them as an attractive middle ground between equity and debt that allows them to not bear the full costs of either one. Indeed, on one hand, convertible bonds can reduce the adverse selection costs related to directly issuing equity, while also providing an equity-like financing. On the other hand, also the costs of debt issuance are mitigated as

[14] See also Hull (2022)[51]

the issuance of convertibles, unlike traditional bonds, may reduce the potential for financial distress linked to debt. Additionally, when a call provision is also embedded in the convertible bond and conversion can be forced, convertibles can be seen as an indirect equity issuance, only with a weaker adverse effect. Such a theory is thus known as the "backdoor equity" and it carries some useful implications: (1) issuance of convertible bonds usually leads to a less negative effect when compared to a similar sized equity issue, (2) firms that are highly-leveraged, highly-volatile and have a large R&D or intangibles portfolio are the ones that tend to issue convertibles, (3) most convertible bonds are called and forcibly converted soon after the call protection period ends.

The second theory is based on the reduction of the agency costs related to the principal-agent relationship between bond holders and "insiders" [15]. This theory, commonly called the "risk-shifting" hypothesis, states that issuers prefer convertible bonds as opposed to traditional ones since the agency costs of issuing the firsts are lower than for the latter ones. In accordance with this, Green (1982)[45], finds that insiders have incentives to overinvest in risky projects relatively to safer ones and that such risk incentive problem can be controlled by issuing convertible bonds. Indeed, these instruments, thanks to their hybrid nature, reduce the ability of the firm's management to exploit the benefits of financing through straight debt.

The third model is proposed by Mayers (1998) [77] and can be considered similar to Stein's (1992)[94] as it focuses on information asymmetries. However, the two theories look at different kinds of frictions: Stein's (1992)[94] models convertibles as a solution to financing constraints at the time of issuance related to existing assets, while Mayers' (1998)[77] theory focuses on the uncertainty of future financing choices, thus solving possible financing issues only in the future [16]. Mayers (1998) [77] argues that the issuance of convertible bonds for capital financing provides a solution to the problems created by the application of sequential financing strategies[17] (i.e., raising capital in multiple stages to match funding with the needs of planned investments). Some examples of the effects of sequential financing include: managers may reduce their effort as later funding instalments may never come; an initial investment that is too low can make the project fail pre-

[15] Green (1982)[45] refers to "insiders" as those "who wish to maximize the value of their residual claim while financing operations with debt. The use of value maximization as the decision makers' objective ignores distinctions between equity holders and management".

[16] See also See also Renneboog (2006) [86]

[17] Firms carry out sequential financing strategies as they help in controlling management incentives to over-investing when funds are provided up front for the initial project and for any other sequential investments in the project.

maturely; early performance can be deceitfully increased to attract further investments (Cornelli et al. (2003)[22]) and high issuance costs for sequential financing may be high due to funds being raised multiple times (Mayers (1998)[77]). Thus, according to Mayers (1998)[77], firms can issue convertible bonds to fund the initial project, then force their conversion to finance their subsequent needs without incurring in additional costs of financing and also reducing the agency costs that arise due to conflicts of interests between management and debt holders.

According to the fourth theory, the popularity of convertible bonds as financing instruments is due to their ability to reduce information asymmetries in markets. In particular, as firstly demonstrated by Brennan and Kraus (1987)[12], convertibles allow companies to reveal the private information of corporate insiders to investors, thus reducing the adverse selection problem present in markets[18]. For this reason, they represent an appropriate strategy for capital financing. Furthermore, as later proposed by Brennan and Schwartz (1988) [14], convertible debt financing mitigates the misalignment caused by information asymmetries between management and bond holders in estimating the issuing firm's risk. According to their expanded theory, in fact, investors are willing to buy a convertible bond instead of a straight bond only because its hybrid nature makes it relatively insensitive to the risk of the issuing company. In particular, thanks to the embedded equity option, convertible holders are less concerned about management increasing risk to seek higher returns: while this would decrease the value of the straight bond component, it would increase the value of the option. CBs can therefore be issued on terms that look fair to the management, even when markets are wrongly overpricing the firm's risk and are requesting a high coupon. In this way issuance of convertible bonds can serve as a signal of the correct firm's perceived risk, thus contributing to the reduction of information asymmetries.

The four theories presented, even though they do not represent the totality of research conducted on convertible bonds issuance, as demonstrated by Dutordoir et al. (2014)[30], are to be considered the benchmarks in the understanding of issuers' motives. They are, in fact, the only models for which empirical data has consistently demonstrated validity.

[18] Companies aim to maximise the difference between the funds raised and their actual value. In equilibrium, each financing approach is chosen by the least suited firm (Akerlof's (1970)[1] "market for lemons" dilemma). So, by signalling company quality, convertible securities, as well as junior bonds and bonds with warrants, reduce adverse selection.

1.4.1 Impact on capital structure and shareholders

Following the discussion on the rationale for convertible bonds issuance, we now address how they affect capital structure and shareholder value.

Lewellen(1973)[64] sheds light on the dilutive effects of convertible debt financing. As bond holders exercise their conversion rights, the issuing firm will provide them with newly issued stocks, thus increasing the number of shares and reducing the ownership portion of existing shareholders. This will in turn lead to the reduction of residual earnings of the firm accruing to existing shareholders. In other words, evidence is provided that *"the most successful convertible bonds – as properly judged by immediate wealth impact on present shareholders – are those which are expected never to be converted"*.

King (1984) [60] also presents some research on the effect that issuing convertible bonds has on dilution of equity and firm's leverage. Firstly, the study reveals that convertible bonds have a significant equity component, representing 16.7% of book values and 18.4% of market values, thus underscoring the hybrid role of CBs and highlighting their potential impact on shareholders' equity. Indeed, convertibles are shown, through their equity component, to contribute to the dilution of common equity, with such dilution being considerable for some firms. This dilutive effect occurs independently of the conversion event [19] as it arises from the fact that CBs – as potentially dilutive securities – embed an equity value in them. This, in turn, is a cost for shareholders and is represented by the reduction of their residual interest in the firm's value. Such a cost, if CBs are correctly priced, is compensated by the lower coupon paid on convertible vs traditional debt.

However, from a strategic and investor standpoint, dilution should not be viewed as intrinsically negative. Gillet et al. (2010) [44], argue that, while existing shareholders can be negatively impacted by the dilution effects of convertible bonds, their issuance can also provide some positive effects. First of all, a CB issue does not always result in a detrimental dilution. Furthermore, issuance may act as a positive signal for investors about the firm's intent to restructure liabilities and optimise its debt structure. Finally, convertible bonds help in generating future value for the company by allowing it to pursue additional – and potentially profitable – investments.

In conclusion, while CB issuance has a negative dilution effect on stocks, its extent is not uniform and is critically dependent on the specific conversion features of the instrument, as previously mentioned. Additionally, other factors can influence actual dilution such as the firm's and security's settlement policies. These will be presented in following sections.

[19] The dilution effect due to the possibile conversion of the convertible bonds is the so-called "potential dilution"

1.5 Convertibles strategies

A convertible bond arbitrage strategy is based on identifying the presence of any market mispricing and taking a position in the security to get a positive return. As this usually also entails getting exposure to other factors, some hedging is needed to hold the desired position in the mispriced instrument while, to the greatest extent feasible, neutralising the risk from all other sources of exposure.

Keep in mind that convertible bonds arbitrage is only a so-called arbitrage as it still involves some risk for the investor. Let us consider a case in which a market undervaluation of a CB is identified and, consequently, a long position is taken on the mispriced security. In addition to the possible incorrect mispricing identification, this position is exposed to two other main risks: movements in underlying stock prices and in interest rates. As this is a long position, the first source of risk is likely to be hedged by opening a short position on the stock. The following paragraph will provide a more in-depth description of this hedging procedure. To hedge the interest rate risk, short positions in the benchmark government bonds or in interest rates futures can be taken.[20] In particular, such rates risk can be measured through the effective price duration, also called *Price Value of a Basis Point* or PV01[21]. This measures the bond's price sensitivity to changes in the benchmark yield curve, specifically indicating how much the price will shift for a 1 basis point change in the yield curve. The PV01 can then be used to calculate the hedge ratio:

$$\text{Hedge Ratio}_{IR} = \frac{\text{PV01 of CB to be hedged} \cdot \text{Yield beta}}{\text{PV01 of hedging vehicle}}$$

where the *Yield beta* is defined as the slope coefficient β from the simple linear regression of changes in the yield of the bond to be hedged, $\Delta yield_{\text{CB}}$, on changes in the yield of the hedging instrument, $\Delta yield_{\text{HedgeVehicle}}$[22].

Overall, the long position in the CB that we have just described generates both some inflows and some outflows. Convertible bond coupon payments

[20] Short positions must be "covered", thus implying a stock borrowing procedure. Naked short positions are not allowed in most markets

[21] For USD-denominated securities, the *Dollar Value Duration* or the DV01 is used. It is the equivalent of the PV01 as it measures the change in dollar value corresponding to a one basis point change in yield.

[22]

$$\Delta yield_{\text{CB}} = \alpha + \beta_{\text{yield}} \, \Delta yield_{\text{HedgeVehicle}} + \epsilon$$

and rebates[23] on the cash collateral provided for the stock lending are some of the sources of cash inflows. Cash outflows, instead, include dividends on the shorted shares which must be paid to the securities lender.

1.5.1 Hedging underlying stock risk

Just like for interest rate risk of CBs, it is possible to measure the exposure that convertible bonds have, through their embedded equity option, to underlying stocks. In particular, as supported by literature (see for instance Burlacu (2000)[17], Prokop et al. (2024)[84]), stock risk is to be assessed using the *Delta* (Δ) measure. In the context of CBs, the Δ specifically measures the sensitivity of the convertible bond price to changes in the underlying stock price and it can take values between 0 and 1. A Delta close to 1 – thus a higher sensitivity to stock price changes – indicates that a convertible bond's behaviour is similar to that of equity, whereas a value closer to 0 implies that the CB is more debt-like.

The Delta introduced above is the stock option Delta and it is derived from the well known Black and Scholes' (1973) [11] model for option pricing, later adjusted by Merton (1973)[78] to account for continuous dividend payments. It can be mathematically expressed as:

$$\Delta = e^{-\Delta T} \cdot N \left(\frac{\ln \frac{S}{K} + (r - \Delta + \frac{\sigma^2}{2}) \cdot T}{\sigma \sqrt{T}} \right)$$

where S is the current stock price, K is the conversion price, Δ is the continuously compounded dividend yield, r is the continuously compounded risk-free rate, σ is the annualized stock volatility, T is the time to maturity, and $N(\cdot)$ is the cumulative standard normal distribution.

In order for the stock risk to be hedged, a Delta neutral portfolio of convertible bond positions and stock positions must be constructed. The Delta neutrality implies that the long and short positions in the portfolio are so as to eliminate any exposure to the stock price movements. For the portfolio to be Delta hedged, for each long position on a CB, the investor has to open a short position on a number of shares given by:

$$N_{\text{ShortStocks}} = \Delta \cdot \text{Conversion Ratio}$$

where Δ is the Delta of the convertible bond.

[23] Shares to cover short positions are borrowed according to a securities lending agreement which usually includes some collateral posting. Collateral is often constituted of cash or marketable securities and provides the borrower with a rebate on its reinvestment.

Such $N_{\text{ShortStocks}}$ can also be referred to as a hedge ratio for the stock component of the convertible bond (Hedge Ratio_{Eq}).

However, the arbitrage setup is not fixed, it varies over time. As the stock price rises and approaches the conversion price, the Delta measure of the convertible bond will increase, thus pushing the investor to short more underlying stocks to maintain the portfolio Delta neutrality. The opposite holds as the stock price falls.

1.6 Conversion and settlement

Having defined the structural features, the valuation methodologies and the strategic applications of convertible bonds, it is useful for the purpose of this study to examine how investors exercise their conversion rights and how settlement of convertible bonds is carried out.

1.6.1 Mechanics of conversion. ITM, ATM, OTM

Convertible bonds, thanks to their hybrid nature, present a unique payoff structure that combines aspects of both equity and debt. To understand the CBs behaviour it is useful to plot the convertible's price against the level of the underlying stock as in Figure 1.1.

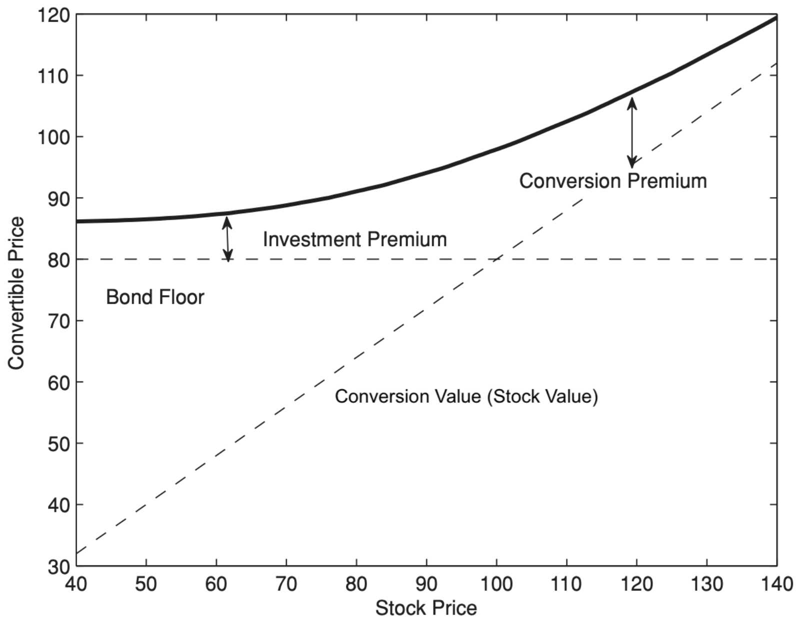

Figure 1.1: Boundaries on convertible price: bond floor and conversion value.
Source: De Spiegeleer et al. (2011) [93]

From this, two key features are highlighted: the premium and the conversion value[24].

For lower stock prices, the premium increases; while for higher ones, it decreases thus leading to the convertible price converging to the conversion value. This positive convexity (also measured by the Gamma[25] of the CB) guarantees upside equity exposure, while the bond floor serves as a protection against downward movements.

The graphed behaviour, however, can vary from reality. In case of a sharp stock price drops, the issuer's credit worthiness may deteriorate, making the bond floor decrease and pushing the convertible's value towards the conversion value and, in some specific cases, creating zones of negative Gamma. This is illustrated in Figure 1.2.

[24]In Fabozzi (2020)[36], the conversion value is referred to as Parity. However, to avoid confusion with the bond parity price, the term conversion value is used.

[25]The Gamma (Γ) of a convertible bond is the same as an option's Gamma. It is a measure of the Delta (Δ) sensitivity to changes in underlying stock price. For additional details on the so-called Greeks, please refer to the Appendix

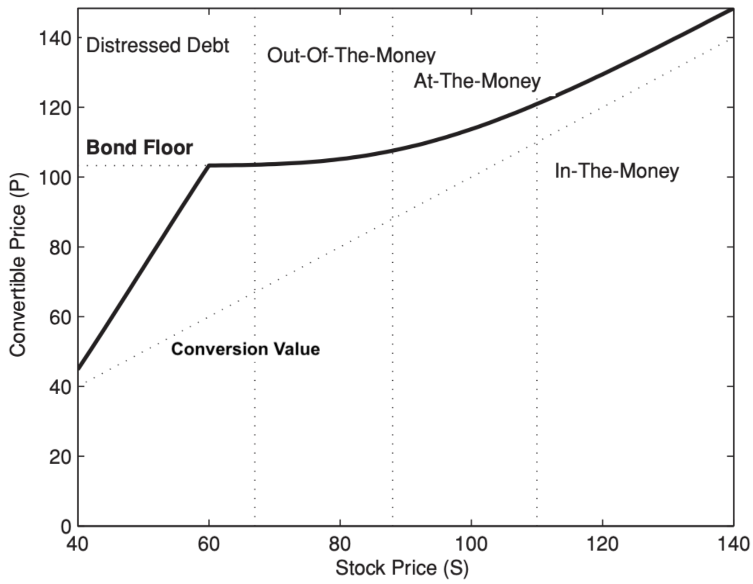

Figure 1.2: Profile of convertible, where the bond floor is affected by a low share price. *Source: De Spiegeleer et al. (2011) [93].*

According to Figure 1.2., the convertible bonds' behaviour can be divided into 4 main categories: distressed debt, out-of-the-money, at-the-money, and in-the-money.[26]

Distressed convertibles may trade below the theoretical bond floor, having lost the majority of their premium, and trading near conversion value. These convertibles, due to their high Gamma, are very equity-like. This means that small changes in underlying stock result in larger Delta changes. In contrast with the other phases where the bond floor provides some downward protection, for distressed convertibles credit spreads[27] increase rapidly.

Out-of-the-money convertibles are the ones which present a conversion value much higher than the market stock price. Their payoff is mostly bond-like and it is influenced by yield curves and changes in interest rates; their Delta is between 10% and 40%. At this point, the investment premium may drop to 15% or less, getting closer to the bond floor, while the conversion premium is typically above 50%.

