Coopetition and insider trading profitability

Abstract

This study examines the association between coopetition and insider trading profitability. We find that insiders in coopetition firms generate less trading profit. To address endogeneity issues, our identification strategies include difference-in-differences analysis in a quasi-experiment design, falsification tests, an instrumental variable approach, and the Heckman two-stage model. Our results are robust to alternative proxies and the inclusion of additional control variables. Further, we perform heterogeneity tests across information asymmetry and show that the influence of coopetition on insider trading is more pronounced when the level of information asymmetry is low. Overall, our findings suggest that coopetition reduces information asymmetry, leading to decreased insider trading profitability.

Keywords: Coopetition, insider trading, information asymmetry.

1. Introduction

The rise of globalisation over the recent decades has led to fierce competition in the product market. To survive, collaboration between competing firms has become an important corporate strategy to reduce business uncertainty. By sharing unique complementary resources, competitors are able to generate value that they could not achieve alone. Since the 1990s, Apple, IBM, and Motorola have collaborated to develop new generation RISC-based microprocessors in order to compete with Microsoft and Intel (Duntemann and Pronk, 1994; Vanhaverbeke and Noordehaven, 2001). In this case, the different product market established by the new microprocessor would benefit all participating firms.[1]

Cooperating with competitors enables a firm to outsmart other market participants and enhances firm performance. For example, Apple and Samsung have successfully collaborated with each other which benefits each of their businesses. After a decade of competition, even Vimeo and YouTube have begun to embrace one another (Garrett, 2019). In both academic scholarship and corporate practice, this relationship is termed as '*coopetition*' (see e.g., Nalebuff and Brandenburger, 1996; Bengtsson and Kock, 2000; Tsai, 2002). The advantage of coopetition over traditional innovation processes is that it helps firms reduce the initial investment for specific projects through risk and expense sharing (e.g., Samsung and Sony), channel sharing (e.g., YouTube and Vimeo), co-marketing, and collaborative invention (e.g., Apple, IBM, and Motorola), all of which benefit industry players in ways that they could not achieve on their own.

Overall, the extant literature demonstrates that coopetition creates significant positive net present value for partnering firms (see e.g., Gnyawali and Park, 2011; Ritala, 2012). Thus, firms have incentives to devote significant resources to coopetition process.

[1] Similarly, Sony and Samsung have collaborated to create joint technological research and manufacturing facilities in South Korea to ensure an uninterrupted supply of LCD panels for television assembly lines (Ritala et al., 2014).

In line with the agency theory, the 'ownership' and 'control' of public firms are separate (Fama and Jensen, 1983), which positions managers or senior officers uniquely to determine whether to cooperate with other industry participants or not. These manager or senior officials in 'control' have privileged access to material information related to firm value and can utilize relevant information to generate personal gains. Prior studies mainly focus on how coopetition strategies benefit the firm itself (see e.g., Jorde and Teece, 1990; Bengtsson and Kock, 2000; Rochet and Tirole, 2002; Luo, 2007; Gnyawali and Park, 2011; Raza-Ullah et al., 2014) paying limited or no attention to corporate insiders with value-sensitive information. There is little evidence that shows whether corporate insiders exploit such corporate events.

Specifically, outside investors may be unaware of the nature and timing of the coopetition, which may exacerbate the information asymmetry between corporate outsiders and insiders. The left side of Figure 1 shows how information flows to outside investors. Normally, individual investors purchase the stock through a broker, and the broker may provide the analysts' recommendations and relevant reports. Investors can also gather information through media such as Bloomber

[Insert Figure 1 here]

Information intermediaries help retail investors to monitor the agent's behaviour, however corporate insiders understand their business better than any analyst (Lakonishok and Lee, 2001). Thus, corporate insiders may trade on information. A relevant example is the case of ImClone. The firm developed a new cancer medicine (Erbitux) in December 2001. However, the Food and Drug Administration (FDA) did not authorize it and the firm's stock price fell sharply. The decision hampered ImClone's future growth since the anticipation was getting approval of the medicine. Prior to the announcement, numerous executives sold their shares in the company, including the CEO Samuel Waksal and his family and friends.[2] This cause

[2] Samuel Waksal was imprisoned between 2003 and 2009 and fined $4 million for his actions.

indicates that the uniformed investors may lack of financial literacy. Even though the information intermediaries reduces the information asymmetry between insiders and other market participants. The insiders can still take advantage of outsiders.

Coopetition is an emerging corporate strategy to advance technological innovation (Ritala et al., 2014), which requires the firm to engage in an R&D collaboration with competitors. In this coopetition environment, insiders are more likely to have superior information compared to corporate outsider counterparts, for example, in case when a new product is released, when stocks are stacking up, when profit margins are improving etc. Hence, there is a benefit for a better understanding of insider trading behavior in coopetition firms.