At-the-money convertibles, which are also referred to as *balanced convertibles*, present the highest convexity. Their Delta, which ranges between about 40% and 80%, shows a balanced sensitivity to changes in fixed-income

[26]De Spiegeleer et al. (2011)[93], Fabozzi (2020) [36]

[27]From Figure 1.2. it is very easy to see how much the difference between the bond floor value and the CB value increases as stock prices fall under a certain threshold. This difference is the credit spread.

dynamics and to equity price movements. ATM convertibles also have an investment premium of 15% to 25% and a conversion premium of 15% to 40%.

Finally, convertibles are said to be *in-the-money* when the stock price rises significantly above the conversion value. Indeed, their behaviour is strongly correlated to equity, as convexity drops and their Delta rises above 80%. In particular, these instruments show an investment premium greater than 40% and a conversion premium at 15% or lower, and are likely to be converted by bond holders.

1.6.2 Settlement types

A convertible bond's settlement-method specifies the way in which the bond holder will be paid upon exercise of the equity option embedded in the security. There are three main categories of settlement for convertibles: physical, cash, and combination settlement.

In a *physical settlement*, physical stocks of the issuing company are delivered to the investor, based on the conversion ratio of the convertible bond. Any fractional shares, which cannot be delivered, are remunerated in cash to the bond holder. As the CBs physical settlement-method, however, requires the issuance of new stocks, it has a strongly dilutive effect on the underlying stocks' value for the existing shareholders. Building on this, in recent years, issuers have developed some specific contract designs that mitigate dilution while also keeping the benefit of a lower coupon vs traditional bonds. These contract innovations have been studied by the literature. For instance, Korkeamaki (2005)[61] analyses the inclusion of soft and hard call features, Marquardt and Wiedman (2005)[75] study the use of contingent conversion features, finally, Henderson and Zhao (2014)[50] focus on concurrent transactions.

Another notable antidilutive innovation is represented by cash settlement features, which were investigated by Lewis and Verwijmeren (2011)[67]. *Cash settlement* involves the cash payment of the conversion value to the bond holder. Such conversion value is computed upon conversion based on the market price of the stock that would have been delivered if settlement was physical (the value is usually averaged over a short time frame called observation period, so that short-term fluctuations are smoothed out).

Finally, *combination settlement* is a hybrid between the two previously-described settlement-methods. It involves splitting the conversion amount to be delivered to the bond holder between cash and stocks. A popular variant of this approach is *net share settlement* in which the bond holder receives the principal repayment of the convertible's fixed income component in cash, while any excess value above this is delivered in shares.

1.6.3 Arbitrage with different settlement types

The type of settlement at conversion has a significant impact on the arbitrage activity involving convertible bonds. Investors having a short exposure to the underlying shares of physically settled notes, to maintain a delta-neutral hedge, will convert the CB and use some of the received shares to close out their positions. Any excess stock will then possibly be sold on the market or held. Furthermore, if an investor anticipates receiving more shares than those needed to cover the short position, an additional hedging strategy may be implemented against the stock price fluctuations happening in the period between the conversion date and the delivery date. This is achieved by short selling on the conversion date exactly the number of stocks that will be received (on delivery date) in excess of the ones needed for the CB arbitrage strategy. [28]

In case of cash settlement, the bond holder receives cash based on the volume-weighted average price (VWAP) of the underlying stock over a predetermined multi-day observation period just before the so-called "convertible until date". Thus, in order for the arbitrageur to hedge its position, he/she has to buy shares on the market. This, however, is done in a way that minimizes exposure to the stock price fluctuations over the observation period: the daily stock purchases are thus structured so that the average price paid approximates the VWAP. By following this strategy, the investor eliminates the risks entailed by price movements as on days of upward movement, the price paid for the purchase will be higher but so will be the cash amount received upon settlement.

Also in the case of combination settlement, the investor will follow a similar strategy by making stock purchases on the market throughout the observation period. The considerations on the amount of shares to be bought will however be different, as in this case the investor expects to receive also some physical shares upon settlement, which can be directly used to close the short position. [29]

[28] As both the sale and the conversion transactions will be settled on a t+2 basis, in this way the investor locks in the trading price on conversion date while delivering the stocks upon conversion settlement date. If settlement also includes cash or combination provisions, this process becomes more complex.

[29] See also Rodgers and Banghai, Latham and Watkins (2024)[87].

1.7 Market participants

Due to the complexity of the securities, the convertible bonds markets are dominated by specialised investors. According to Fabozzi (2012)[35], the majority of holdings have historically been made up of convertible arbitrage hedge funds and dedicated outright (long-only) convertible bond funds, which together have accounted for at least 75% of market and secondary flows during the period 2002-2012. The appeal of convertibles is mainly due to the positively convex payoff that characterises them, thus minimising losses in volatile markets while profiting from the upside pressure of equity rallies.

1.7.1 Convertible arbitrageurs: hedge funds

Hedge funds are particularly large players in the convertible bonds market. They became the market leaders for convertibles in the late 1990s, and by 2008, according to Fabozzi (2012)[35], controlled a similar percentage of ownership and about 80% of daily trading volumes. However, the 2008 global financial crisis caused a major decline in the convertible arbitrage hedge fund market, as many participants were forced to leave due to funding and deleveraging issues. In the crisis aftermath, according to Masters (2009)[76] , hedge funds accounted for less than half of the purchasers of new convertible bond issues, highlighting the extent of their retrenchment. Despite this slump, in 2012, these investors still accounted for between 50% and 75% of daily trading volumes and about 40% of convertible bond ownership.

Hedge funds focus on convertible bonds arbitrage with the aim of achieving a high information ratio for their fund, while also producing returns that have a low correlation to the stock market. Their intense activity in this market can be justified by the fact that convertible bonds' embedded equity option is often undervalued, allowing them to profit from large stock price changes. In order to maximise the benefits of the convertibles' convexity, hedge funds usually focus on convertibles issued by companies with volatile stocks and for which the stock price is between 80% and 130% of the conversion price.

The main risk in a Delta-hedged convertible bond position is the residual credit-spread or default exposure. To hedge such risk, credit default swaps (CDS) are usually bought. While the use of CDS reduce the carry of the position, they offer a protection against default events and credit-spreads widening too much. However, in practice, convertible arbitrageurs typically rely only on equity hedges, except for highly stressed issuers. They take advantage of the convertible bond's convexity and positive Gamma characteristics, while dynamically changing the hedge ratio to minimise the residual credit exposure.

1.7.2 Dedicated outright convertible bond funds

In addition to convertible arbitrage hedge funds, another large category of convertible bond investors is funds that focus on managing portfolios of convertible bonds on an outright, or unhedged, basis—typically against a convertible bond benchmarking index. Indeed, according to Fabozzi (2012)[35], in the early to mid-1990s, these "outright players", which included both equity-focused investors and specialised convertible bond funds, dominated the market. However, as convertible bonds became more and more incorporated into hedge fund strategies, their market share dropped to just roughly 10–20% by 2005. As the hedge fund industry shrank and leverage was drastically cut after the 2008 financial crisis, outright investors once again gained traction. According to Fabozzi (2012)[35], by 2010, 15–20% of ownership and daily trading volumes were made up of dedicated outright funds. Even though outright funds evaluate some similar factors to arbitrageurs when selecting convertible bonds, their performance will be more influenced by their views on a given company's equity valuations. In contrast to arbitrage funds, they typically favour issuers with more stable fundamentals and focus on convertibles with a "balanced" equity sensitivity, where the underlying stock price is between 80% and 120% of the conversion price. At the portfolio level, outright funds manage large exposures to credit, equity, interest rate risk, and equity volatility. Usually, equity risk is the main factor influencing performance, but credit risk is also very important. In contrast, due to the common short duration of CBs, interest rate risk and equity volatility are typically less significant, with the exception of extremely stable market conditions.[30]

[30] Fabozzi (2012) [35].

Chapter 2

Literature Review

Building on the core concepts covered in the previous sections, this chapter examines the body of research on the reaction of financial markets to convertible bonds. The literature on convertible bonds has generally developed along two main lines: empirical studies of equity market reactions at issuance and pricing models attempting to capture the hybrid nature of these securities. As the research most relevant for this thesis focuses on market responses to issuance and conversion events, the following review will focus on event-study evidence. It will specifically look at how stock prices and trading activity are impacted by convertible bond announcements and issuances, as well as how arbitrage tactics and settlement procedures influence these results.

2.1 Event studies of convertible bonds

As event studies enable researchers to measure the extent to which equity markets take into account information about issuance and conversion events, they have been extensively used in the analysis of convertible bonds. Because convertibles are hybrid securities that involve intricate relationships between debt and equity holders, this approach is especially appropriate for them. Particularly, the literature in this field has mostly examined the longer-term performance of issuing firms as well as the short-term stock price responses to the announcement of new issues. Another line of inquiry looks at how trading volumes, settlement features, and arbitrage activity influence markets. When taken as a whole, these studies offer valuable insights into how convertible financing decisions signal and how financial intermediaries influence stock price dynamics. A more thorough review of this literature is provided in the following sections, with an emphasis on the effects of announcements and issuances, long-term performance, and the function of arbitrage and settlement-mechanisms.

2.1.1 The announcement and issuance effects for convertible bonds

One of the most studied topics in the field of convertible bonds is the effect of convertible bonds issuance on the underlying stocks. Most of this large body of existing literature converges on the fact that the announcement of convertible bond issuance by companies is associated with negative abnormal returns. Consistent with the pecking order and adverse selection hypotheses thought by Myers et al. (1984)[83], Dann et al. (1984)[24] and Mikkelson et al. (1986)[80] argue that US financial markets generally view CB issuance as a negative signal. When management believes the stock is overpriced, convertible bonds may represent a more attractive capital-raising choice. Should this hold and/or markets were to reach consensus on this view, stock prices would likely be driven down by sell-off pressures. Indeed, Dann et al. (1984)[24] report average abnormal stock returns of -2.31% during the announcement period while Mikkelson et al. (1986)[80] found a -1.97% change in issuers' stock prices. An exceptional result is to be found in Fields and Mais (1991)[42] who looked at privately placed convertible debt and documented a +1.80% average abnormal reaction to convertibles issuance.

However, convertible bond issuance announcements have been proven to have diverse effects on other non-US markets. For instance, Kang and Stulz (1995)[57] show that issuance of convertibles in Japanese financial markets has been linked to positive abnormal returns of underlying stocks. Roon and Veld (1998)[28] also find significantly positive announcement impact at CB issuance in the Dutch market. In French markets, results contrast depending on the size of the sample and the methodology applied. While Hamon and Jacquillat (1992)[48] report negative market responses, Maati-Sauvez (1998)[73] finds no significant impacts and Burlacu (2000)[17], by controlling for debt and equity components, shows positive abnormal returns.

Additionally, since the convertibles' specific offering terms – like the coupon rate, offering price, and conversion ratio – are usually communicated at issuance rather than announcement, markets may also exhibit abnormal reactions at issuance. Dann and Mikkelson (1984)[24] support this view, showing that common stockholders encounter negative abnormal returns both upon the date of announcement and of issuance for convertible bonds. Nonetheless, existing studies on CBs present less consistent findings for issuance effects than for announcement responses. According to Prokop et al. (2024)[84], literature on US markets shows on average ex-financials

CAARs equalling to -1.03%, while Ammann et al. (2006) [2] reports a 0.40% on average for European markets (specifically Germany and Switzerland)[1].

There are however conflicting studies on the statistical significance of CAARs, with the majority of the literature presenting significant and negative CAARs (for instance, see Dann and Mikkelson (1984)[24], Mikkelson and Partch (1986)[80], Billingsley et al. (1990)[10], de Jong et al. (2011)[27], de Jong et al. (2012)[26]) while some others reporting the non-significance of CAARs (Arshanapalli et al. (2004)[5], Ammann et al. (2006)[2]).

Furthermore, several researchers examine the key drivers of the cumulative abnormal returns associated with the convertibles' issuance. In particular, according to Janjigian (1987)[55], the market reaction to CBs issuance is negatively related to the equity component of the security. Jen et al. (1997)[56], Burlacu (2000)[17], Ammann et al. (2006)[2], Loncarski et al. (2008)[71], de Jong et al. (2011)[27], and de Jong et al. (2012)[26] support this finding. CARs around the announcement date are also negatively related to time to conversion, as shown by Davidson III et al. (1995)[25].

Additionally, Jen et al. (1997)[56], Lewis et al. (1998, 1999)[65][66], Burlacu (2000)[17], Chang et al. (2004)[20], and de Jong et al. (2011)[27] present evidence that CARs are higher for growth companies and more leveraged firms. With regards to credit rating, the body of research does not converge: Jen et al. (1997)[56] report higher CARs for speculative grade bonds, while Lewis et al. (1999)[66] presents evidence that markets react more negatively to convertible debt offers from non-investment-grade firms. Another point of disagreement is about stock return volatility as, while Dutordoir et al. (2016)[31] argue that CARs are negatively related to it, Marquardt and Wiedman (2005)[75] and Suchard (2007)[95] find evidence of a positive relation. The latter two are in accordance with Chang et al.'s (2004)[20] statement that firms with higher ex-ante volatility in their stock returns face higher uncertainty about their cash flows, thus incurring in larger costs of financial distress.

Also, according to the existing literature, cumulative abnormal returns greatly benefit from better market performance (Ammann et al. (2006)[2], Li et al. (2016)[68]), higher profitability (Marquardt and Wiedman (2005)[75]), higher market volatility (Dutordoir et al. (2016)[31]), dividend payments (de Jong et al. (2012)[26], Loncarski et al. (2008)[71]), less diversified firms (Chang et al. (2004)[20]) and tax benefits (Dutordoir and van de Gucht (2007)[33], Marquardt and Wiedman (2005)[75]).

There are inconclusive findings on issue size, issuer size, and financial

[1]The restriction of the analysis to only Germany and Switzerland causes the research to ignore larger, EU-wide contexts

slack. While Kang et al. (1996)[57], de Jong et al. (2012)[26], Dutordoir et al. (2016)[31], and Li et al. (2016) find evidence of issuer size having a negative impact on CARs, Arshanapalli et al. (2004)[5], Marquardt and Wiedman (2005)[75] find the opposite effect.

2.1.2 Price impact and arbitrage opportunities at issuance

A similar line of research focuses on how the issuance of convertible bonds is linked to arbitrage opportunities. According to Loncarski et al. (2009)[72], the participation of hedge funds in convertible arbitrage can amplify the short-term negative stock price movements by opening a short position on the underlying equity to hedge their convertible position. This microstructure-based process may help explain the magnitude of the downward pressure on stock prices upon CB issuance. This idea is supported by Hackney (2020)[47]. Furthermore, Choi et al. (2010)[21] study the possible role of arbitrageurs as capital suppliers in convertible bonds issuance and demonstrate that the supply of capital from arbitrageurs has a major impact on convertible bond issuance, with issuance sharply declining during the 2008 short-selling ban.

Additionally, according to Yildiz (2018) [98], arbitrage activities have not only a short-run impact, but also affect stock price movements in the long-run.

Furthermore, by building a simulated arbitrage portfolio, Hutchinson and Gallagher (2010)[52] investigate the risk characteristics of convertible bond arbitrage hedge funds. They demonstrate that simulated portfolio have the same statistical characteristics of hedge fund indices (e.g., negative skewness and excess kurtosis), and that default risk, term-structure risk, and excess return are the major drivers of returns. Their findings also show that convertible bond arbitrage funds typically have modest abnormal risk-adjusted returns, and that the performance of the funds is heavily reliant on stable market conditions.

2.2 The impact of settlement-mechanisms in prior research

While most of the body of research has focused on pricing effects, announcement and issuance reactions in the market and arbitrage activity, there has been less attention towards the conversion, settlement and maturity of convertible bonds. This is also linked to the fact that convertible bonds have typically not survived to their claimed maturity, with Asquith (1995)[6] reporting that more than 90% of his raw sample was either recalled, repurchased or retired around a decade after issuance. Also Korkeamaki and Michael (2013)[62] report that around 25% of their raw sample had to be removed as it was impacted by M&A proceedings, while in Grundy and Verwijmeren's (2016)[46] study almost one-third of the bonds were called early, and fewer than 10% of their sample made it to maturity. Due to this, one of the few available studies on the topic was carried out by Gatti and Sperl (2024)[43], who offer an analysis of the impact of cash-settled convertible bonds at maturity. They argue that at settlement, in contrast with physical settled CBs which often present negative abnormal returns, cash-settled convertibles present positive abnormal returns for the underlying stocks. This phenomenon can be attributed to the intense market trading activity carried out by arbitrageurs and option dealers in the period before the CBs' settlement, which in turn leads to increased trading volumes and lower equities short-interest.

2.3 Gaps in current research

By reviewing the current literature, it can be easily noticed that a number of areas are still lacking in development. Firstly, the impact of settlement-mechanisms on market outcomes has not been thoroughly examined. Although there has been general discussion of convertible contract design, virtually no research has specifically examined the impact of cash versus physical (or combination) settlement at maturity.

Additionally, not enough research has been done on the conversion/maturity phase itself. It is unclear how markets will handle the concentrated stocks trading flows and hedging adjustments that take place as bonds get closer to their final conversion date.

In addition, current research rarely establishes a settlement-specific connection between hedging activity and observable market metrics like trading volume spikes, abnormal returns, or short-interest dynamics. Even though it does not distinguish between contracts where hedges are crucial in the market (cash settlement) and those where share delivery (physical settlement) enables positions to be closed without involving significant transactions, the arbitrage literature does document general hedging behaviour.