Insider trading is mainly driven by information asymmetry. Lower level of analysts' coverage, voluntary management disclosure, and news coverage are the three main sources of information asymmetry, leading to information-based trades by insiders (Frankel and Li, 2004). Wu (2018) finds that the information asymmetry is lower when analysts devote more resources to gathering information. Disclosure is one of the most efficient mediums of communication between corporate insiders and outsiders. Prior research shows that high-quality management disclosure improves the information environment and enhances market efficiency (see e.g., Ball and Brown, 1968; Sutton, 1997; Frankel and Li, 2004). News coverage also reduces information asymmetry by providing an additional understanding of the relationship between insider trading and information source (e.g., analyst forecasts and annual reports).

We, in this paper, explore how coopetition affects insider trading profits. We adopt a setting in which companies cooperate with rivals through standard-setting organisations (SSOs)[3]. Further, R&D information plays an important role in information asymmetry

[3] Unlike other forms of inter-firm collaboration processes such as strategic alliances, coopetition firms are subject to sharing R&D information under this setting and do not allow 'cheap-talk ' (Baron and Spulber, 2018; Ranganathan et al., 2018; Bushee et al., 2021).

determinants (Aboody and Lev, 2000). Thus, coopetition will affect the firm's information environment (Bushee et al., 2021), leading to a change in insider trading profitability.

There are two competing views on how coopetition influences the information environment. On the one hand, before coopetition, releasing patent information to the public to raise capital may draw the attention of rivals, resulting in the loss of a competitive edge. Thus, the proprietary cost of disclosing information is unfavorable to the patent-holding firm (Verrecchia, 1983). After coopetition, the superior patent information will no longer be exclusively owned by the possessor. Disclosing such patent information to the public to attract more potential investors will be favorable to the firm, as trade secrets will become available to competitors through R&D cooperation activities. Thus, information become less opaque as we move from competition to coopetition. Chen et al. (2021) demonstrate that coopetition motivates firms to increase narrative R&D information in the 10-K report, while Glaeser (2018) finds that disclosing trading secrets increase corporate transparency. Coopetition increases the firm's transparency, enabling investors to ascertain the value of a firm's patent, and, thus, reducing information asymmetry between corporate insiders and outsiders. Therefore, we anticipate corporate insiders will find it difficult to gain from their information-based trading when information environment is more transparent. Specifically, coopetition reduces insider trading profitability because of increased corporate transparency.

On the other hand, there is an alternative explanation that coopetition may increase information opacity. Kepler (2021) finds that private communication between competitors reduces public disclosure, as internal collaboration is more efficient. For instance, a firm can access complementary resources through the cooperative R&D process instead of raising capital through investors. Thus, public disclosure becomes less beneficial. In addition, prior literature suggests that firms use their public disclosure to coordinate production, pricing, and other business activities with competitors (e.g., Arya and Mittendorf, 2016; Bloomfield, 2021;

Bourveau et al., 2020). Coopetition allows competitors to communicate through a private channel. Thus, internal communication among coopetition firms reduces public disclosure, creating information asymmetry between corporate insiders and outsiders. Therefore, we alternatively predict that coopetition may, in fact, increase insider trading profitability. According to the competing arguments in the above literature, how coopetition affects insider trading remains an open question.

In our empirical setting, we use propensity score matching to eliminate the self-selection bias of coopetition, since firms have the discretion to decide on coopetition participation. We only consider insider purchase transactions to examine the association between coopetition and firms' insider trading profitability. Prior studies suggest that insider sales are not informative, as the management may sell shares for other purposes such as liquidity (Lanknoishok and Lee, 2001). Our sample include 322 unique firms and period spans from 1996 to 2017. We adopt an event study approach to measure the insider trading profitability over three-month and six-month investment horizon using the Carhart four-factor model (Carhart, 1997). We capture coopetition by a dummy variable that equals one if firms join the coopetition relationship during the year and zero otherwise. We find that coopetition reduces insider trading profitability. The magnitude of the decrease in insider trading profitability is economically significant (-0.05 with *t*-statistic = -3.08). A one standard deviation increase in coopetition participation is associated with a 29.9% and 36.23% decrease in insider trading profitability over the three months and six months holding periods, respectively.

Next, we perform a difference-in-differences (DID) estimation to demonstrate the causal effect between coopetition and insider trading. Following Rahman et al. (2021), we examine the impact of coopetition on insider trading by only considering the periods surrounding each coopetition event. We consider three sets of windows, first, a time window of one year before

and after (-1/+1); second, two years before and after (-2/+2); and third, three years before and after (-3/+3) the event. This allows us to better capture changes in insider trading profits in the treatment and control group after coopetition. The results suggest that coopetition firms have a larger drop in insider trading profits in the three years before and after (-3/+3) coopetition compared to the other time windows. This implies that the impact of coopetition on insider trading is more pronounced when firms stay in a coopetition relationship for a longer time horizon. We also perform falsification test to support the DID regression findings by altering the definition of treatment and control groups and re-estimating the DID model and find support in favor of our baseline results.