Lastly, despite the growing use of cash and net-share settlements in US-markets, there is little empirical data regarding their effects. This creates a gap in the knowledge of how contractual design decisions can affect price behaviour and liquidity around maturity, both academically and practically.

Chapter 3

Hypotheses development

The existing literature that has just been introduced has primarily focused on announcement and issuance effects, with the end of life phase and the function of settlement-mechanisms remaining relatively understudied, as previously pointed out. This chapter fills in these gaps by formulating a series of hypotheses intended to examine the ways in which various settlement clauses affect market outcomes as convertible bonds get closer to the "convertible until" date. The three observable aspects of equity market activity—trading volumes, abnormal stock returns, and short-interest—that are specifically connected to arbitrageurs' hedging behaviour are the focus of this study. These hypotheses are based on well-established theoretical frameworks on arbitrage and price pressure, as well as more recent empirical findings like those of Gatti and Sperl (2024)[43].

3.1 Hypotheses

- H1: Trading volume increases significantly in the days before the "convertible until" date, and this increase is larger for cash-settled convertibles than for physically settled ones. Trading volumes increase more under cash and net share settlements.

- H2: Around the final conversion/maturity date, stocks of firms with cash-settled convertible bonds exhibit stronger abnormal returns than firms with physically settled convertible bonds, followed by a more pronounced reversal in the days after.

- H3: For cash-settled convertible bonds, short-interest drops before maturity, but it remains relatively stable for physically settled convertibles.

3.2 Rationale

3.2.1 H1 - trading volume

Settlement-mechanisms of convertible bonds significantly influence the arbitrageurs' hedging strategies as convertible bond's "convertible until" date approaches. In order to preserve delta neutrality, convertible arbitrageurs usually maintain a long position in the bond and a short position in the underlying stock (Burlacu (2000)[17]). These hedges need to be dynamically modified as the bond approaches its convertible date (Loncarski et al. (2009)[72]) and the delta of the convertible bond changes. In particular, in the case of cash-settled convertibles, arbitrageurs must repurchase stock on the market prior to settlement as they are unable to rely on receiving shares at settlement to cover short positions. As this creates a buying pressure, traded volumes may rise above average. It is possible that similar dynamics may affect net-share and combination settlements as these mechanisms do not provide arbitrageurs with sufficient shares to cover their short positions, thus pushing them to engage in market activity.

This hypothesis is consistent with theory. According to Hull (2022)[51], the delta of derivative positions becomes more sensitive as maturity draws near, necessitating more frequent rebalancing. This suggests that arbitrageurs need to buy/sell more of the underlying equity as the convertible bonds approach maturity.

3.2.2 H2 – abnormal returns and reversals

Stock prices are significantly impacted by the hedging flows that cause variations in trading volume. Since no physical shares are delivered in cash-settled convertibles, arbitrageurs must repurchase stock on the open market prior to the maturity date in order to replicate the settlement value. Stock prices experience brief upward pressure as a result of this process. In contrast, arbitrageurs can use the delivered shares to close their short positions in physically settled convertibles, limiting price distortions and removing the need for significant open-market transactions.

The price-pressure hypothesis, which states that predictable buying can influence prices in the short term even when the market fully anticipates the information, theoretically explains this mechanism (Harris and Gurel (1986)[49]). According to Kaul et al. (2000)[58], inelastic demand curves for stocks suggest that short-term supply and demand imbalances have the potential to push prices above fundamentals. However, arbitrage is expensive and imperfect, according to the limits-to-arbitrage framework (Shleifer and Vishny (1997)[92], Wurgler and Zhuravskaya (2002)[97]), so these deviations cannot be arbitraged away entirely. Hedging activities related to cash-settled convertibles should therefore result in brief but quantifiable abnormal returns. This latter dynamic is also supported by empirical research: Gatti and Sperl (2024)[43] demonstrate that cash-settled convertibles in particular produce abnormally high trading volumes prior to maturity, while Loncarski et al. (2009)[72] document that hedging activity surrounding convertibles influences market activity.

3.2.3 H3 – short-interest

In order to preserve delta neutrality, convertible bond arbitrage usually entails holding a long position in the bond and a short position in the underlying stock (Burlacu (2000), Loncarski et al. (2009)). The bond's settlement type has a direct impact on how this hedging is carried out.

Arbitrageurs cannot rely on getting shares at maturity for cash-settled convertibles. Rather, near maturity, they must repurchase stock on the open market to cover their short positions. A decrease in short-interest should be the outcome of this phenomenon.

In contrast, arbitrageurs anticipate receiving shares at maturity for physically settled convertibles, which they can use to close their short positions. As a result, the short-interest level of CBs settled as such should stay relatively stable since there is little reason to unwind hedges beforehand.

For cash settlement, this expectation is supported by empirical studies: Gatti and Sperl (2024)[43] find a significant decrease in short-interest prior to maturity for cash-settled convertibles.

Chapter 4

Data and sample

4.1 Sample construction

The sample is constructed to obtain a dataset that can be considered as representative of US convertible bonds with the following features:

- Pricing date since year 2000 (January 1st, 2000)
- Maturity date no later than 2024 (December 31st, 2024)
- Issued amount greater than USD 50.00 million[1]
- Amount outstanding at the "convertible until date" greater than USD 50.00 million
- If physical or combination settled, shares delivered must be the issuer's (neither a basket of shares, nor ordinary shares of a third party)
- The underlying stock traded near the conversion price at the beginning of the event window (convertible bond is "near-the-money")

Following Gatti and Sperl (2024)[43], this initial raw sample is obtained from Bloomberg Terminal using the *Fixed Income SRCH* function. In particular, the following characteristics are extracted for each convertible security: (security) ticker, issuer, company ticker, issuance date, ISIN, description notes, CUSIP, seniority, conversion price, conversion ratio, "convertible until date" (the date by which it is possible to exercise the conversion option),

[1] Not all convertible bonds in the sample are denominated in US Dollars. Despite this, all data was downloaded in US Dollars to allow for an easier comparison between the convertible bonds' issues.

maturity, country/territory of risk, amount issued, coupon, default (Y/N), Bloomberg Industry Classification Standard (BICS) level I and level II[2].

This initial raw sample consists of 1,463 convertible bonds.

The convertible bonds for which the exercise of the embedded conversion option is mandatory (5 items), and those with embedded call and put options (338 bonds) are removed from the sample. Convertible bonds that defaulted (57 items) are also taken out of the sample.

Of these remaining 1063 convertible bonds, 352 were issued by firms in the financial industry (Bloomberg Industry Classification Standard (BICS) level I = 'Financials'). These were removed from the sample. This choice is in line with most empirical research on convertible bonds, which generally excludes financial institutions due to their structurally different regulatory framework and balance sheet composition. Lewis et al. (1999)[66], for example, do not include financials because their leverage and issuance motivations are very different from those of industrial firms. In their study, Ammann et al. (2006)[2] adopt an analogous approach, eliminating utilities and financials to preserve sample homogeneity. Similarly, in their US dataset, Duca et al. (2012)[29] eliminate issuers with SIC codes that correspond to utilities (4900–4999) and financials (6000–6999), highlighting how these sectors' regulatory restrictions and debt structures make them less comparable to industrial issuers. In their cross-country comparison, Li et al. (2016)[68] also emphasise that non-financial issuers are a fundamentally different group. Thus, overall, this exclusion of financial institutions is a common practice in the literature, particularly in US samples, as confirmed by Rahim et al. (2014)[85] in their analysis of 15 convertible bond event studies. Furthermore, my dataset covers the years of the 2007–2008 financial crisis, when financial issuers and their stocks were greatly impacted by other much stronger factors than the conversion of CBs. Indeed, many convertible bonds issued by banks and other financial institutions during this period were either linked to M&A proceedings or recapitalization efforts, and/or many of these issuing firms were later bought out or filed for bankruptcy soon after they repaying their bonds. Including this data would therefore add event-specific noise that might bias the results. The reliability and representability of the sample is thus further strengthened by excluding these companies.

On the other hand, utilities are not excluded from the sample used in

[2]"Bloomberg classifies companies by tracking their primary business activities as measured by their primary source of revenue; it then groups them together according to market based industries. Members of groupings should exhibit similar behaviour in market cycles and should be correlated. Each company is reviewed at least once a year and following significant changes such as an M&A." See also Bloomberg, *Bloomberg Global Equity Indices Methodology*, Appendix X: Bloomberg Industry Classification System (BICS)

this study. While some studies, like Ammann et al. (2006)[2] and Duca et al. (2012)[29], eliminate both utilities and financials, their arguments for doing so are not as strong as those for financials. First, as shown in the Table 4.3 which will be later presented, utilities only make up a very small portion of my final dataset – just 1 out of 153 bonds, or 0.65%. The overall statistical results cannot be materially distorted by utilities because of their small weight. Second, utility companies do not issue convertibles for regulatory capital purposes like financial institutions do. Instead, they do so for standard corporate financing purposes like managing capital structure or funding investment programmes. As a result, their issuance motivations are similar to those of service and industrial companies than banks or insurers.

After removing financials, the raw sample contains 711 observations. Twelve bonds were represented twice in the sample[3]: duplicates were removed (6 items).

From these remaining 703 convertible bonds issuances, I removed instruments that did not meet the criteria for inclusion in the final sample. Specifically, were excluded CBs that became convertible into shares of other companies during their life (5 items), became exchangeable (13 items), credit-linked notes (2 items), contingent convertibles (CoCo) (1 item), promissory notes (1 item), an issue settled long after maturity (1 item), bonds issued in the context of bankruptcy procedures (2 items), a bond for which maturity was subsequently changed (1 item), an issuance in Canada (1 item).

Additionally, for ten (10 items) bonds it was not possible to find indentures.

For bonds in the sample of 668 convertible bonds, the 10-K forms, company announcements and other SEC documents are collected from SEC EDGAR (full search) database, Bloomberg and issuers' websites. These are then used to gather information on the settlement type of the bonds, (if any) repurchases of partial or full issued amount, impacts of mergers and acquisitions on the bond. Within this sample, 302 convertible bonds were found to have an outstanding amount near maturity below USD 50.00MM [4]. These bonds were excluded from the final dataset.

Additionally, 43 issuers were affected by mergers and acquisitions that completely changed the structure of the company, thus changing the underlying stock and all characteristics of the convertible. This caused the exclusion of additional 47 convertibles from the sample.

[3]Bloomberg for these items divided the A class common share and the ordinary common share in two lines despite the amount reported in each of the lines was the total amount issued for both of the share classes.

[4]Early conversions, buybacks, and exchanges frequently cause the outstanding amounts to decline.

Finally, to the remaining bonds, I apply a *near-the-money*[5] screen based on equity moneyness around each bond's "conversion-until" date to focus on bonds for which conversion was economically significant. In particular, for each CB i, having conversion price CP_i, moneyness is computed as

$$m_t = \frac{S_t - CP_i}{CP_i},$$

where S_t is the equity market closing price on the trading day corresponding to the beginning of the event window. Then CBs are classified according to moneyness as:

$$\begin{cases} \text{ATM} & \text{if } |m| \leq 0.02, \\ \text{ITM} & \text{if } m > 0.02, \\ \text{OTM} & \text{if } m < -0.02 \;. \end{cases}$$

After removing OTM bonds, the final sample includes 153 US near-the-money (NTM) convertible bonds.

Table 4.1 below summarizes the sequential filters applied in the sample construction, starting from the raw dataset, excluding issues based on instrument characteristics, issuer type, or data availability.

[5]Since the equity delta and the consequent hedge rebalancing demand of convertibles rise sharply when the CB trades near ATM (Hull (2022)[51]), conversion-related hedging and price-pressure effects are most noticeable when the stock price is close to (or slightly above) the conversion price (Choi et al (2010)[21]). Also, the exact at-the-money condition is susceptible to bid-ask spreads, microstructure noises and adjustments. While still being economically orientated, the use of a narrow NTM band enhances classification and statistical power (Brown and Warner (1985)[16]); Campbell, Lo, and MacKinlay (1997)[18]; MacKinlay (1997)[74]). In line with this logic, I do not include deep OTM bonds that are not likely to undergo conversion-driven hedging flows.

Table 4.1: Sample selection process

Step	Remaining convertible bonds
Raw sample	1,463
– minus mandatory conversion	1,458
– minus call/put embedded	1,120
– minus defaults	1,063
– minus financial issuers	711
– minus repeats	703
– minus special types[6]	678
– minus missing indentures	668
– minus outstanding < 50MM	366
– minus M&A affected companies	319
– minus deep-OTM convertible bonds	153
Final sample	**153**

As a point of comparison, Rahim et al. (2014)[85] list 15 event studies on the announcement impact for US convertible bonds in a meta-analysis of event studies linked to convertible bonds. According to this, the median sample size is 132. Thus, compared to existing event studies on the announcement effect for US convertible bonds, my revised sample size (n = 153) presents a large enough number of observations.

The composition of the final sample is illustrated below in Table 4.2.

Table 4.2: Distribution of near-the-money convertible bond issuances by year

Year of issuance	**Count**	**Percentage (%)**
2003	1	0.65
2005	1	0.65
2006	8	5.23
2007	10	6.54
2008	5	3.27
2009	25	16.34
2010	16	10.46
2011	11	7.19
2012	7	4.58
2013	12	7.84
2014	13	8.50
2015	2	1.31
2016	8	5.23
2017	13	8.50
2018	8	5.23
2019	9	5.88
2020	3	1.96
2022	1	0.65
Total	**153**	**100.0**

The final sample divided for industry distribution, as indicated by Table 4.3, shows that convertible bond issuance is concentrated in growth-oriented sectors. More than half of the sample is made up of Technology (31.37%) and Healthcare (24.18%), with significant shares also coming from Consumer Discretionary (16.99%) and Industrials (8.50%). Consumer staples (2.61%) and Utilities (0.65%), on the other hand, are hardly represented. The observed concentration is consistent with the theoretical and empirical literature that links convertible financing to companies that have significant R&D expenditures, high valuation uncertainty, or strong growth opportunities. Convertibles are a financing tool that reduces adverse selection and acts as "backdoor equity", according to Brennan (1987) [12] and Stein (1992) [94]. This makes them especially appealing for businesses that may be undervalued or that face information asymmetries.

Lewis et al. (1998, 1999) [65, 66] provide empirical evidence of this, showing that companies with high growth and R&D intensity are typically convertible issuers in the US. Additional proof from Canadian and foreign markets that convertible issuance is concentrated in growing and riskier industries comes from Loncarski et al. (2009) [72] and De Jong et al. (2011) [27]. Furtherly, in line with the sectorial differences observed in my sample, Dutordoir et al. (2014) [30] examine the literature and verify that convertibles are typically issued by companies with significant growth potential, particularly in the technology and healthcare sectors.

Table 4.3: Industry distribution (BICS Level 1) — near-the-money sample

Industry	**Count**	**Percentage (%)**
Technology	48	31.37
Health Care	37	24.18
Consumer Discretionary	26	16.99
Communications	14	9.15
Industrials	13	8.50
Energy	7	4.58
Consumer Staples	4	2.61
Materials	3	1.96
Utilities	1	0.65
Total	**153**	**100.0**

Turning to the convertible bond seniority, the majority of securities in my sample (96.73%) are issued as senior unsecured debt, with only 3.27% subordinated (see Table 4.4). This result is in line with earlier data showing that senior unsecured convertibles predominate in issuance. In their analysis of dividend-protected convertibles, Grundy and Verwijmeren (2012) [46] note that convertibles in the US are almost always structured as senior unsecured. Convertibles are also assumed to be senior unsecured in early valuation studies, such as Ingersoll (1976) [53] and Brennan and Schwartz (1980, 1988) [13] [14], thus indicating that this structure is the market practice. The same trend is supported by data from European markets: the majority of Western European issuers choose senior unsecured convertibles, with subordinated structures being much less common, according to Dutordoir et al. (2009) [32]. Therefore, my findings support the global trend present in the literature: the securities are almost always issued as senior unsecured debt, even though convertible issuance is concentrated in growth industries.

Table 4.4: Seniority of convertible bonds in the sample

Seniority	Count	Percentage (%)
Senior unsecured	148	96.73
Subordinated	5	3.27
Total	153	100.0

4.2 Classification by settlement type

In order to categorise the convertible bonds in the sample according to their settlement, I conducted a thorough research on all the documents related to the issuance of the convertible bonds as well as the issuer itself. In particular, for each security, I reviewed prospectuses and indentures obtained from the SEC EDGAR database, performing full-text searches across filings and filtering the resulting documents by wording related to convertible bonds such as "conversion," "convertible," and "settlement". I supplemented this with 8-K and 10-K filings, which frequently contain contractual changes, conversion results, or clarifications on settlement procedures when settlement provisions were not explicitly explained in other documents. I also examined issuer investor-relations websites and Bloomberg Terminal descriptions of CBs, which often include summaries of settlement-mechanics in debt offering memoranda. To further verify specific issues, I cross-checked legal databases such as *Justia.com*, which archive indentures and contracts.

Because settlement provisions are highly contract-specific and frequently allow for multiple possible settlement options (such as cash, physical, or net-share), as also highlighted by Dutordoir and Van de Gucht (2007)[33] and Hutchinson and Gallagher (2010)[52], this multi-source approach was needed.

Indeed, this process allowed me to classify all convertible bonds in the sample as physically settled, cash-settled, or combination/net-share settled.

Among the 153 convertible bonds in my final sample, 47 (30.72%) are physically settled, 41 (26.80%) are cash-settled, and 65 (42.48%) adopted some form of combination, net share, or flexible settlement structure.

The settlement breakdown by year of issuance and by year of maturity is shown below in order to better present these dynamics. The issuance-based perspective, summarised in Table 4.5, represents the evolution of contractual design in response to changes in market practice, investor demand, and regulations by reflecting the time at which firms chose to adopt cash, physical, or hybrid (combination/net-share) settlement-mechanisms.

Table 4.5: Settlement type by year of issuance

Year	Sample	Physical		Cash		Combination	
		#	%	#	%	#	%
2003	1	1	100.00	0	0.00	0	0.00
2005	1	1	100.00	0	0.00	0	0.00
2006	8	3	37.50	3	37.50	2	25.00
2007	11	4	36.36	4	36.36	3	27.27
2008	5	2	40.00	1	20.00	2	40.00
2009	25	14	56.00	2	8.00	9	36.00
2010	14	3	21.43	7	50.00	4	28.57
2011	13	7	53.85	2	15.38	4	30.77
2012	7	3	42.86	1	14.29	3	42.86
2013	12	0	0.00	5	41.67	7	58.33
2014	13	2	15.38	5	38.46	6	46.15
2015	1	0	0.00	1	100.00	0	0.00
2016	8	1	12.50	2	25.00	5	62.50
2017	13	2	15.38	3	23.08	8	61.54
2018	9	2	22.22	3	33.33	4	44.44
2019	3	1	33.33	1	33.33	1	33.33
2020	3	1	33.33	0	0.00	2	66.67
2022	1	0	0.00	1	100.00	0	0.00
Total	**153**	**47**	**30.72**	**41**	**26.80**	**65**	**42.48**

A closer look at combination settlements, as depicted by Table 4.6, reveals that issuer-option "menu"[7] structures are most common. *Net share, physical or cash* clauses account for 36 issues (55%) out of the 65 non-physical/non-cash cases. This suggests that many issuers lock-in cash settlement for principal while maintaining flexibility to deliver the conversion premium in cash, shares, or to elect full cash/physical settlement at conversion. While *Net share or cash* appears in 6 issues (9%), stricter *Net share* provisions – cash for principal with the premium mandatory in shares – represent 23 issues (35%). This distribution makes clear that, in reality, "combination" mostly refers to an architecture that postpones the final equity–cash mix until the settlement date.

[7] A "menu" clause allows the issuer to select at conversion between settlement-methods, usually net-share (cash for principal, premium in shares), full cash, and/or physical (all shares).

Table 4.6: Breakdown of non-physical and non-cash settlement types

Settlement type (prospectus language)	**Count**
Net share	23
Net share or cash	6
Net share, physical or cash	36
Total non-physical / non-cash	**65**

By contrast, the maturity-based perspective in Figure 4.1 shows when those bonds actually come due and when settlement provisions are expected to influence trading activity, short-interest, and hedging flows. This is the relevant view for testing the hypotheses of this thesis, since arbitrage unwinding, price pressure, and abnormal returns are realized near maturity, not at issuance (Gatti and Sperl (2024)).

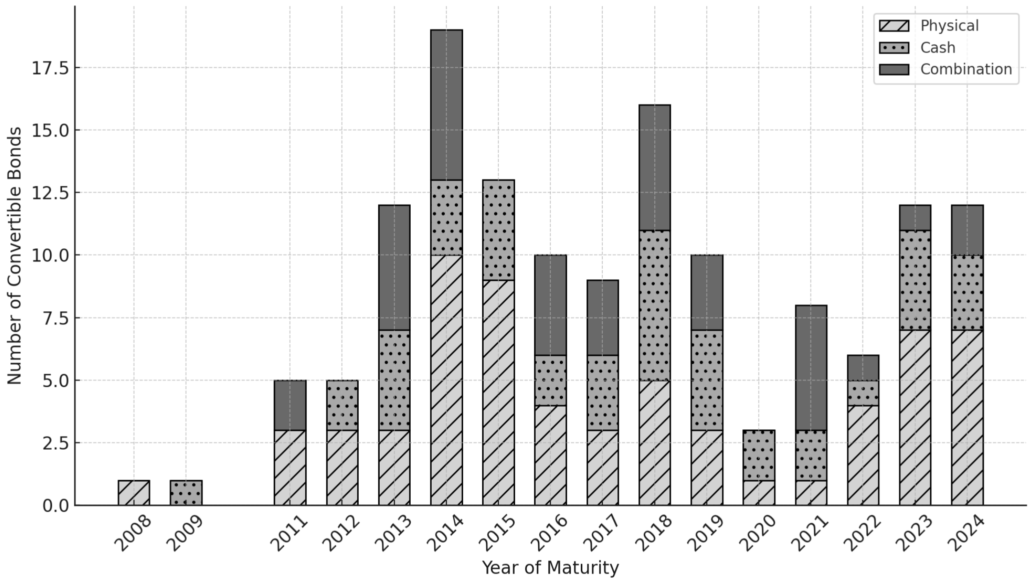

Figure 4.1: Settlement type by year of maturity

Presenting both perspectives is therefore essential. The issuance-based view provides insight into the evolution of market practice and issuer preferences over time, while the maturity-based view highlights the periods when settlement-related frictions actually materialize in equity markets. Together, they allow me to connect the contractual design decisions observed at issuance to the market outcomes that occur when those provisions become binding at maturity.

4.3 Descriptive statistics

According to Table 4.7, the convertible bonds in the final sample have an average time to maturity at issuance of approximately 5 years, with a minimum of just above 1.2 year and a maximum of slightly above 10 years. The distribution of maturities is relatively tight, as reflected in the standard deviation of only 1.2 years. Issue sizes in the sample range from USD 55 million to USD 2.5 billion, with an average of USD 446 million. The high standard deviation of USD 412 million indicates that there is a strong heterogeneity in issuance sizes, where a few very large bonds increase the mean.

Table 4.7: Summary statistics for convertible bonds

Statistic	Time to maturity at issuance (years)	Amount issued (mn USD)
Minimum	1.22	55
Maximum	10.01	2,500
Mean	5.32	446
Std. Deviation	1.26	412

The average time to maturity at issuance by year is displayed in Table 4.8. The averages vary within a small range around the overall mean of 5.32 years, remaining relatively constant across issuance years. This trend is in line with earlier research findings. Indeed, according to a survey by Calamos Investments (2022)[8], *"the typical convertible bond has a maturity of about five years"*, which confirms that the maturities observed in my sample are in line with both academic and industry benchmarks. Verwijmeren (2020)[96] documents median maturities of around 5–7 years depending on the decade. By contrast, Lee et al. (2023)[63] find somewhat longer maturities, on average around 8 years, and Grundy and Verwijmeren (2012)[46] report an average of 15.56 years for a set of dividend-protected convertibles, many of which had contractual maturities of 20 years or more. Compared to these studies, my dataset represents the typical convertible bond market, which is dominated by short- to medium-term maturities. However, my sample is limited to bonds issued since 2000 and maturing by the end of 2024, which may cause

[8]See Calamos Investments (2020)[54]

maturities to be skewed downward by leaving out long-dated bonds that are past the end year in my sample construction criteria.

Table 4.8: Average time to maturity at issuance by year

Year	Maturity (yrs)	Year	Maturity (yrs)
2003	5.03	2013	5.51
2005	6.77	2014	5.61
2006	5.94	2015	5.01
2007	5.93	2016	5.82
2008	5.81	2017	5.23
2009	5.28	2018	4.80
2010	5.14	2019	5.00
2011	5.11	2020	3.03
2012	5.14	2022	2.11
		Overall average	**5.32**

Regarding issuance sizes, Grundy and Verwijmeren (2012)[46] reported USD 256 million for a set of dividend-protected convertibles issued between 2000 and 2006, which is less than my sample average of USD 445 million. The large disparity in issue sizes suggests that the inclusion of some very large offerings in my dataset may be partially responsible for the discrepancy. In line with the higher average found in my sample, Lee et al. (2023)[63] also note that more recent convertible offerings typically have larger sizes. As with maturities, the sample construction methodology, which only includes bonds issued after 2000 and maturing by 2024, has an impact on my size statistics. Although very large, long-dated issues may be excluded by this selection criterion, the dataset is still representative of the mainstream USconvertible bond market during the past 20 years.

4.4 Ordinary shares data

In order to carry out the empirical analysis, data on ordinary shares underlying the convertible bonds in the final sample must be gathered.

Particularly, daily mid-prices[9] and traded volumes of ordinary shares are extracted from LSEG Data & Analytics [10].

[9] The mid-price of a stock is the average price between the (seller's) ask price and the (buyer's) bid price on the market.

[10] Formerly Refinitiv. Following LSEG's acquisition of Refinitiv, the former Refinitiv

The choice of daily frequency is motivated by several methodological and substantive considerations. Firstly, daily frequency represents the standard in existing event-study applications as it allows to capture market reactions with great precision around the date of the event, thus minimizing the possible data contamination problem that, according to Brown and Warner (1985)[16] and MacKinlay (1997)[74], arises for lower data frequency (e.g., monthly). Additionally, several studies show that daily frequency increases the statistical power of tests by providing larger samples and by enabling the detection of short-run dynamics (Campbell et al. (1997) [18]).

From a substantive perspective, the use of daily data is especially relevant for convertible bonds, as their values are strongly influenced by daily arbitrage and hedging activities. It is indeed common practice in CB studies to analyse daily data (for instance, see Ammann et al. (2006)[2], Lewis et al. (1999)[66], De Jong et al. (2011)[27], Dutordoir and Van de Gucht (2007)[33], Gatti and Sperl (2024)[43]).

In addition to prices and volumes, following Gatti and Sperl (2024)[43], information on short-interest is gathered from Bloomberg Terminal. Short-interest refers to the total number of common shares that have been sold short but have yet to be covered[11] or closed out. In the convertible bonds studies – see for instance Brennan and Schwartz (1988)[14], Loncarski et al. (2009)[71]) – short-interest data is of particular relevance as it allows to analyse the strategies of convertible bonds arbitrageurs. Dynamics of short-interest are thus crucial for the study of arbitrage activities, their impact and intensity. In the US, according to FINRA regulation[12], short-interest data must be reported by brokers and dealers twice a month (around the 15th of the month and the end of the month). While this data can be extracted with a lower frequency vs stock data, it still remains an informative indicator of shifts in arbitrageurs' tactics around convertible bond events.

company was rebranded as LSEG Data & Analytics.

[11] With the terms "yet to be covered" I do not refer to naked short selling - short-selling any type of marketable asset without first borrowing it from another party - which is illegal in the US according to SEC Regulation SHO. I refer to short positions which have not been "closed" by opening a new long position.

[12] *FINRA requires firms to report short-interest positions in all customer and proprietary accounts in all equity securities twice a month. All short-interest positions must be reported by 6 p.m. Eastern Time on the second business day after the reporting settlement date designated by FINRA.* FINRA, Short Interest Reporting

Chapter 5

Methodology

5.1 The event-study framework

In economics and finance, event studies have greatly been applied due to their ability to quantify how markets incorporate information into securities' prices.[1] In particular, event studies are used to examine abnormal stock price changes (or abnormal stock returns) around the time of the occurrence of a specific event such as the announcement of a corporate action or earnings announcements.

The first main assumption on which such methodology finds its foundations is the Fama (1970)[38] semi-strong market efficiency hypothesis, according to which the price of an asset incorporates all publicly available information. Additionally, the model assumes the valuation principle whereby an asset's price equals the present value of all future cash-flows deriving from it.

In accordance with these, the usefulness of event studies comes from the fact that, in a market characterised by rational agents, the effect of an event will immediately be included in the price of the assets.

The majority of applications specifically focuses on how an event affects the price of a specific class of securities, usually ordinary shares. Indeed, the currently used methodology was first developed by Fama, Fisher, Jensen, and Roll (1969)[39], whose research on stock splits supported the semi-strong form of market efficiency by showing that equity prices quickly react to public announcements, as well as by Ball and Brown (1968)[7] who focused on the information content of earnings announcements and stock price reactions.

Since the publication of these studies and building on them, some modifications to the model have been proposed. Particularly, these refinements

[1] MacKinlay (1997) [74] and Campbell et al.(1997)[18].

were introduced by Brown and Warner (1980, 1985)[15][16] to deal with issues arising from statistical violations in early work and to take into consideration more specific hypotheses. Implementation issues for data sampled monthly are examined in the 1980 paper, while issues for daily data are covered in the 1985 paper.

The outline of an event-study general structure will now be given for additional clarity. While the format of the event-study varies from analysis to analysis and from application to application, the framework of the event-study methodology is usually composed of the following seven stages. The event definition first establishes the type of event that will be studied and the time frame for the security prices analysis. For example, when studying the stock price impact of merger and acquisitions announcements, one could define the event as the window that includes the day of the announcement and the subsequent day to capture any after-market-close disclosure of information. Additionally, to investigate the occurrence of pre-announcement information leaks or the persistence of price adjustments, pre and post-event periods may also be examined.

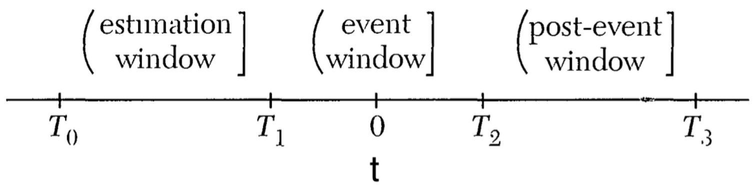

Figure 5.1: Timeline for event studies. *Source: MacKinlay (1997)[74]*

The second step involves deciding on the sample selection criteria or, in other words, specifying which companies or securities are to be included in the analysis. This is usually determined by data availability, listing on specific exchanges, or industry. At this point, it is common practice to list the sample's attributes, including firm size, industry composition, and event distribution over time, along with any potential biases that may have resulted from the selection process.

Thirdly, to understand the impact of the event, the computation of abnormal returns is required. Abnormal returns are defined as the ex-post excess returns of the security in the event window above normal returns in the same window. Normal returns are thus to be considered as the expected returns conditional on the non-occurrence of the event.

In the fourth step, the parameters of the selected normal-return-model must be estimated. Usually, a pre-event estimation window is used for this, such as a 120 trading days before the event in daily-data studies that use the market model. The exclusion of the event period ensures that parameter estimates for the normal return model are not biased by the actual event.

Then, the fifth stage involves the specification of the testing procedure including the definition of null hypotheses to be tested, the selection of relevant test statistics and, finally, the decision on how absolute returns are to be aggregated into cumulative abnormal returns (whether over time or across firms).

Finally, following the estimation of abnormal returns, relevant diagnostic checks are included with the results. After that, these findings are interpreted to understand how the event affects security prices.

5.1.1 Computing normal returns

According to MacKinlay (1997)[74] and Campbell 1997 [18], the computation of a given security's return can follow multiple approaches. Broadly speaking, two main categories exist: *economic models* and *statistical models*. Models in the former group rely on assumptions about the behaviour of investors as well as statistical assumptions which must be included to allow for the practical model application.

As implied by their name, statistical models, such as the constant mean return model or the market model, are only based on statistical hypotheses about how asset returns behave and are independent of any economic reasoning. Following this, there is a potential advantage stemming from the use economic models due to the inclusion of economic restrictions in addition to mere statistical ones.

The key assumptions for statistical models are that asset returns are both jointly multi-variate normal and independently and identically distributed (*i.i.d.*) in time. According to MacKinlay (1997)[74] and Campbell 1997 [18], these assumptions are sufficient for the two main models - *constant mean return model* and *market model* - to be specified correctly. Also, despite their strength, the models' assumptions usually do not impact the applicability of the models as they are empirically reasonable and inferences using the models are robust to deviations from them.

The so-called *constant mean return model* is the most used statistical model and it assumes that the mean return of a financial instrument is constant in time. Let us define π_i as the mean return (constant in time) for the asset i. Formally, the model can be expressed as:

$$R_{i,t} = \pi_i + \epsilon_{i,t}$$

where $R_{i,t}$ is the return on the i security for the period t, while $\epsilon_{i,t}$ is the disturbance term with

$$\mathbb{E}(\epsilon_{i,t}) = 0$$

and

$$Var(\epsilon_{i,t}) = \sigma^2_{\epsilon_{i,t}}$$

Despite the model's simplicity, Brown and Warner (1980, 1985) [15][16] present evidence that this model frequently yields comparable outcomes to those of much more sophisticated alternatives. This is due to the fact that the implementation of more elaborated models does not have a strongly significant impact on the reduction of the variance of abnormal returns.