We adopt an instrumental variable (IV) approach to further demonstrate the causality between coopetition and insider trading as reverse causality and other confounding events may drive our results. Following Chen et al. (2021), we construct our instrumental variable based on the policy[4] change related to licensing fees for coopetition organizations. We only consider firms that are not engaging in coopetition prior to the policy change. The instrumental variable captures a firm's willingness to join the coopetition relationship only after the coopetition organization reduces the cost of coopetition. Under this setting, the policy change is unlikely to directly affect insider trading profitability. Also, a firm does not have the authority to amend coopetition organisation's policy. Thus, our IV meet both the relevance condition and exclusion restriction. The results of the IV approach are consistent with our primary analysis. We further employ Heckman's two-stage approach to further address unobservable differences between coopetition and non-coopetition firms. We find that our baseline results remain unchanged.

[4] In standard-setting organisations, firms participating in coopetition are required to pay a 'royalty rate' to be able to use the patent. Prior studies argue that the licensor can charge royalty at a higher rate and abuse the market power gained through their intellectual property rights (Sidak, 2013). In 1996, the 'royalty rate' has started to disappear from individual coopetition organisations, therefore, reducing the cost of coopetition.

We also conduct a number of additional robustness tests. First, we use the number of competitors that the coopetition firm cooperates with as an alternative proxy for coopetition to re-estimate the baseline model. This captures the magnitude of coopetition. Second, we re-estimate the baseline model using buy-and-hold abnormal return as an alternative measure for insider trading profitability. Third, we re-estimate the baseline model by adding additional control variables including trading size, firms' self-imposed insider trading restrictions (corporate governance), and insider fixed effects. Overall, our results are robust to additional tests.

We then focus on the economic mechanism because of which insiders of coopetition firms make less profit by trading on inside information. We show that information asymmetry is the mechanism by which coopetition affects insider trading profitability. Information asymmetry is an important channel of insider trading profitability (Wu, 2018). Prior studies (see e.g., Kyle, 1985; Wu, 2018) suggest that insiders could exploit less private information when the degree of information asymmetry is low. We conduct heterogeneity tests based on three proxies of information asymmetry such as analyst forecast errors, idiosyncratic volatility, and management voluntary disclosure. Taken together, we find that the impact of coopetition on insider trading is more pronounced when information asymmetry is low.

Our study contributes to the insider trading literature in several important ways. First, Aboody and Lev (2000) document that insiders from firms with more R&D activities generate greater insider trading profits. Our findings add to the literature on determinants of insider trading profitability by demonstrating that an increase in inter-firm R&D activities reduces insider trading profitability, as coopetition increases the firms' public disclosure.

Second, our work contributes to the literature on intra-industry information exchange. Prior research demonstrate that intra-industry knowledge transmission happens mostly through a firm's public disclosure (e.g., Foster, 1981; Han and Wild, 1989). We find that intra-industry

information transmission can also take place through a private channel. Our findings show that disclosing R&D information to competitors increases firms' internal control because of the reduced likelihood of managerial rent-seeking activities.

Finally, our findings contribute to a growing body of literature on firms' coopetition behavior. Previous research largely focuses on coopetition strategies and the associated advantages (Jorde and Teece, 1990; Bengtsson and Kock, 2000; Rochet and Tirole, 2002; Luo, 2007; Gnyawali and Park, 2011; Raza-Ullah et al., 2014; Ranganathan et al., 2018). We contribute to this body of knowledge by demonstrating how coopetition is associated with insider behavior as the corporate information environment changes.

The remainder of this paper is organized in the following manner. Section 2 reviews the relevant literature, and Section 3 develops hypotheses. Section 4 describes the research methodology, and Section 5 presents the results of the baseline. Section 6 reports the results of identification strategies, and Section 7 presents the robustness tests. Section 8 details the heterogeneity analysis based on the level of information asymmetry. Finally, Section 9 concludes the paper.

2. Literature review

2.1 Coopetition

Coopetition is a term that refers to two or more competitors who compete while also cooperating, which is a critical strategy for participating firms to obtain an advantage (Jorde and Teece, 1990; Bengtsson and Kock, 2000; Rochet and Tirole, 2002; Luo, 2007; Raza-Ullah et al., 2014; Ranganathan et al., 2018). The co-existence of collaboration and competition amongst rivals does not imply competing against one opponent and cooperating with another; it means competing against and cooperating with the same competitor. The competitors increase their performance through collaborative relationships by pooling resources and

committing to a mutual purpose in a specific area, while also taking individual activities to compete and improve their own performance (Luo, 2007).

Firms have several motivations to invest significant resources in coopetition process (Farrell and Saloner, 1985; Vries, 1999; Tassey, 2000; Baron and Spulber, 2018). First, coopetition firms agree on a technical standard with competitors. These standards enable firms to specify a generally accepted technical standard, product, or service along one or more dimensions, including functional levels, performance, service life, efficiency, safety, and environmental effect (Tassey, 2000). For instance, when a client purchases a car, the manufacturer must guarantee that the vehicle passes a number of safety tests before being sold to the buyer. The agreed on standards establish a minimum level of performance that serves as a barrier to entry for other firms in the same industry. Thus, coopetition improves a product's quality, reliability, and industry attractiveness.