In addition to the mean constant model, several other statistical frameworks have been introduced for performance estimation. *Factor models* are also among of the most widely applied statistical models in event studies. They aim at additionally reducing the variance of abnormal returns by including multiple common factors that may explain more of the normal return variation. The *market model* that will now be introduced can be regarded as a one-factor model. This is based on the idea that the return of a security is related to the market portfolio's return. When compared to the constant mean return model, the market model may offer an improvement as it reduces the variance in abnormal returns by controlling for the security's return associated with changes in market return. We can specify the market model for security i as:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \xi_{i,t}$$

where $R_{i,t}$ and $R_{m,t}$ are respectively the return on the i security and on the market portfolio for the period t, α_i, β_i and $\sigma^2_{\xi_{i,t}}$ are the model parameters, while $\xi_{i,t}$ is the disturbance term with

$$\mathbb{E}(\xi_{i,t}) = 0$$

and

$$Var(\xi_{i,t}) = \sigma^2_{\xi_{i,t}}$$

The possible reduction of abnormal return variance due to the application of the market return vs. the constant mean return is directly linked to the R^2 of the first. The higher the model's R^2, the lower the variance of abnormal returns and the bigger the benefit from applying a market model.

Other additional factor models include, for example, the issuer's industry classification as another factor (Sharpe (1970) [91] and Sharpe et al. (1995) [89]).

While factor models can still be seen as statistical in their nature, they set the basis for economic models. Indeed, building on the idea of integrating common risk factors to explain variation of abnormal returns to a greater extent, *economic models* additionally introduce economic reasoning and restrictions into the methodology framework. Among the most known economic models we find the CAPM and the APT.

The Capital Asset Pricing Model (CAPM) by Sharpe (1964)[90], Treynor (1962), Lintner's (1965a, 1965a) [69][70] and Mossin (1966)[82], which can be thought as as theoretically driven modification of the market model, laid the foundation for the identification of systematic risk factors affecting equity excess returns. This model posits that the expected return of an asset is determined by its covariance with the market portfolio excess return. Another pivotal forerunner in the field of economic models, and in particular of multi-factor models, is Ross' (1976)[88] Arbitrage Pricing Theory (APT). According to this, the expected return of an asset is explained by a linear function of its covariance with various risk factors.

Following the introduction of CAPM and APT, a more thorough analysis of such models resulted in the implementation of several other equity risk factor models, starting with the widely recognised *Fama-French 3-factor model* (Fama and French (1992))[40] which includes β_{CAPM}, a Size Factor (SMB) capturing the excess returns of small-cap stocks over large-cap stocks, and a Value Factor (HML) measuring the additional returns that value stocks (with high book-to-market ratios) have historically shown over growth stocks (with low book-to-market ratios). A modification of the Fama-French model comes from *Carhart*'s (1997)[19] *Four Factor Model* which additionally includes a momentum factor (MOM).

A summary of the models mentioned is provided in the Table 5.1.

Table 5.1: Overview of Normal Return Models

Model	Type	Specification
Constant Mean Return	Statistical	$R_{i,t} = \pi_i + \epsilon_{i,t}$
Market Model	Statistical	$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \xi_{i,t}$
CAPM	Economic	$R_{i,t} = \alpha_i + \beta_{i,m}(R_{m,t} - R_{f,t}) + \epsilon_{i,t}$
Fama–French 3-Factor	Economic	$R_{i,t} = \alpha_i + \beta_{i,m}(R_{m,t} - R_{f,t}) + \beta_{i,SMB} SMB_t + \beta_{i,HML} HML_t + \epsilon_{i,t}$
Carhart 4-Factor	Economic	$R_{i,t} = \alpha_i + \beta_{i,m}(R_{m,t} - R_{f,t}) + \beta_{i,SMB} SMB_t + \beta_{i,HML} HML_t + \beta_{i,MOM} MOM_t + \epsilon_{i,t}$

5.1.2 Abnormal returns

The main focus of event studies is the abnormal return (AR), which measures the difference between a security's actual ex-post return and the return predicted by the selected performance model in the absence of the event. Mathematically, the abnormal return of security i for the event date t is described by:

$$AR_{it} = R_{it} - \mathbb{E}(R_{it} \mid X_t)$$

where AR_{it}, R_{it}, $\mathbb{E}(R_{it} \mid X_t)$ are respectively the abnormal, actual, and normal returns for time t. X_t is the conditioning information set used in modelling the normal return. In other words, it represents the non-occurrence of the event under study. Depending on the chosen model to compute the normal return $R_{i,t}$ (Table 5.1), the specific calculation of abnormal returns will vary.

After calculating abnormal returns for every security in the corresponding event window, these returns are combined over time to create average abnormal returns (AARs) and cumulative abnormal returns (CARs). The *cumulative abnormal returns* between event days t_1 and t_2, for $T_1 < t_1 \leq t_2 \leq T_2$ is computed as:

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{i,t}$$

While *average abnormal returns* over a period [t_1, t_2] of length of T days can be expressed as:

$$AAR_i = \frac{1}{T} \sum_{t=t_1}^{t_2} AR_{i,t}$$

5.2 Applying the event-study methodology

In this section, I describe the application of the general event-study framework presented in the previous section to the selected US convertible bond sample. Although event studies' simple reasoning is widely accepted in the finance literature (see MacKinlay (1997) [74], Brown and Warner (1985)[16]), applying them requires making several design decisions about the estimation window, how to calculate normal and abnormal returns, and how to handle trading activity metrics like volume and short-interest.

These choices must be made in accordance with previous applications in the literature on convertible bonds as well as statistical validity (e.g., Lewis et al. (1999) [66]; Ammann et al. (2006) [2]; Dutordoir and Van de Gucht (2007)[33]). Therefore, the structure of the estimation window, the models that will be used to calculate expected returns, the methods for calculating abnormal and cumulative abnormal returns, and the additional measures used to capture trading activity related to arbitrage are all covered in detail in the following subsections.

5.2.1 Estimation and event windows

One of the most important steps in event studies is choosing the estimation window to simulate normal returns prior to the occurrence. In addition to being long enough to yield precise parameter estimates, the estimation window must be sufficiently distant from the event to avoid contamination by information leakage or anticipation effects. The literature on events regarding convertible bonds and other related instruments offers some useful information about the estimation window length. For instance, to make sure that parameter estimation is not impacted by the event itself, Ammann et al. (2006)[2], employ an estimation window extending from day −200 to day −21 previously to the announcement date of convertible bond issuance, thus also increasing the accuracy of estimated model parameters. In a similar way, in their studies of convertible debt issuance, Lewis et al. (1999)[66] and Dutordoir and Van de Gucht (2007)[33] employ estimation periods of 120 to 200 days, also highlighting that longer estimation windows increase the accuracy of estimated model parameters.

Such estimation window lengths are also supported by general methodological contributions. In their examination of event-study methodologies, Brown and Warner (1985)[16] suggest estimation periods ranging from 100 to 300 trading days, depending on the frequency of data. They argue that windows that are too long may incorporate structural breaks in firm risk, while shorter windows may produce estimates that are not very precise. On a similar note, MacKinlay (1997)[74] highlights that the estimation length needs to be a balance between potential bias from independent structural changes and variance reduction. More recently, El Ghoul et al. (2022)[34] examine global event studies and verify that, depending on the data frequency and event type, the most frequently window used in practice is between 100–250 trading days.

My analysis uses a 100-day estimation window that ends 50 days prior to the start of the event window, which is consistent with previous research. This 50-day buffer allows to retain for statistical accuracy while also preventing bias from pre-event rumours, trading adjustments, or early information releases that could influence prices in the immediate pre-event period. In other words, the 50-day buffer guarantees that parameter estimates are obtained from uncontaminated pre-event data, and the 100-day length is the common estimation window choice in convertible bond studies.

Determining the event window during which abnormal returns are measured is also required in order to supplement the estimation period. The event window, which frames how the market reacts to the announcement, should be both long enough to record possible effects of anticipation and delayed adjustments and short enough to reduce interference from unrelated news or market movements.

Short symmetric windows are common in the literature on convertible bonds. For instance, Loncarski et al. (2008)[71] and Duca et al. (2010)[29] use $[-1, +1]$ as their main event window to capture the immediate market response to the announcement. In order to ensure robustness, Ammann et al. (2006)[2] studies changes in research results across multiple intervals and concentrate on short windows, such as $[0, +1]$.

These approaches reflect the idea that most of the price impact happens in the days immediately near the event. Thus, longer windows run the risk of being contaminated by unrelated events (Brown and Warner (1985)[16]).

Therefore, in accordance with the existing literature, an event window $[-1, +1]$ is chosen as a benchmark. This ensures comparison with previous research and focuses on the time frame during which stock prices are most significantly impacted by the announcement. Moreover, in order to capture the various dynamics surrounding the "conversion until to" date, other three event windows are analysed.

A $[+2, +5]$ window is employed to assess the persistence of potential abnormal returns following the event, consistently with existing post-event drift in event studies (MacKinlay (1997)[74], Bernard and Thomas (1989)[9]).

Instead, a $[-5, 0]$ window is used to analyse the period just before the event, when arbitrageurs are expected to engage in hedging activities more intensively (Duca et al. (2012)[29]).

Lastly, anticipatory trading and information leakage, which have been demonstrated to affect stock prices in the days preceding convertible bond announcements (Brown and Warner (1985)[16]; Kim and Verrecchia (1991) [59]), are evaluated using the $[-10, 0]$ window.

5.2.2 Normal returns

Normal returns are estimated using two different benchmark models, consistent with convertible bond practice in event studies and in line with the methodology applied by Gatti and Sperl (2024)[43]. Firstly, the market model will be implemented based on MacKinlay's (1997) [74] methodology. According to this, daily excess returns for each stock are regressed on a market proxy over a pre-event estimation window of 100 trading days that ends 50 trading days prior to the event, following Lewis et al. (1999)[66], Ammann et al. (2006)[2], Dutordoir and Van de Gucht (2007)[33]. The applied market model can be written as:

$$(R_{i,t} - R_{f,t}) \ = \ \alpha_i^{MM} \ + \ \beta_i^{MM} \, (MKT{-}RF)_t \ + \ \varepsilon_{i,t}^{MM}$$

For the market proxy, I use the daily US MKT-RF series from the Kenneth R. French Data Library. According to Fama and French (2023)[41], the market factor equals the value-weighted return on a broad CRSP universe of US common stocks minus the one-month Treasury bill rate.

Since November 2012, the market factor ($MKT{-}RF$) has been constructed as the value-weighted return on all CRSP firms incorporated in the

US and listed on the NYSE, AMEX or NASDAQ with share code 10 or 11 at the beginning of month t, valid shares outstanding and price at the beginning of t, and valid return data for t. Prior to this change, the market return was taken from the CRSP value-weighted market index of NYSE, AMEX and NASDAQ stocks. In both cases, the risk-free leg is the one-month Treasury bill return, so that

$$(MKT-RF)_t = R_t^{MKT} - R_{f,t}.$$

Additionally, to account for possible factor biases in the sample and to mitigate model-specific biases, the *Carhart four-factor model* (Carhart, 1997 [19]) is also employed to compute normal returns. This multifactor specification adds size (SMB), value (HML), and momentum (MOM) to the market factor and is estimated using the same pre-event estimation window:

$$\begin{aligned}(R_{i,t} - R_{f,t}) = \alpha_i^{Car} &+ \beta_{m,i}\,(MKT-RF)_t + \beta_{SMB,i}\,SMB_t \\ &+ \beta_{HML,i}\,HML_t + \beta_{MOM,i}\,MOM_t + \varepsilon_{i,t}^{Car}\end{aligned}$$

This extension is appropriate for convertible bond samples, as they frequently include firms with smaller capitalisation, lower book-to-market ratios, and strong recent performance – characteristics that can cause biases in the residuals of the simple market model. The application of the *Carhart four-factor model* in the convertible bond field is supported by Ammann et al. (2010)[3], who demonstrate that the model successfully explains returns of convertible bond portfolios. In contrast, Brown and Weinstein (1985)[16] argue that the marginal benefits of complex economic models such as the APT are often outweighed by their additional complexity compared to the market model.

5.2.3 Abnormal returns

Once normal returns have been computed under the market model and the *Carhart four-factor model*, abnormal returns are defined as the residuals from these regressions. For the market model, abnormal returns for security i at time t are given by:

$$AR_{i,t}^{MM} = (R_{i,t} - R_{f,t}) - \left(\hat{\alpha}_i^{MM} + \hat{\beta}_i^{MM}\,(MKT-RF)_t\right),$$

while under the *Carhart four-factor model*, abnormal returns are computed as:

$$\begin{aligned}AR_{i,t}^{Car} = (R_{i,t} - R_{f,t}) - \Big(&\hat{\alpha}_i^{Car} + \hat{\beta}_{m,i}\,(MKT-RF)_t \\ &+ \hat{\beta}_{SMB,i}\,SMB_t + \hat{\beta}_{HML,i}\,HML_t + \hat{\beta}_{MOM,i}\,MOM_t\Big).\end{aligned}$$

Following Gatti and Sperl (2024)[43], I calculate cumulative abnormal returns (CARs) from daily abnormal returns. For firm i, the cumulative abnormal return between event days t_1 and t_2 is:

$$CAR_i^{MM}(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{i,t}^{MM}, \qquad CAR_i^{Car}(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{i,t}^{Car}.$$

Similarly, for a window of length $T = t_2 - t_1$, I compute average abnormal returns (AARs) as:

$$AAR_i^{MM}(t_1, t_2) = \frac{1}{T}\sum_{t=t_1}^{t_2} AR_{i,t}^{MM}, \qquad AAR_i^{Car}(t_1, t_2) = \frac{1}{T}\sum_{t=t_1}^{t_2} AR_{i,t}^{Car}.$$

5.2.4 Trading activity and hedging measures

In addition to abnormal returns, I examine the impact of the convertible bond's "conversion until date" on market trading dynamics in the underlying equity. Following the approach of Gatti and Sperl (2024)[43], I focus on two proxies for arbitrage activity: trading volume and short-interest.

Trading activity is measured by the abnormal value ratio relative to a pre-event baseline. The baseline for every company and event is the average daily share volume during a 100-day estimation window that concludes 50 trading days prior to the start of the event window (as for stock prices, a 50-day buffer is used to prevent contamination).

Let $\overline{Vol}_i^{\text{base}}$ denote the baseline mean. For a given event window $[t_1, t_2]$ (e.g., $[-1, +1]$, $[-10, 0]$, $[-5, 0]$, or $[+2, +5]$), let $\overline{Vol}_i^{\text{event window}}$ be the mean daily volume. Then, abnormal volume is

$$AVOL_i(t_1, t_2) = \frac{\overline{Vol}_i^{\text{event window}}}{\overline{Vol}_i^{\text{baseline}}} - 1.$$

A statistically significant abnormal volume would be consistent with arbitrageurs adjusting their hedging positions in the underlying equity at that date. Statistical significance is assessed using a two-sided t-test under the null hypothesis of no change ($H_0 = 0$).

Hedging intensity is further captured by short-interest ($SI_{i,t}$), defined as the number of shares sold short but not yet covered. To detect changes in hedging activity, I compare the last two observations before the "conversion until" date. As short-interest in US equities is published only twice a month, this procedure ensures the closest available measurement to the event.

As a robustness check, I compare the second-to-last and third-to-last observations before the "conversion until" date, SI_{-2} and SI_{-3}, to test whether hedging demand was already increasing further in advance:

$$\Delta SI_i^{robust} = SI_{i,-2} - SI_{i,-3}$$

This distinction allows me to separate gradual hedging from a concentrated increase in the final reporting interval. Statistical significance of both ΔSI^{main} and ΔSI^{robust} is evaluated using a two-sided t-test under the null hypothesis of no change ($H_0 = 0$) and a Wilcoxon signed-rank test, consistent with Gatti and Sperl (2024)[43]. The interpretation of these measures is straightforward. If both ΔSI^{main} and ΔSI^{robust} are positive and statistically significant, this indicates that hedging demand was building steadily in the period leading up to the "conversion until" date. If only ΔSI^{main} is significant, hedging build-up was concentrated in the final reporting interval, right before the until date. If neither is significant, there is no clear evidence of systematic hedging demand in short-interest.

Statistical significance of both ΔSI^{main} and ΔSI^{robust} is evaluated using a two-sided t-test under the null hypothesis of no change ($H_0 = 0$) and a Wilcoxon signed-rank test, consistent with Gatti and Sperl (2024)[43].

5.2.5 Cross-sectional analysis

In order to separate settlement-mechanism effects from pure dilution and other firm characteristics that are not taken into account by the *Four-factor Carhart model*, an estimation of cross-sectional ordinary least squares (OLS) regressions of event-level outcomes on settlement dummies and controls is carried out. The abnormal volume (AVOL), average abnormal return (AAR), and cumulative abnormal return (CAR) are the dependent variables. These are calculated for the benchmark window [-1,+1] and, independently, for the alternative windows [-10,0], [-5,0], and [+2,+5].

Then, the explanatory variables are defined as follows. Settlement type is captured by two dummy variables, one for combination settlement and one for physical delivery, with cash settlement serving as the omitted category. To control for expected dilution under the physical settlement-mechanism, I include the logarithm of the conversion ratio as a proxy for the number of shares that would enter the amount of outstanding shares upon conversion. As a larger the value of such proxy implies a more the dilutive impact of conversion, the regression coefficient of such variable is expected to be negative.