Second, coopetition enhances a product's compatibility or interoperability (Farell, 1985, Tassey, 2000; Baron and Spulber, 2018). Collaborating with a competitor during the R&D process can lead to the development of products that are able to interact with complementary goods inside innovation ecosystems (Ranganathan et al., 2018); for instance, Microsoft computers can connect with Apple Bluetooth earphones. This improved product quality and technological interchangeability lead to increased consumer confidence (Vries, 1999; Tassey, 2000; Hesser et al., 2006) and, in turn, firm value (Ramakumar and Cooper, 2004).

This paper builds on a range of studies that examine firms' coopetition behaviour in the context of standard-setting organisations (SSOs) (e.g., Ranganathan and Rosenkopf, 2014; Baron and Spulber, 2018; Ranganathan et al., 2018; Bushee et al., 2021; Chen et al., 2021). SSOs provide an efficient setting to investigate coopetition and insider trading profitability. Firstly, SSOs allow firms to produce compatible products with competitors by developing a technical standard. This standard is a consensus-based agreement that is accepted by both

parties. To reach this agreement, all members must credibly exchange the R&D information. Thus, a firm's information environment will be changed, as Aboody and Lev (2000) suggest that a firm's R&D activity is a key source to determine the information asymmetry between corporate insiders and outsiders. Secondly, the market that relies on SSO-coordinated standard setting is substantial. For instance, Qualcomm increased its R&D spending on SSOs to over $1 billion in 2005, up from less than $350 million in 2000 (Miller & Toh, 2020; Bushee et al., 2021). The annual issue of technical standards through SSOs has increased dramatically over the last 35 years, from fewer than 5,000 in 1980 to about 35,000 in 2012 (Baron & Spulber, 2018). The number of coopetition participants has similarly increased in a dramatic fashion (Baron & Spulber, 2018). Therefore, SSOs provide a suitable setting to measure how coopetition affects information environment and insider trading profitability.

Chen et al. (2021) show that sharing information inside coopetition organisations (SSOs) gives competitors private access to firms' trade secrets that reduces firms' disclosure costs, thereby, increases the public R&D disclosure. Similarly, Bushee et al. (2021) find that active coopetition behavior allows firms to access competitors' proprietary information. The managers will have a better understanding of the participating firms' future prospects, enabling the firms' management to provide more accurate sales forecasts. Thus, the firms' coopetition relationship will benefit all the coopetition participants. In sum, Chen et al. (2021) and Bushee et al. (2021) demonstrate that coopetition improves corporate transparency by narrowing the information gap between corporate insiders and outside investors.

Alternatively, Kepler (2021) documents that the main purpose of firms' public disclosure is to coordinate their pricing and product decisions. A private channel for inter-firm communication between firms reduces the incentives and benefits to disclose material information to the public. Thus, coopetition exacerbates information asymmetry between corporate insiders and other market participants.

Overall, studies on coopetition concentrate on how coopetition strategy benefits the firm by creating additional value. There is little evidence that shows how coopetition affects market efficiency, with the exceptions of Chen et al. (2021) and Bushee et al. (2021). Also, insiders act as a contracting mechanism for market efficiency (Roulstone, 2003). Thus, there is a scope of performing a comprehensive empirical analysis of insider trading behavior in coopetition firms.

2.2 Insider trading

. Seyhun (1986) documents that corporate insiders strategically time their stock purchases and sales by buying before price rises and selling before price drops. This will discourage participants in the trading market, as uninformed investors are always 'losing' on trades with informed investors (Dolgopolov, 2004). Consequently, uninformed investors might impose a reputational penalty on the firm, or even the whole capital market, by purchasing fewer stocks or even not buying stocks at all, resulting in a lower or even a crash in stock price (Cornell and Sirri, 1992). Thus, the higher adverse selection costs deteriorate market liquidity. Although, the SEC has enacted the 'short-swing' rule [5] that imposes punishments for opportunistic insider transactions, insiders can escape regulatory penalties and achieve abnormal returns by timing their trades and releasing announcements during the post-trading period (Chen & Keung, 2019). Hence, insiders may be able to evade rules imposed by authorities to detect information-based trades.

The agency theory defines corporate insiders as the 'agent' and shareholders as the 'principals' (Jensen and Meckling, 1976). The principals delegates the decision-making authority to the management. However, the agent does not always act on behalf of the best interests of the shareholders. For instance, management may fail to provide timely disclosure

[5] The 'short-swing' rule prohibits insiders from profiting on offsetting trades within six months of the announcement. Therefore, insiders seeking to benefit from their private information will trade ideally six months in advance of the actual occurrence of the event.

about corporate decisions spurring information asymmetry. Similarly, coopetition has been recognised as a 'win-win' corporate strategy that capitalizes on the benefits of R&D collaboration (Gnyawali et al., 2011). Self-interested managers will exploit this information advantage by trading stocks before releasing positive news, as insiders' abnormal returns highly rely on changes in future stock prices and earnings (Lakonishok and Lee, 2001).

Kyle (1985) notes that insiders can profit from their information advantage. In his model, insiders act as the 'monopolist', as only insiders know the actual value of the risky asset. Consequently, insiders trade on this unique private information. In contrast, the uninformed investors trade randomly. Therefore, information asymmetry can be recognized by the variance of the bid-ask spread. Baiman and Verrecchia (1996) incorporate corporate disclosure into Kyle's (1985) model, finding that an increase in the quality of public disclosure reduces insider trading profits. We draw on from Kyle (1985) and Baiman and Verrechia (1996) who establish the link between corporate disclosure, information asymmetry, and insider trading profitability.

Aboody and Lev (2000) further demonstrate the association between R&D related private information and insider trading profitability. They argue that firms' internal R&D activity is a specific source of information, leading to increased information asymmetry between corporate insiders and outsiders. Uninformed investors normally lack financial literacy. Therefore, their inability to estimate the value of a firm's R&D project will contribute to the information advantage of corporate insiders. As a result, insiders generate much larger profits in R&D-intensive companies compared to firms that do not engage in R&D activities.

The extant literature documents that coopetition behavior creates a private inter-firm communication channel (Ritala et al., 2014), which allows a firm to exchange R&D information. Consequently, coopetition changes a firm's information environment (Bushee et al., 2021; Chen et al., 2021). Thus, all else remaining equal, coopetition engagement leads to a change in insider trading profits.

Furthermore, the coopetition literature (e.g., Baron and Spulber, 2018; Ranganathan et al., 2018) documents that coopetition is a value-adding corporate strategy that allows firms to generate additional profits that they could not achieve on their own. The organizational literature (Coase, 1937) also suggests that individuals will attempt to build efficient organizations since such organizations generate higher profits to be shared. Thus, the managers in coopetition firms have the incentives to maintain corporate efficiency through improved firm performance.

However, the insider trading literature shows that managers' ability to generate an abnormal return from private information can lead to corporate decisions that create information asymmetry (see e.g., Frankel and Li, 2004). Coopetition firms' R&D collaboration may in fact enable the manager to generate more private information, leading to larger insider trading profits. The coopetition literature (D'Aspremont and Jacquemin, 1988; Silipo, 2008; Baron and Pohlmann, 2018) suggests that firms can generate endless synergy via R&D coordination by delegating tasks among competitors, hence minimizing unnecessary duplication of effort. Consequently, coopetition enables firms to access resources from rivals instead of communicating with potential investors. Hence, corporate insiders may have more opportunities to execute information-based trades. Overall, how coopetition affects insider trading still remains an open debate.

In summary, Kyle's (1985) model empirically shows that insider trades are profitable. Further, Aboody and Lev (2000) find that for firms with more R&D activities, insider trading profits are greater. However, there is no evidence of how insiders perform when firms engage in inter-firm R&D activities. We will further contribute to this stream of literature by showing how inter-firm R&D activities affect insider trading profitability.

3. Hypothesis development

The impact of coopetition on insider trading profitability is twofold. Information asymmetry occurs when companies do not have sufficient incentive to provide quality disclosure, thus leading to conflicts of interest between corporate insiders and outsiders (Jensen and Meckling, 1976). Prior to coopetition, disclosing patent information to the public will attract competitors' attention. Under the coopetition relationship, the entity's superior intellectual property will no longer be exclusive to themselves. Rather, to attract potential investment, disclosing patent information to the public benefits the company, as trade secrets will become already available to competitors through R&D collaboration activities. Glaeser (2018) finds that withholding trade secrets decreases corporate transparency, while Chen et al. (2021) document that the coopetition relationship induces a company to include more narrative on R&D material in its 10-K report, indicating that a firm is more likely to increase public disclosure after coopetition. Coopetition promotes corporate transparency, allowing investors to determine the worth of a firm's trade secret, hence lowering information asymmetry between corporate insiders and outsiders. Thus, with lower information asymmetry due to coopetition, ceteris paribus (all else being equal), we anticipate a negative association between coopetition and insider trading.

H1A: Coopetition is negatively associated with insider trading profitability.

Clinch and Verrecchia (1997) show that firms use public disclosure to coordinate with competitors' production decisions to generate additional profits. For instance, companies may disclose that product demand is less than anticipated to inform competitors to limit their own outpu and the product then can be sold at a higher price. Thus, public disclosure becomes less advantageous in the context of coopetition, as internal collaboration with competitors is more efficient (Kepler, 2021). Additionally, past research indicates that firms use public disclosure to coordinate manufacturing, pricing, and other commercial operations with competitors (e.g.,

Arya and Mittendorf, 2016; Bourveau et al., 2020; Bloomfield, 2021). Coopetition allows participating firms to pool their resources together to achieve a mutual purpose in a specific area by delegating tasks across the member firms as well as establishing private communication channels to facilitate timely and efficient decision-making (Luo, 2007). Thus, inter-firm communication reduces the quality of public disclosure, resulting in information asymmetry between corporate insiders and outsiders. Hence, we alternatively expect that coopetition may increase the profitability of insider trading since corporate insiders may withhold more private information after coopetition, in line with agency theory (Jensen and Meckling, 1976).