Additionally, the regression model analyses the relation of each dependent variable to equity–convertible sensitivity. To study this, I include a near-money moneyness variable measured as

$$\frac{P - C}{C}$$

where P is the underlying equity price and C is the conversion price. This is computed at the event day for [-1,+1] and at the beginning of each window for [-10,0], [-5,0], and [+2,+5]. Regression coefficients on moneyness are expected to be negative. Indeed, investors generally anticipate the possibility of converting a convertible bond into equity when it is in the money (or very closed to be in-the-money), which implies that the conversion option is already factored into the stock price. In these situations, the incremental abnormal return should be muted and the "convertible until date" approaching should not offer much new information.

Lastly, I incorporate BICS Level-1 sector fixed effects to account for wide industry heterogeneity; these prevent settlement effect estimates from being biased by sector-specific return or trading patterns.

Combining these elements, it is possible to write the baseline cross-sectional regression equation as:

$$Y_i = \alpha + \beta_1 \,\text{Phys}_i + \beta_2 \,\text{Comb}_i + \beta_3 \,\log(\text{ConvRatio}_i) + \beta_4 \,\text{Moneyness}_i + \gamma' \,\text{SectorFE}_i + \epsilon_i,$$

where Y_i represents CAR, AAR, or AVOL for the bond i. While β_3 and β_4 capture the role of dilution and moneyness, β_1 and β_2 measure the relative effects of physical and combination settlement-mechanisms compared with cash settlement.

I perform cross sectional OLS using two-way clustered standard errors (by issuer and by year) and year fixed effects. Because of this, the results are robust to heteroskedasticity and error correlation both within-issuer and within-year. The findings rely on the standard assumptions that there is no perfect multicollinearity, clusters are independent of one another, and regressors are exogenous.

Additionally, Variance Inflation Factors (VIFs) are computed to make sure that results are not being driven by multicollinearity among explanatory variables.

5.3 Variables

To summarise, the empirical analysis examines three main sets of variables to capture the effects of convertible bond "convertible until" dates on the underlying equity. First, I analyse abnormal returns (AR), together with their aggregated measures, average abnormal returns (AAR) and cumulative abnormal returns (CAR). These are computed using both the market model and the *Carhart four-factor model*, allowing for robustness against potential factor tilts and model-specific biases. Second, I investigate trading activity, proxied by the abnormal trading volume. Specifically, this is described as the mean daily share volume for event windows (i.e. [-1,+1], [-10,0], [-5,0], [+2,+5]) in comparison to a baseline mean calculated during a 100-day estimation period that concludes 50 trading days prior to the event window. Finally, I assess hedging intensity directly by examining short-interest (SI) in the issuer's equity. For each firm, the last two observations before the until date are compared, with an additional robustness check based on the second-to-last and third-to-last observations. Taken together, these variables provide a comprehensive view of price effects, trading dynamics, and hedging pressures around the convertible bond conversion event.

Table 5.2: Overview of variables examined in the analysis

Variable	**Definition**	**Purpose**
AR, AAR, CAR	Actual − model-predicted return (Market Model; Carhart); AAR/CAR aggregate over the window	Test for abnormal performance at the conversion until date
AVOL (volume)	mean daily share volume for event windows in comparison to a baseline mean calculated during a 100-day estimation period that concludes 50 trading days prior to the event window	Detect trading spike at the conversion until date, consistent with hedging adjustments
short-interest (SI)	Bi-monthly level of shares shorted in the market	Proxy hedging demand before the conversion until date; avoid post-event unwinding effects

Chapter 6

Empirical results

6.1 H1: Trading volume patterns

By studying abnormal trading volume around the "convertible until" date, strong evidence is found in support of Hypothesis 1's predictions. In particular, the findings shown in Table 6.1 indicate that, while no unusual activity is found during the immediate event window ([-1,+1]) or in the days that follow ([+2,+5]), trading activity rises noticeably in the days preceding maturity. In particular, abnormal volume is significantly positive throughout the sample in the [-10,0] window, and this effect is still present in the [-5,0] window, even though somewhat more muted. On the other hand, there are no statistically significant departures from usual trading volumes during the event window or the post-event period: instead of responding at or after the event date, this pattern implies that arbitrageurs concentrate their market activity prior to maturity by rebalancing or unwinding their positions in advance.

By closely looking at the settlement types, it is possible to notice that there is a distinct hierarchy in the magnitude of these volume effects. The largest pre-maturity spike is seen in cash-settled convertibles, which have an abnormal volume of roughly 0.19 in the [-10,0] window (highly significant at the 1% level). This result is in line with the theoretical prediction that arbitrageurs must repurchase stock on the open market to cover their short positions since they are unable to rely on receiving shares at maturity. Increased trading activity may be a direct result of the need for this adjustment.

Because of the embedded uncertainty in these contracts, combination-settled bonds also show a notable increase in volume (about 0.14, significant at the 5% level). Due to issuers' discretion over whether to deliver cash, stock, or a combination of both, arbitrageurs are unable to accurately forecast their exposure and must therefore start covering their positions ahead of time. On the other hand, the idea that arbitrageurs can rely on receiving shares at maturity to close their hedges and thereby face less immediate pressure to unwind positions in the open market is supported by the fact that physically settled convertibles only exhibit weakly significant increases in volume (around 0.14, significant at the 10% level).

Table 6.1: Abnormal volume (AVOL) by event window, returns model, settlement kind

Model	Settlement	Mean	t	N
Panel A: Post (days 2–5)				
carhart	cash	0.127	1.290	40
carhart	combination	0.016	0.312	63
carhart	physical	0.075	0.680	45
market	cash	0.127	1.290	40
market	combination	0.016	0.312	63
market	physical	0.075	0.680	45
Panel B: Pre (days 10–0)				
carhart	cash	0.191	3.165**	39
carhart	combination	0.142	2.323*	64
carhart	physical	0.137	1.760†	47
market	cash	0.191	3.165**	39
market	combination	0.142	2.323*	64
market	physical	0.137	1.760†	47
Panel C: Pre (days 5–0)				
carhart	cash	0.156	2.513*	40
carhart	combination	0.143	2.060*	63
carhart	physical	0.126	1.469	48
market	cash	0.156	2.513*	40
market	combination	0.143	2.060*	63
market	physical	0.126	1.469	48
Panel D: Event (days -1,+1)				
carhart	cash	0.102	1.579	40
carhart	combination	0.034	0.458	64
carhart	physical	0.120	1.139	48
market	cash	0.102	1.579	40
market	combination	0.034	0.458	64
market	physical	0.120	1.139	48

* $p < 0.05$, ** $p < 0.01$, † $p < 0.10$.

When combined, these findings give support to Hypothesis 1, which projected a pre-maturity rise in trading volume that was weaker for physically settled instruments, but more noticeable for convertibles and combination-settled instruments. Additionally, the results are consistent with the larger body of research on convertible arbitrage. While Choi et al. (2020) report anomalous trading activity concentrated prior to conversion events, Burlacu (2000) and Loncarski et al. (2009) emphasise that hedging dynamics vary based on settlement design. These studies support my findings, which show that physical settlement exhibits relative stability while cash settlement produces the most pronounced pre-event trading spike.

The conclusion that the observed spikes are anticipatory and hedge-driven rather than the result of noise or mechanical settlement effects is further supported by the lack of unusual trading activity in the post-event period ([+2,+5]). Trading activity returns to normal after the maturity date and settlement, demonstrating that the market has already incorporated the required portfolio adjustments.

All things considered, the main mechanism proposed in Hypothesis 1 is strongly supported by the carried out trading volume analysis. Settlement design plays a critical role in determining the timing and severity of arbitrageurs' proactive behaviour, which involves unwinding positions before they mature. The findings highlight how variations in settlement types result in different market pressures and validate the significance of contractual features in convertible bond markets.

6.2 H2: Trading price patterns

No strong evidence of systematic price effects is found in the event-study analysis of abnormal returns (AAR and CAR) around the "convertible until" date. Under the market model and the *Carhart four-factor* specification, the estimated abnormal returns are statistically insignificant and economically small, usually near zero, across all settlement types and event windows. Hypothesis 2 predicted that cash-settled convertibles would show positive abnormal returns before maturity, reflecting the repurchase pressure created by arbitrageurs covering short positions, followed by partial reversals right after conversion. This lack of detectable price pressure contrasts with that prediction.

A number of factors could account for the absence of notable price effects. First, the unwinds of short positions seem to be dispersed over a wider horizon, which reduces their impact on stock prices in the limited [-1,+1] or short pre-/post-event windows, even though the results presented in the previous section showed distinct pre-maturity increases in trading activity. Second, these arbitrage-related flows are probably absorbed by the depth and liquidity of the US equity markets without producing long-term departures from equilibrium pricing.

Table 6.2: Average Abnormal Returns (AAR) by event window, returns model, settlement kind

Model	Settlement	Mean	t	N
Panel A: Post (days 2–5)				
carhart	cash	−0.001	−0.267	40
carhart	combination	0.001	0.239	63
carhart	physical	0.001	0.565	45
market	cash	−0.001	−0.345	40
market	combination	0.001	0.275	63
market	physical	0.001	0.452	45
Panel B: Pre (days 10–0)				
carhart	cash	−0.001	−0.773	39
carhart	combination	0.000	0.304	64
carhart	physical	0.003	3.207**	47
market	cash	0.000	−0.374	39
market	combination	0.000	0.217	64
market	physical	0.003	3.219**	47
Panel C: Pre (days 5–0)				
carhart	cash	0.000	−0.019	40
carhart	combination	0.001	0.754	63
carhart	physical	0.003	2.368*	48
market	cash	0.001	0.695	40
market	combination	0.001	0.526	63
market	physical	0.003	2.374*	48
Panel D: Event (days -1,+1)				
carhart	cash	−0.006	−2.715**	40
carhart	combination	0.002	1.143	64
carhart	physical	0.003	1.299	48
market	cash	−0.006	−2.605*	40
market	combination	0.001	0.757	64
market	physical	0.002	0.893	48

* $p < 0.05$, ** $p < 0.01$, † $p < 0.10$.

This result is consistent with a large portion of the previous research on convertible bonds, which typically reports negligible or subdued price effects beyond the issuance phase. Ammann et al. (2006)[2] and Burlacu (2000)[17], for instance, examine announcement and issuance events and demonstrate that although convertible securities can affect the underlying stock prices, the abnormal returns are frequently negligible or statistically insignificant. Similarly, when hedge funds open short positions at issuance, convertible arbitrage can push equity prices lower, but as the bonds get closer to maturity, there is little indication of systematic return effects, according to Loncarski et al. (2009)[72].

In light of this, my analysis's lack of notable abnormal returns at maturity seems to support the notion that any distortions brought on by hedging are mostly absorbed by the market before they expire. This implies that the market effectively predicts the hedging flows related to maturity or that arbitrageurs may gradually unwind positions, smoothing potential price adjustments.

These results, however, contradict more recent research by Gatti and Sperl (2024)[43], which shows that short-interest and associated market effects for cash-settled convertibles have significantly decreased before maturity. Compared to my study, their findings suggest more robust maturity-related price adjustments. The disparity might be the result of variations in the institutional context and sample composition.

All things considered, my research adds to the body of knowledge by demonstrating that, in contrast to issuance announcements, maturity events are not linked to consistently abnormal returns in the underlying stocks. Rather than price levels themselves, possible maturity effects appear to be more apparent in trading activity and short-interest (see Sections 6.1 and 6.3).

Table 6.3: Cumulative Abnormal Returns (CAR) by event window, returns model, settlement kind

Model	Settlement	Mean	t	N
Panel A: Post (days 2–5)				
carhart	cash	−0.002	−0.267	40
carhart	combination	0.003	0.239	63
carhart	physical	0.004	0.565	45
market	cash	−0.002	−0.345	40
market	combination	0.003	0.275	63
market	physical	0.003	0.452	45
Panel B: Pre (days 10–0)				
carhart	cash	−0.008	−0.773	39
carhart	combination	0.004	0.304	64
carhart	physical	0.033	3.207**	47
market	cash	−0.004	−0.374	39
market	combination	0.003	0.217	64
market	physical	0.031	3.219**	47
Panel C: Pre (days 5–0)				
carhart	cash	0.000	−0.019	40
carhart	combination	0.007	0.754	63
carhart	physical	0.019	2.368*	48
market	cash	0.005	0.695	40
market	combination	0.005	0.526	63
market	physical	0.018	2.374*	48
Panel D: Event (days -1 to +1)				
carhart	cash	−0.019	−2.715**	40
carhart	combination	0.006	1.143	64
carhart	physical	0.008	1.299	48
market	cash	−0.017	−2.605**	40
market	combination	0.004	0.757	64
market	physical	0.006	0.893	48

* $p < 0.05$, ** $p < 0.01$, † $p < 0.10$.

6.3 H3: Short-interest dynamics

The average change in short-interest by settlement type is shown in Table 6.4. The robust measure ($\Delta SI_{\text{robust}}$) is a placebo difference between the second-last and third-last observations, intended to test whether short-interest movements are merely normal fluctuations. The main variable (ΔSI_{main}) measures the change between the last and second-last observations surrounding the conversion date.

Hypothesis 3 is only partially supported by the findings. In contrast to the evidence presented by Gatti and Sperl (2024)[43] and the expectation of a systematic unwind before "conversion until date", the mean change in short-interest for cash-settled convertibles is negative but statistically insignificant. One possible explanation is that arbitrageurs spread out their repurchases over a longer time horizon rather than unwinding their hedges within a limited event window, partially due to borrowing costs or liquidity constraints. Consequently, in the brief event windows used here, the decline may be more gradual and less obvious. Additionally, differences with Gatti and Sperl (2024)[43] may be due to the differences in the sample construction.

Additionally, findings show that different settlement-mechanisms exhibit significant heterogeneity. In contrast with the results for cash settled CBs, the average -717,000 shares SI difference for combination-settled bonds indicates a statistically and economically significant drop in short-interest ($t = -2.04$, $p = 0.045$; Wilcoxon $p = 0.001$). This pattern shows that the option to settle partially in shares creates stronger pressure for short-interest reduction, which is consistent with short sellers covering positions in anticipation of having to deliver stock upon conversion.

For physically settled convertibles, the average changes in short-interest are negative but not statistically significant. The lack of a noticeable impact for these bonds was expected and can be attributed to the fact that the delivery of shares upon conversion eliminated the arbitrageurs' need to cover their short underlying positions by buying stocks on the market.

Crucially, the last and second last observations show that the placebo measure ($\Delta SI_{\text{robust}}$) is small and negligible for all settlement groups. This supports the idea that the drop in short-interest seen for combination-settled bonds is an event-driven phenomenon focused around the conversion rather than a component of a broader trend or regular volatility in short positioning. Therefore, the robustness check increases confidence that the primary findings are not erroneous or the result of data timing artefacts.

When combined, these findings demonstrate how settlement design plays a special role in influencing the behaviour of short sellers. The conversion event only causes a noticeable change in short-interest when issuers maintain the ability to deliver shares, highlighting the direct correlation between the contractual characteristics of convertible bonds and noticeable market activity.

Table 6.4: Short-Interest analysis by settlement type

Settlement	Measure	Mean	t-stat	Wilcoxon p	N
Cash	ΔSI_{main}	-108,944	-0.32	0.952	40
Cash	ΔSI_{robust}	-10,100	-0.03	0.174	40
Combination	ΔSI_{main}	-716,837	-2.04*	0.001***	64
Combination	ΔSI_{robust}	-172,572	-0.51	0.082†	64
Physical	ΔSI_{main}	-528,659	-0.63	0.596	47
Physical	ΔSI_{robust}	-215,784	-0.67	0.038*	47

Notes: Two-sided t-tests on means and Wilcoxon signed-rank p-values reported. Significance markers: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, † $p < 0.10$.

6.4 Cross-sectional analysis

Once dilution, moneyness, and industry composition are taken into account, the cross-sectional results for abnormal volume (AVOL) demonstrate that trading activity around maturity is not influenced by the settlement-mechanism. The coefficients on the physical and combination dummies are small and statistically indistinguishable from zero in all windows, suggesting that there is no independent settlement-specific effect on volume. Rather, two economically significant trends show up. First, there is a distinct sectoral footprint: utilities have a significant negative loading in the pre-windows, whereas technology, industrials, materials, and (to a lesser extent) health care and consumer discretionary show large, positive, and statistically significant loadings in the event and pre-event windows.

This profile supports the notion that, rather than the contractual settlement clause itself, arbitrage and hedging activity scales with the turnover, volatility, and investor clientele typical of high-beta, high-liquidity industries. This notion is also well-known from the issuance literature (see Loncarski et al. (2009)[72]; Choi et al. (2010)[21]; Hutchinson and Gallagher (2010)[52]). Second, moneyness is a strong predictor prior to maturity: the moneyness coefficients at the beginning of the window are negative and significant in both $[-5, 0]$ and $[-10, 0]$, suggesting that deeper in-the-money convertibles show less abnormal trading in the period leading up to the "convertible until" date.

This aligns with delta hedging mechanics, which reduce high-frequency rebalancing and, consequently, temporary trading pressure in the closing days as the bond moves further ITM and the remaining equity optionality is mostly realised and the hedge ratio stabilises. The dilution proxy is the only systematic effect that remains after maturity: the log conversion ratio loads positively and significantly in $[+2, +5]$, which is consistent with larger share-equivalent positions necessitating more clean-up trades as dealers and arbitrageurs unwind residual hedges after settlement procedures are completed.