Furthermore, prior studies suggest that firm voluntary disclosure is positively associated with the intention to raise external finance (Frankel et al., 1995; Collett and Hrasky, 2005; Hyytinen and Pajarinen, 2005), as firms can reduce the cost of capital by increasing their voluntary disclosure. The coopetition literature documents a synergy effect that can be created by delegating tasks among rivals through R&D coordination to reduce excessive duplication of effort (D'Aspremont and Jacquemin, 1988; Silipo, 2008; Baron and Pohlmann, 2018; Chen et al., 2021). Additional benefits such as product compatibility, quality, and reduced cost suggest that coopetition reduces external finance needs via shared R&D information through a private channel. Thus, there is little need for voluntary disclosure. Following Aboody and Lev (2000), corporate insiders are able to generate much larger profits when disclosing less R&D information to the public. Thus, if coopetition, ceteris paribus, increases information asymmetry, we anticipate a positive association between coopetition and insider trading profitability.

H1B: Coopetition is positively associated with insider trading profitability.

4. Research Methodology

4.1 Data

To investigate the association between coopetition and insider trading, we obtain coopetition data from the Searle Center Database, spanning 1992 to 2014. We collect the insider trading transactions from Thomson Financial Insider Filing Data (TFN). We only consider common stocks with the CRSP share codes 10 and 11. We collect each firm's financial information and stock return data from Compustat and CRSP. Following Rahman et al. (2021), we limit our time window to three years before and three years after a firm enters into a coopetition relationship. We focus on the period surrounding each coopetition event as it allows us to better capture the influence of coopetition on insider trading. We undertake a difference-in-differences analysis in a quasi-experimental design to compare each coopetition firm to its matched non-coopetition firm. Due to the unavailability of suitable non-coopetition firms to match with coopetition firms between 1992 and 1995, our sample period covers 1996 to 2017.

4.2 Sample construction

We first combine the firms' coopetition participation data with financial (Compustat) and stock market (CRSP) data. However, a coopetition firm may have several names in the coopetition database. For instance, a firm may be included in the database under three different names, such as 'Apple Computer', 'Apple Computer Inc', and 'Apple Computer Ltd'. To merge the database more accurately, we remove punctuation and words identifying the legal form of the company in the coopetition database. In the above example, the cleaned company would become 'Apple Computer' in all situations. Next, we implement the same approach to clean up all the firm names in Compustat. Then, we merge the two datasets using the cleaned company names. We remove financial and utility industries (SIC codes 4900-4999 and 6000-6999, respectively) from our sample, as these are regulated industries and lack coopetition engagement in these industries across our study period.

We next remove sample observations with missing values to ensure the validity of all observations in our empirical analysis. As firms have the discretion to enter into a coopetition engagement, we use propensity score matching to mitigate the self-selection bias. We define firms engaged in coopetition relationships as the pre-match treatment group, and firms that have never entered into a coopetition relationship as the pre-match control group. By implementing the PSM procedure, we use firm-year observations for coopetition companies one year prior to coopetition engagement to match the control group to build the samples.

Further, we obtain the insider trading data from the Thomson Reuters Filing Data. To determine the information-based trades, we limit our sample to open market purchases, since coopetition engagement is considered a positive firm-level event. Prior studies suggest that managerial entrenchment can be detected through abnormal returns from insider purchases since sales can be triggered by reasons other than private information. For instance, the CEO may sell their shares for the purpose of diversifying their own investment portfolio (Lakonishok and Lee, 2001; Cziraki et al., 2014; Akbas et al., 2020). To mitigate the influence of insider trading liquidity, we exclude transactions involving less than 100 shares. This filtering ensures that our sample contains only significant trades (Gao et al., 2014, Rahman et al., 2021). When an insider executes multiple trades on the same stock on the same day, the total number of shares traded is aggregated to the daily level in accordance with Rahman et al. (2021), since multiple transactions executed on the same day can skew the statistical results.

We report the sample[6] and industry distribution of coopetition firms in Panel A of Table 1. The coopetition database initially consists of 1,777 unique US listed coopetition companies. After filtering[7], the sample of coopetition firms is decreased to 325. Additionally, we lose three firms during the PSM process due to a lack of suitable control firms, resulting in a sample of

[6] The PSM process is detailed in the online appendix.

[7] 1,371 firms are dropped due to missing value and 81 firms belong to the financial and utility industries.

322 unique coopetition firms. Since we use a one-to-one nearest-neighbor propensity score with a 0.005 caliper in the matching process, our final sample includes 644 firms. We then merge the insider trading data, which results in a total of 5,196 transactions across our sample period.

Panel B of Table 1 presents the Fama-French 12 industry distribution of the coopetition firms. We find that high technology firms are more likely to enter into coopetition relationships. Each industry represents a similar proportion of our total sample firms, demonstrating that our sample is representative.

[Insert Table 1 here]

4.3 Variable Construction

4.3.1 Coopetition and insider trading

Following Chen et al. (2021), we define coopetition participation (*COOPETITION*) as a dummy variable equal to one if a firm engages in a coopetition relationship during the year and zero otherwise.