When considered collectively, the AVOL cross-section agrees with the overall data presented in Section 6.2: activity concentrates in volumes, whereas price effects (AAR/CAR) are minor and largely non-significant. This is further highlighted by the cross-section, which demonstrates that the primary factors influencing the intensity of trading around maturity are the bond's moneyness (where it falls on the equity–debt continuum) and the size of the potential share issuance (conversion ratio). Persistent sectoral heterogeneity captures structural variations in turnover across industries.

Turning to abnormal returns, I start with the [-1,+1] event window and work my way through the cross-sectional regressions. There are two clear messages. First, both physical and combination settlement are linked to higher announcement-window abnormal performance compared to the omitted cash benchmark: the coefficients on the settlement dummies are positive and statistically significant for both CAR (roughly +2.4–2.6 p.p.) and AAR (roughly +0.8 p.p.). Second, the moneyness control enters with the expected sign: more in-the-money convertibles show weaker incremental reactions around the event. This is in line with the theory that there is less room for additional announcement-window repricing when conversion optionality is already largely reflected in prices.

The log conversion ratio, a dilution proxy, is negligible and small at the event horizon, indicating that any expectations investors may have about the equity supply of larger potential share issuance are either foreseen well in advance of the [-1,+1] window or are obscured by concurrent hedging flows. These findings are not contradicted by sector effects, which are weak on their own.

A different configuration is revealed when the analysis is expanded to the longer pre-maturity windows. The log conversion ratio enters positively for CAR/AAR and becomes statistically and economically significant in both [-10,0] and [-5,0]. Larger conversion ratios are indicative of deals where the equity component is more predominant, and those names tend to rise up into maturity in my sample. This pattern aligns with the cross-section sorting on contracts that are closer to the conversion time and more equity-sensitive. To put it another way, the positive coefficient in the pre-event windows should not be interpreted as a "dilution premium," but rather as a composition effect that links equity-like issuers that perform well until the deadline with higher conversion capacity. This suggests that the windowed means in Section 6.2 are primarily determined by broad characteristics (such as how close to the money the bond is or how equity-like the issuer is) rather than settlement clauses per se. In these pre windows, the settlement dummies either become weaker or lose significance once controls are included. Energy does so in [-5,0], which probably reflects sector-specific fundamentals over the sample rather than settlement-mechanics. Utilities frequently load negatively prior to maturity. The main event-study message in Section 6.2 is supported by post-event ([+2,+5]) results, which show no strong evidence of systematic price pressure or reversal linked to settlement. Once controls are included, neither combination nor physical dummies matter. Rather, any cross-sectional structure manifests along industry lines (positive for Materials and Utilities) and, to a lesser degree, through a loading on the conversion ratio that is weakly positive. When combined with the event-study results, this suggests that any settlement-related repricing that takes place is limited in scope and concentrated, if it happens at all, around the event-window; after that, issuer and sector characteristics appear to dominate returns.

The AAR effects are basically the per-day counterparts of CAR, with the same signs and significance (e.g., positive physical/combination loadings and a negative moneyness slope in [-1,+1]). The coefficients of the CAR and AAR regressions match up as they should. The interpretation that the cross-sectional patterns are actually incremental day-level reactions rather than cumulation artefacts is supported by this. Additionally, it helps to reconcile Sections 6.2 and 6.4. The event-study means in 6.2 show economically small, generally insignificant abnormal returns at maturity overall, whereas the regressions in 6.4 recover modest but significant differentials once we take sector heterogeneity and moneyness into account, especially the drawback of cash versus share-delivering settlements at the exact moment of the event. To put it another way, settlement design tilts the cross-section by roughly 20–30 basis points per day (AAR) or 2–3% over [-1,+1] (CAR) in relation to cash, but it does not create strong price pressure.

Lastly, the lack of significant settlement-driven price effects reported in Section 6.2 can be better understood in light of the pre-event windows. How equity-sensitive and "near-the-money" a convertible is (moneyness and conversion capacity) provides a better explanation for abnormal returns into maturity than whether settlement is cash or share-delivering. This is consistent with the idea that arbitrage-motivated hedging flows are distributed and absorbed by market depth, as well as with a large portion of the issuance literature that, after controlling for firm characteristics, finds modest abnormal returns.

Once we condition on moneyness, conversion capacity, and sectoral composition, the cross-section shows that settlement clauses are not first-order drivers of returns before or after maturity, but they do matter at the margin—most notably when comparing cash with physical/combination during the limited event window.

The inference on settlement effects is not dependent on expected-return modelling decisions because all cross-sectional specifications are estimated using OLS with two-way clustered standard errors (issuer $\times$ year) and are run independently on results obtained from the market model and the *Carhart four-factor model*; the qualitative conclusions are the same under both benchmarks. The variance-inflation factors for the primary regressors of interest (moneyness, log conversion ratio, and settlement dummies) are comfortably low, suggesting that multicollinearity is not an issue for the magnitudes or p-values shown in the tables (see Appendix 9.3). This indicates that the design matrix behaves well. Overall, Section 6.4 supports Section 6.2 by demonstrating that, when sectoral heterogeneity, convertible sensitivity, and expected dilution are taken into consideration, the cross-section shows only slight relative differences across settlement-mechanisms in the event window and a stronger, economically intuitive adjustment in when trading activity occurs (pre-event and shortly post-event) as opposed to how much prices move on the event date.

6.5 Complementary mean–difference evidence (Welch tests)

I perform Welch unequal-variance tests, which compare unconditional means across settlement types, to supplement the cross-sectional regressions. The Welch tests offer a straightforward, model-free check that is also robust to variance heterogeneity, and the regressions already employ two-way clustered (issuer $\times$ year) inference throughout the chapter, so this is not a re-estimation with alternative standard errors. The results closely match the cross-sectional findings. Cash-settled issues underperform combination settlements and physical settlements by a small but statistically significant margin in the narrow event window [-1,+1]. The cash-versus-combination and cash-versus-physical comparisons for CAR (and similarly for AAR) yield t-statistics of approximately -2.5 to -2.9 and p-values of about 0.005 to 0.015 for both the market and Carhart models. This is consistent with section

6.4, which states that after controlling for dilution, moneyness, and sector composition, the physical and combination dummies load positively in relation to cash. The differences are mostly eliminated outside of that window closer to the "convertible until date". The regression evidence of no systematic reversal or follow-through by settlement type is mirrored in the post window $[+2, +5]$, where none of the cash-vs. share-delivering differences are significant ($|t| < 1$, $p > 0.10$). With one exception: cash versus physical is significantly different in $[-10, 0]$ under both return models, and only slightlyin $[-5, 0]$. This supports the conclusion in §6.4 that pre-event variation is mainly arranged by moneyness and conversion capacity (as well as industry mix), rather than by settlement clauses in and of themselves. All things considered, the Welch tests support the primary findings from sections 6.2-6.4. The magnitude of potential share issuance (conversion ratio), the convertible's equity-likeness (moneyness), and ongoing sectoral heterogeneity better explain broader pre- and post-maturity dynamics, while any settlement-related price effect is, at most, a modest, announcement-window phenomenon—economically small and short-lived.

Chapter 7

Final discussion

7.1 Summary of main results and relation to prior literature

While combination and physical settlements are not statistically different from zero, the market and Carhart models both show cash-settled bonds earning negative abnormal performance within the event window [-1,+1] (CAR about -1.7% to -1.9%, t = -2.6 to -2.7, p-value = 0.01). Pairwise Welch tests confirm that cash underperforms both combination and physical in this narrow window (p-values around 0.01-0.02). Before the event, physical delivery shows the strongest positive signal: over the [-10,0] window, CAR is approximately +3.1% to +3.3% (t = 3.2, p-value = 0.002), while over the [-5,0] window, CAR is approximately +1.8% to +1.9% (t = 2.37, p-value = 0.022). These findings hold true for both factor specifications. There is no evidence of systematic differences by settlement type in the post-event [+2,+5] window.

Regarding abnormal volumes, while there is no noticeable increase during the [-1,+1] event window, AVOL rised before the "convertible until date" for some settlement types, most notably and significantly for cash and combination in [-10,0] and [-5,0] windows. This is consistent with the occurrence of hedging activity or of general increased market trading prior to the "convertible until date".

In the cross-section regression, while the physical dummy is positive but only marginal (p-value = 0.056), the combination dummy loads positively and significantly for CAR and AAR. For AVOL, settlement dummies are not significant, thus showing a lack of an effect of settlement kind on the registered abnormal volumes. The event-study patterns are consistent with these cross-sectional estimates: cash appears weakest during the event, whereas combination and physical appear relatively stronger, with the strongest impact of physical settlement happening before the "convertible until date".

Including BICS Level I fixed effects for industries reveals that the sector mix has little influence on the results in the core [-1,+1] window—sector dummies are tiny and mostly non-significant. Sector patterns, on the other hand, do show up outside on the other event windows: Energy shows weak impact in [-5,0], and Materials and Utilities load negatively during the run-up ([-10,0] and [-5,0]) but shift to positive during the post window ([+2,+5]). The main finding that settlement type does not explain AVOL in the [-1,+1] window remains unchanged despite the fact that sector heterogeneity is even more pronounced for AVOL, with some industries displaying structurally higher abnormal volumes.

Finally, the short-interest (SI) analysis shows that only combination settlements show a significantly negative change in short interest (ΔSI) ($p-value < 0.05$); cash and physical settlements have no significant effects. These results build upon and relate to earlier research. While the event-window underperformance of cash contrasts with the positive cash-settlement effects at maturity reported in Gatti and Sperl (2024)[43], the increased activity and the return variation by settlement are consistent with the classic arbitrage narrative (delta-hedging into known settlement mechanics). Such difference is probably due to the differences in both the sample construction and the event window choices. Indeed, Gatti and Sperl's (2024)[43] research highlights final maturity/settlement episodes and dealer hedging unwind, while this study focusses on the "convertible until" deadline with a near-money screen and narrow windows.

7.2 Limitations

This study has a number of limitations. First, rather than being causal, the results are descriptive as issuers choose the settlement type. This means that the unobserved factors driving this choice - for example, issuer risk, financing requirements, investor clientele, and liquidity conditions - may also have an impact on returns and volumes. Because of that "selection," we are able to record trends but cannot assert that the type of settlement is the direct cause of the results.

Also, possibly there are other information that influence the trading dynamics of the stock in the event window besides the conversion event used. Indeed, the windows may not be completely cleared of earnings, corporate actions, or news specific to a firm.

Third, if moneyness is correlated with firm conditions, the near-money

(ATM/ITM) screen, while improving the comparability of results across bond issues, may bias the results by shrinking the final sample.

Furthermore, statistical power differs between windows and groups. ΔSI tests are limited, particularly for short windows, by the small size of some changes and the low frequency and limited availability of short-interest.

Another possible limitation is due to the fact that key CB settlement information - such as changes in settlement provisions or bond covenants over time - is hard to gather as it either requires access to specific private databases or direct contact with book-runners. This incomplete set of information may thus lead to classification noise and a weakening of the inference.

7.3 Implications and takeaways

The key takeaway for CBs issuers is that trading dynamics around the deadline are shaped by settlement mechanics. Indeed, cash settlement design is linked to small but significant event-window drag, while both physical settlement and combination settlement do not present this effect. Therefore, combination or physical settlement may be better if management is sensitive to short-horizon stock behaviour around conversion milestones (for example, due to concurrent equity transactions or investor relations considerations). Cash settlement clauses are still feasible in situations where dilution prevention is of the utmost importance while short-term stock performance is of secondary importance.

Additionally, the findings emphasise how important it is for book-runners and structurers to communicate settlement mechanisms and borrow availability in a clear and timely manner. In combination cases, the ΔSI decrease and the pre-event AVOL build-up indicate that market players actively adjust hedges as the deadline draws near. Frictions and price impact can be minimised by giving clear instructions on expected share deliverables for combination settlement.

For arbitrageurs, the results are consistent with their mechanical hedging. The increase in pre-event AVOL and the negative ΔSI for combination cases are consistent with a pre-deadline hedge build, followed by an unwind. In particular, results show that, as there is no evidence of systematic price increases near the event, arbitrageurs can cover their short positions in the stock up to the "convertible until date" without having to pay a premium.

Chapter 8

Conclusion

This thesis investigated the relationship between stock-market behaviour around the ”convertible-until” date and settlement design in U.S. convertible bonds. Three patterns were found using a cross-sectional OLS with year fixed effects and two-way clustered standard errors (issuer × year), complementary mean-difference tests, and an event-study with market and Carhart models. First, cash-settled issues perform poorly within the limited [-1,+1] window: pairwise Welch tests show that cash underperforms both physical and combination settlements in this window, and cumulative and average abnormal returns are negative and statistically different from zero. Second, for physical settlement, the strongest positive return signal occurs prior to the event (particularly over [-10,0] and [-5,0]); in the short post window [+2,+5], there is no discernible variation by settlement type.

Third, for specific settlement types, particularly cash and combination, trading activity increases in the run-up to the event rather than during it. This is in line with positioning and hedging adjustments made prior to the observation period. These results are supported by cross-sectional regressions: the physical settlement dummy is positive but only marginal, the combination settlement dummy loads positively (and significantly) for returns. However, settlement dummies do not explain abnormal volumes after year effects are taken into account. These return patterns are directionally consistent with the short-interest results: cash and physical are not statistically different from zero, but the change in short-interest is significantly negative only for the combination settlement.

The study makes two contributions. Empirically, it shows settlement-specific differences between price and volume outcomes that are concentrated in economically limited windows: volume pressure is primarily a pre-event phenomenon, whereas return gaps are most noticeable at the event.

These results are applicable to a variety of agents. It is important for issuers and their advisors to understand how settlement decisions relate to various short-horizon equity dynamics surrounding conversion deadlines. Specifically, cash settlement is linked to lower event-window returns, whereas combination and physical structures do not exhibit the same underperformance during that time frame. The lack of broad-based volume surges at the event, combined with pre-event increases in activity, indicates that any liquidity planning for investors who own convertibles outright should concentrate on the days preceding the observation period rather than the deadline. For arbitrageurs, the fact that short-interest declines are concentrated in combination cases and that prices are not consistently raised near the "convertible-until" date supports the idea that partial covering and hedging are possible even near the deadline without resulting in abnormally unfavourable pricing. Lastly, the cross-section shows that year effects are significant; therefore, after adjusting for settlement, calendar conditions and market regimes continue to be key drivers.

The study's limitations are obvious. Settlement selection and results may be influenced by unobserved issuer characteristics and settlement is not assigned at random. Short windows may be confused by overlapping firm news because the "convertible-until" date is an unreliable indicator of the complete information set. Although it reduces the sample size and may move in tandem with fundamentals, the near-money screen enhances comparability. Noise is introduced by data frictions; estimation-window selections determine volume normalisation. Power is limited during brief windows due to the availability of short-interest at lower frequencies. Although they limit the range of inference, these limitations do not negate the patterns described here.

The most promising directions for future research seem to be two. First, it would be clearer whether the settlement gradients endure finer conditioning if the cross-section was enhanced with firm fundamentals (leverage, liquidity, profitability), sector–time interactions, and contract-level controls (e.g., net-share structures, observation-period length, make-whole provisions). Second, more frequent trade-and-quote data around observation periods could measure how hedging schedules translate into intra-day volume profiles and slippage across settlement types, decoupling inventory management from price-pressure channels. To close the gap between capital-structure design and equity microstructure, a complementary extension would tie primary and secondary bond-level flows to stock outcomes.

All things considered, this thesis demonstrates that settlement design in convertible bonds is related to short-horizon equity outcomes, but in a way that is both time-window-specific and outcome-specific: cash settlement is penalised by event-window returns, pre-event volumes increase most for cash and combination, and cross-sectional results match those trends after year effects are taken into account. For issuers, outright investors, and hedged participants who plan around conversion deadlines, these findings offer specific, practical takeaways and contribute a targeted piece of evidence to the literature on convertibles.

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Chapter 9

Appendix

9.1 Raw sample statistics

In this section I present sample statistics for the raw sample of my analysis. In particular this sample contains 319 convertible bonds that share the same features of the convertibles in the final sample, except for including OTM, ATM and ITM (at the beginning of the event window) instruments.

The composition of the raw sample is illustrated below in Table **??**.

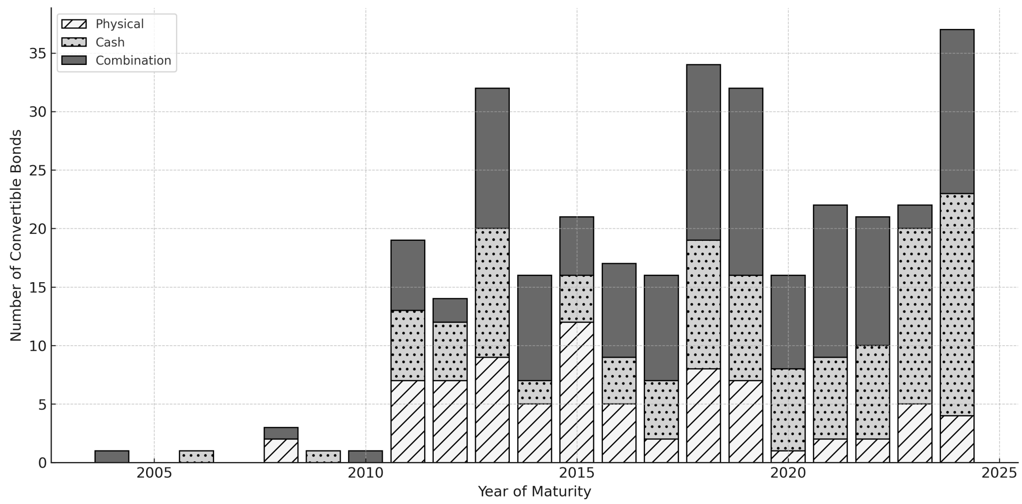

Figure 9.1: Settlement type by year of maturity

Table 9.1: Distribution of convertible bond issuances by year

Year of issuance	**Count**	**Percentage (%)**
2000	2	0.63
2003	3	0.94
2004	1	0.31
2005	2	0.63
2006	23	7.21
2007	30	9.40
2008	11	3.45
2009	33	10.34
2010	18	5.64
2011	23	7.21
2012	12	3.76
2013	29	9.09
2014	34	10.66
2015	12	3.76
2016	14	4.39
2017	24	7.52
2018	23	7.21
2019	16	5.02
2020	6	1.88
2021	2	0.63
2022	1	0.31
Total	**319**	**100.0**

Table 9.2: Industry distribution (BICS Level 1) of raw sample

Industry	**Count**	**Percentage (%)**
Communications	26	8.15
Consumer Discretionary	45	13.17
Consumer Staples	13	4.08
Energy	23	7.21
Health Care	77	24.14
Industrials	33	10.34
Materials	13	4.08
Technology	89	27.90
Utilities	3	0.94
Total	**319**	100.0

Table 9.3: Seniority of convertible bonds in the raw sample

Seniority	**Count**	**Percentage (%)**
Senior unsecured	308	96.55
Subordinated	11	3.45
Total	319	100.0

Table 9.4: Settlement type by year of issuance

Year	**Sample**	**Physical**		**Cash**		**Combination**	
		#	%	#	%	#	%
2000	2	1	50	0	0	1	50
2003	3	2	67	0	0	1	33
2004	1	1	100	0	0	0	0
2005	2	2	100	0	0	0	0
2006	23	5	22	13	57	5	22
2007	30	8	27	12	40	10	33
2008	11	5	45	2	18	4	36
2009	33	16	48	2	6	15	45
2010	18	5	28	7	39	6	33
2011	23	12	52	4	17	7	30
2012	12	3	25	3	25	6	50
2013	29	3	10	9	31	17	59
2014	34	6	18	10	29	18	53
2015	12	3	25	5	42	4	33
2016	14	1	7	2	14	11	79
2017	24	1	4	8	33	15	63
2018	23	3	13	9	39	11	48
2019	16	1	6	5	31	10	63
2020	6	1	17	0	0	5	83
2021	2	0	0	1	50	1	50
2022	1	0	0	1	100	0	0
Total	**319**	**79**	**24.76**	**93**	**29.15**	**147**	**46.08**

Table 9.5: Breakdown of non-physical and non-cash settlement types

Settlement type (prospectus language)	**Count**
Net share	42
Net share or cash	12
Net share, physical or cash	92
Net share or physical	1
Total non-physical / non-cash	**147**

9.2 Cross-sectional regression results

Here below the results for the cross-sectional analysis.

Table 9.6: Cross-sectional regressions of Abnormal Volume (AVOL)

Variable	Coef.	Std. Err.	p
Panel A: Window [-1,+1]			
const	−0.236	0.101	0.020*
phys	−0.042	0.093	0.651
comb	−0.103	0.074	0.167
logConvRatio	0.009	0.021	0.674
MoneynessPct	0.003	0.005	0.514
sect_Consumer Discretionary	0.391	0.124	0.002**
sect_Consumer Staples	−0.076	0.121	0.530
sect_Energy	0.232	0.128	0.071†
sect_Health Care	0.280	0.121	0.021*
sect_Industrials	0.568	0.164	0.001**
sect_Materials	0.391	0.148	0.008**
sect_Technology	0.388	0.098	0.000***
sect_Utilities	−0.092	0.080	0.247
Panel B: Window [pre10,0]			
const	0.015	0.076	0.842
phys	−0.063	0.073	0.384
comb	−0.085	0.062	0.168
logConvRatio	0.012	0.015	0.417
Moneyness_at_start	−0.009	0.003	0.003**
sect_Consumer Discretionary	0.036	0.082	0.661
sect_Consumer Staples	0.076	0.096	0.426
sect_Energy	0.058	0.101	0.566
sect_Health Care	0.162	0.096	0.092
sect_Industrials	0.388	0.153	0.011*
sect_Materials	0.320	0.111	0.004**
sect_Technology	0.264	0.090	0.003**
sect_Utilities	−0.345	0.079	0.000***
Panel C: Window [pre5,0]			
const	−0.094	0.085	0.265
phys	0.016	0.081	0.845
comb	−0.024	0.073	0.745
logConvRatio	0.009	0.016	0.558
Moneyness_at_start	−0.008	0.004	0.040*
sect_Consumer Discretionary	0.133	0.099	0.181
sect_Consumer Staples	0.026	0.117	0.822
sect_Energy	0.066	0.122	0.586
sect_Health Care	0.275	0.119	0.021*
sect_Industrials	0.386	0.143	0.007**
sect_Materials	0.333	0.123	0.007**
sect_Technology	0.300	0.104	0.004**
sect_Utilities	−0.437	0.092	0.000***
Panel D: Window [post2,5]			
const	−0.242	0.100	0.016*
phys	−0.072	0.124	0.563
comb	−0.110	0.085	0.197
logConvRatio	0.039	0.019	0.036*
Moneyness_at_start	−0.005	0.005	0.338
sect_Consumer Discretionary	0.385	0.132	0.004**
sect_Consumer Staples	0.296	0.186	0.111
sect_Energy	0.130	0.135	0.337
sect_Health Care	0.258	0.137	0.059
sect_Industrials	0.430	0.174	0.013*
sect_Materials	0.095	0.116	0.416
sect_Technology	0.190	0.095	0.046*
sect_Utilities	0.540	0.077	0.000***

Notes: OLS with two-way clustered standard errors by issuer and calendar year. Omitted settlement category is cash. Sector FE include all listed BICS L1 dummies; the omitted sector is the base category. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, † $p < 0.10$.

Table 9.7: Cross-sectional regressions of Average Abnormal Returns (AAR)

Variable	Coef.	Std. Err.	p
Panel A: Window [-1,+1]			
const	−0.008	0.003	0.005**
phys	0.008	0.002	0.001***
comb	0.009	0.002	0.000***
logConvRatio	0.001	0.000	0.275
MoneynessPct	0.000	0.000	0.005**
sect_Consumer Discretionary	0.002	0.003	0.617
sect_Consumer Staples	0.003	0.003	0.303
sect_Energy	−0.005	0.004	0.207
sect_Health Care	0.002	0.003	0.488
sect_Industrials	0.005	0.004	0.179
sect_Materials	0.004	0.007	0.509
sect_Technology	−0.002	0.003	0.607
sect_Utilities	−0.003	0.003	0.282
Panel B: Window [pre10,0]			
const	−0.004	0.001	0.002**
phys	0.003	0.001	0.014*
comb	0.001	0.001	0.301
logConvRatio	0.001	0.000	0.000***
Moneyness_at_start	0.000	0.000	0.719
sect_Consumer Discretionary	0.000	0.002	0.894
sect_Consumer Staples	−0.003	0.002	0.252
sect_Energy	−0.002	0.002	0.430
sect_Health Care	−0.001	0.001	0.620
sect_Industrials	−0.002	0.003	0.432
sect_Materials	−0.003	0.002	0.050†
sect_Technology	−0.001	0.001	0.623
sect_Utilities	−0.004	0.001	0.000***
Panel C: Window [pre5,0]			
const	−0.003	0.002	0.176
phys	0.001	0.001	0.311
comb	0.001	0.001	0.634
logConvRatio	0.001	0.000	0.000***
Moneyness_at_start	0.000	0.000	0.807
sect_Consumer Discretionary	0.002	0.002	0.462
sect_Consumer Staples	−0.003	0.002	0.133
sect_Energy	−0.006	0.002	0.011*
sect_Health Care	−0.002	0.002	0.445
sect_Industrials	0.003	0.003	0.374
sect_Materials	−0.004	0.002	0.051†
sect_Technology	−0.001	0.002	0.678
sect_Utilities	−0.009	0.002	0.000***
Panel D: Window [post2,5]			
const	−0.007	0.003	0.028*
phys	0.003	0.002	0.183
comb	0.003	0.003	0.374
logConvRatio	0.001	0.001	0.102
Moneyness_at_start	0.000	0.000	0.132
sect_Consumer Discretionary	0.002	0.003	0.555
sect_Consumer Staples	0.001	0.004	0.888
sect_Energy	−0.007	0.004	0.121
sect_Health Care	0.005	0.003	0.126
sect_Industrials	−0.002	0.003	0.413
sect_Materials	0.013	0.004	0.000***
sect_Technology	0.002	0.002	0.498
sect_Utilities	0.008	0.002	0.000***

Notes: OLS with two-way clustered standard errors by issuer and calendar year. Omitted settlement category is cash. Sector FE include all listed BICS L1 dummies; the omitted sector is the base category. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, † $p < 0.10$.

Table 9.8: Cross-sectional regressions of Cumulative Abnormal Returns (CAR)

Variable	Coef.	Std. Err.	p
Panel A: Window [-1,+1]			
const	−0.025	0.009	0.005**
phys	0.024	0.007	0.001***
comb	0.026	0.007	0.000***
logConvRatio	0.001	0.001	0.275
MoneynessPct	−0.001	0.000	0.005**
sect_Consumer Discretionary	0.005	0.009	0.617
sect_Consumer Staples	0.010	0.009	0.303
sect_Energy	−0.014	0.011	0.207
sect_Health Care	0.007	0.010	0.488
sect_Industrials	0.015	0.011	0.179
sect_Materials	0.013	0.020	0.509
sect_Technology	−0.004	0.009	0.607
sect_Utilities	−0.008	0.007	0.282
Panel B: Window [pre10,0]			
const	−0.045	0.014	0.002**
phys	0.033	0.013	0.014*
comb	0.012	0.012	0.301
logConvRatio	0.013	0.003	0.000***
Moneyness_at_start	0.000	0.001	0.719
sect_Consumer Discretionary	−0.002	0.017	0.894
sect_Consumer Staples	−0.027	0.024	0.252
sect_Energy	−0.017	0.021	0.430
sect_Health Care	−0.007	0.015	0.620
sect_Industrials	−0.021	0.027	0.432
sect_Materials	−0.037	0.019	0.050†
sect_Technology	−0.006	0.012	0.623
sect_Utilities	−0.045	0.011	0.000***
Panel C: Window [pre5,0]			
const	−0.020	0.014	0.176
phys	0.009	0.008	0.311
comb	0.004	0.009	0.634
logConvRatio	0.008	0.002	0.000***
Moneyness_at_start	0.000	0.000	0.807
sect_Consumer Discretionary	0.010	0.014	0.462
sect_Consumer Staples	−0.021	0.014	0.133
sect_Energy	−0.033	0.013	0.011*
sect_Health Care	−0.010	0.013	0.445
sect_Industrials	0.015	0.017	0.374
sect_Materials	−0.025	0.013	0.051†
sect_Technology	−0.005	0.011	0.678
sect_Utilities	−0.053	0.010	0.000***
Panel D: Window [post2,5]			
const	−0.027	0.012	0.028*
phys	0.012	0.009	0.183
comb	0.011	0.013	0.374
logConvRatio	0.004	0.003	0.102
Moneyness_at_start	−0.001	0.001	0.132
sect_Consumer Discretionary	0.007	0.012	0.555
sect_Consumer Staples	0.002	0.017	0.888
sect_Energy	−0.027	0.017	0.121
sect_Health Care	0.018	0.012	0.126
sect_Industrials	−0.009	0.012	0.413
sect_Materials	0.051	0.014	0.000***
sect_Technology	0.007	0.010	0.498
sect_Utilities	0.031	0.006	0.000***

Notes: OLS with two-way clustered standard errors by issuer and calendar year. Omitted settlement category is cash. Sector FE include all listed BICS L1 dummies; the omitted sector is the base category. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, † $p < 0.10$.

9.3 VIF

Variance Inflation Factor (VIF) Diagnostics

Variance inflation factors (VIFs) for cross-sectional regressions with abnormal volume (AVOL), average abnormal returns (AAR), and cumulative abnormal returns (CAR) as dependent variables are presented in this section. Multicollinearity is not an issue because VIF values are comfortably below traditional thresholds (usually 5 or 10) across all specifications.

Table 9.9: VIF diagnostics for CAR cross-section

Variable	VIF
const	18.58
phys	1.87
comb	1.64
logConvRatio	1.33
MoneynessPct	1.49
sect_Consumer Discretionary	2.50
sect_Consumer Staples	1.50
sect_Energy	1.60
sect_Health Care	3.13
sect_Industrials	1.92
sect_Materials	1.24
sect_Technology	3.45
sect_Utilities	1.08

Table 9.10: VIF diagnostics for AAR cross-section

Variable	VIF
const	18.58
phys	1.87
comb	1.64
logConvRatio	1.33
MoneynessPct	1.49
sect_Consumer Discretionary	2.50
sect_Consumer Staples	1.50
sect_Energy	1.60
sect_Health Care	3.13
sect_Industrials	1.92
sect_Materials	1.24
sect_Technology	3.45
sect_Utilities	1.08

Table 9.11: VIF diagnostics for AVOL cross-section

Variable	VIF
const	18.58
phys	1.87
comb	1.64
logConvRatio	1.33
MoneynessPct	1.49
sect_Consumer Discretionary	2.50
sect_Consumer Staples	1.50
sect_Energy	1.60
sect_Health Care	3.13
sect_Industrials	1.92
sect_Materials	1.24
sect_Technology	3.45
sect_Utilities	1.08

9.4 Black and Scholes and greeks (dynamic hedging)

The Black-Scholes-Merton framework is used to value the option component included in convertible bonds. The model makes the following assumptions: a constant risk-free rate, lognormally distributed stock prices with constant volatility, frictionless markets, continuous trading, and no arbitrage opportunities. Given these assumptions, the price of a European call option on a stock that pays dividends would be:

$$C(S,t) = Se^{-q(T-t)}N(d_1) - Ke^{-r(T-t)}N(d_2),$$

with

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r - q + \frac{1}{2}\sigma^2\right)(T-t)}{\sigma\sqrt{T-t}}, \qquad d_2 = d_1 - \sigma\sqrt{T-t},$$

where S is the current stock price, K the strike price (conversion price in the case of convertibles), r the risk-free rate, q the continuous dividend yield, σ the volatility, $T-t$ the time to maturity, and $N(\cdot)$ the cumulative standard normal distribution.

The Black-Scholes call valuation directly contributes to the decomposition of the CB as a straight bond + equity call option since this option for a convertible bond represents the right to convert debt into equity at the conversion ratio.

Investors use the Greeks, which gauge how sensitive the option value is to underlying factors, to control risk:

- **Delta (Δ):** it is the sensitivity to stock price

  $$\Delta = \frac{\partial C}{\partial S} = e^{-q(T-t)}N(d_1).$$

  In the CBs context, Delta determines the hedge ratio, i.e. the number of shares to short in order to build a delta-neutral portfolio:

  $$N_{\text{short}} = \Delta \times \text{Conversion Ratio}.$$

- **Gamma (Γ):** it is the rate of change of Delta with respect to the stock price

  $$\Gamma = \frac{\partial^2 C}{\partial S^2} = \frac{e^{-q(T-t)}\phi(d_1)}{S\sigma\sqrt{T-t}},$$

  where $\phi(\cdot)$ is the standard normal density. A high Gamma implies that Delta is unstable and hedges have to be rebalanced more frequently.

- **Theta (Θ):** it is the sensitivity to the passage of time. Options lose value as maturity approaches, capturing time decay.
- **Vega (ν):** it is the sensitivity to volatility. Since convertibles include equity optionality, their value is strongly responsive to volatility. Arbitrage strategies often aim to capture undervalued Vega.
- **Rho (ρ):** it is the sensitivity to changes in interest rates. It is relevant especially for long-dated convertibles.

9.5 Ingersoll (1976)

The assumptions of the Ingersoll (1976)[53] model are:

A1. Perfect markets: capital markets are perfect, without transaction costs, without taxes and equal access to information for all market participants

A2. No dividend: there are no dividend payments or dividend distributions to stockholders

A3. Constant conversion terms: the convertible bond has constant terms over time

A4. Modigliani-Miller theorem: there are no corporate taxes and the Modigliani-Miller proposition I holds

A5. No call notice: issuers are not required to issue a call notice and, once the convertible has been called, investors have to immediately either convert or redeem their debt repayaments

A6. Flat term structure: the term structure of interest rates is flat and non-stochastic. The instantaneous compounding rate of interest is r.

A7. Frictionless markets

A8. Ito dynamics: the market value of the company follows an Ito diffusion:

$$dV = (\Gamma V - C)dt + \sigma V dz$$

with C being the total cash outflow per time unit, Γ is the instantaneous expected return and σ^2 is the volatility

A9. Capital structure: There is only one senior issue of the company and is the one of convertibles. The only other liability is common equity.