The dependent variable is the cumulative abnormal returns (*CAR*). We implement an event study approach to assess the profitability of each insider transaction. By calculating profits from insiders' trades over a variety of investment horizons (three months and six months) following the transaction's completion, we can more precisely capture corporate insider trading behavior. Following Wu (2018), we adopt the parameter-estimation window from day -250 to day -50 (trading days) relative to the insider-transaction dates. The following procedure is used to estimate the positive alpha:

$$R_{i,t} - R_{f,t} = \beta_{0,i} + \beta_{1,i}(R_{m,t} - R_{f,t}) + \beta_{2,i}(SMB_t) + \beta_{3,i}(HML_t) + \beta_{4,i}(MOM_t) + \varepsilon_{i,t}. \quad (1)$$

$$AR_{i,t} = R_{i,t} - E(R_{i,t}) = R_{i,t} - [\hat{\beta}_{0,t} + \hat{\beta}_{1,t}(R_{m,t} - R_{f,t}) + \hat{\beta}_{2,t}(SMB_t) + \hat{\beta}_{3,t}(HML_t) + \hat{\beta}_{4,t}(MOM_t) \quad (2)$$

$$CAR(0,T) = \sum_{t=0}^{T} AR_{i,t.} \quad (3)$$

Here, $R_{i,t}$ denotes the return of stock i in the parameter-estimation window t, and $R_{f,t}$ represents the risk-free rates in the parameter-estimation window t. R_m, *SMB, HML,* and *MOM* are the market return, size, value, and momentum factors that are available on Kenneth French's website. We calculate the excess alpha by subtracting the expected returns from the realised stock returns.

Finally, we measure the cumulative abnormal return for different investment horizons following Wu (2018), assuming 21 trading days per calendar month. Thus, investment horizons of three months and six months correspond to cumulative abnormal returns of T = 63 days and 126 days, respectively.

4.3.2 Control variables

We construct firm-level control variables by following prior literature (Aboody and Lev, 2000; Huddart and Ke, 2007; Gao et al., 2014). The natural logarithm of the asset is a proxy used to measure a firm's size. *ANALYST* following is computed as log (1 + the number of analysts following a firm), reflecting information asymmetry. The book-to-market ratio (*BTM*) is a measure of growth potential calculated by dividing the book value of equity by the market value of equity. Aboody and Lev (2000) suggest that firms with higher R&D expenditures have greater information asymmetry. Thus, we generate a dummy variable (*RESEARCH*) equal to one if the firm incurs research expenses and zero if the firm does not. *PROFIT* is the ratio of revenue to total assets before unusual items (Huddart and Ke, 2007). *SALES_GROWTH* is calculated by averaging the previous five years' sales growth (Gao et al., 2014). Table 2 provides detailed definitions of all variables.

Further, following (Ravina and Sapienza, 2010; Rahman et al., 2021; Wu, 2018), we also include some stock-level control variables: stock volatility (*VOLATILITY*), trading volume (*TURNOVER*), and past return (*PASTRETURN*). We define *VOLATILITY* as the standard deviation of daily stock returns over a one-year. *TURNOVER* is constructed as the average

trading volume divided by the number of outstanding shares over a one-year. *PASTRETURN* is the one-month cumulative abnormal returns prior to insider transactions (day -21 to day -1).

[Insert Table 2 here]

4.4 Regression model

To examine whether coopetition has an impact on insider trading profitability, we estimate the following regression model:

$$CAR_{i.t} = \alpha_0 + \alpha_1 COOPETITION_{i.t} + \sum_{k=4}^{11} \alpha_k CONTROLS_{i.t-1} + Industry\ FE + Year\ FE + \varepsilon_t \quad (4)$$

where $CAR_{i.t}$ is a proxy for the cumulative abnormal return over three months (63 calendar days) and six months (126 calendar days) for a firm *i* in period *t* *COOPETITION* is a dummy variable that equals one if the firm is a coopetition firm, and α_1 indicates the incremental effects of the coopetition on insider trading.

All continuous variables are winsorised at the 1st and 99th percentiles to eliminate the effect of outliers or extreme events. The *t*-statistics are clustered at the firm level, since failure to control for within-cluster error correlation can result in large *t*-statistics and low p-values. The Fama-French industry-fixed and year-fixed effects are included to control time-invariant industry-level potential influences and time-variant macro-level factors.

4.5 Descriptive statistics

Table 3 summarizes the statistics for the variables in the baseline model, including mean, standard deviation, median, and percentiles. The insiders' trading transactions generate abnormal returns of 6% (*CAR3MONTH*) and 8% (*CAR6MONTH*) on average for 3-month and 6-month investment horizons, respectively.

[Insert Table 3 here]

In Panel B of Table 3, *COOPETITION* measures coopetition participation, which equals one if the firm enters into a coopetition relationship during the year and zero otherwise. In Panel C. The average size of the firm is 7.29, and the average *BTM* is 0.56. On average, a firm

in our sample has 4.37 analyst coverage. The volatility and turnover are 0.03 and 1.67, respectively. The standard deviations of our control variables are consistent with prior studies.

[Insert Table 4 here]

The Pearson correlation matrix for the variables in the baseline model is shown in Table 4. The findings show that insider trading profitability is negatively correlated with *COOPETITION*. This result is consistent with our conjecture that disclosing trade secrets to competitors would reduce insiders' trading profitability on the proprietary information due to decreased information asymmetry between corporate insiders and outsiders. The majority of correlations between all other variables are statistically significant. Moreover, since the variance inflation factors (VIF) are relatively low, multicollinearity is unlikely to be an issue.

5. Baseline results

Table 5 shows the baseline results for the relationship between coopetition and insider trading. Our dependent variables are *CAR3MONTH* and *CAR6MONTH*. The independent variable is *COOPETITION*. Columns (1) and (2) present results with *CAR3MONTH*, and columns (3) and (4) show results for *CAR6MONTH*. The coefficients of *COOPETIITON* are negative and statistically significant in all specifications. This implies that the insiders of coopetition firms are less likely to profit from private information-based trading. In terms of economic significance, we find that the coefficients of *COOPETITION* in columns (2) and (4) are -0.039 and -0.063, indicating that a one standard deviation increase in *COOPETIITON* is associated with 29.9% and 36.23% decrease in insider trading profitability for three and six months, respectively[8]. Overall, the results are consistent with our conjecture that coopetition reduces insider trading profitability.

[8] The standard deviation of *COOPETITION* is 0.46, with coefficients 0.039 and 0.063 for *CAR3MONTH* and CAR6MONTH, respectively. The means of *CAR3MONTH* and *CAR6MONTH* are 0.08 and 0.06. Thus, one standard deviation increase in *COOPETITION* is associated with 29.9% (0.039/0.06×0.46) and 36.23% (0.063/0.08×0.46) decreases in insider trading profitability over three and six months, respectively.

[Insert Table 5 here]

6. Identification strategy

6.1 Difference-in-differences (DID) analysis

Figures 2 and 3 plot the estimate of insider trading profitability relative to the treated year in the seven-year window surrounding a firm's coopetition event. The figures demonstrate that the difference in insider trading profitability between coopetition and non-coopetition firms is statistically indistinguishable prior to coopetition engagement. The difference in insider trading profitability between coopetition and non-coopetition firms increases significantly once the coopetition firms initiate coopetition behavior, and the divergent pattern remains unaltered thereafter. The findings support the evidence that insider trading profitability decreases after coopetition behaviour.

[Insert Figure 2 and Figure 3 here]

To further identify the causal effects of coopetition on insider trading, we implement a difference-in-differences approach, allowing us to compare each coopetition firm with its matched non-coopetition firm. Our difference-in-differences estimation includes all of our baseline control variables in Equation (4). In spirit of Rahman et al. (2021), we examine the impact of coopetition on insider trading only considering the time periods surrounding each coopetition event. In the analysis, we consider three time windows. The first window examines insider trading observations one year before and after (-1/+1), the second window investigates insider trading observations two years before and after (-2/+2), and the third window includes insider trading observations three years before and after (-3/+3).

[Insert Table 6 here]

Table 6 reports the results from our difference-in-differences regression. *CAR3MONTH* and *CAR6MONTH* are the primary proxies for insider trading profitability. *COOPETITION* is a dummy variable that equals one if a firm engages in a coopetition relationship during the year

and zero otherwise. *POST* is a dummy variable that equals one for firms after coopetition participation and zero otherwise. For firms in the treatment group (coopetition firm), the effective year is the year they began coopetition behaviour, whereas for firms in the control group, the effective year is the year they were matched using the PSM technique.[9] *POST*×*COOPETITION* is an interaction variable that measures insider trading profitability of the treated firms (coopetition firms) after establishing a coopetition relationship with their competitors.

Columns (1) - (3) and (4) - (6) present the findings for *CAR3MONTH* and *CAR6MONTH* within the time window of one year before and after (-1/+1), two years before and after (-2/+2), and three years before and after (-3/+3) the coopetition event, respectively. We find that firms in the coopetition group prior to coopetition participation have no association with insider trading profitability, as the coefficients of *COOPETITION* are statistically insignificant in all specifications.

Furthermore, we find the coefficients of *POST*×*COOPETITION* are negative and statistically significant in all columns. The negative coefficients of *POST*×*COOPETITION* imply that coopetition behaviour decreases insider trading profitability. To elaborate, the results of both coefficients and *t*-statistics in columns (3) and (6) are more dominant than in other columns in Table 6, indicating that the impact of coopetition on insider trading profitability is more pronounced for the time window of three years before and after (-3/+3) the coopetition event. Overall, the difference-in-differences results are consistent with our baseline results that coopetition behaviour is associated with decreased insider trading profitability.

6.2 Falsification tests

[9] The PSM procedure and ex-ante summary statistics are reported in the online appendix.

Although the DID results show that coopetition behaviour decreases insider trading profitability, the results may still be driven by unobserved or confounding events. To enhance the credibility of the DID results, we implement two placebo tests as follows.

First, we construct the hypothetical timeline of the coopetition participation. In detail, we randomly assign the treated year for coopetition firms when coopetition behaviour did not occur. The selected placebo coopetition engagement years occur before the actual coopetition behaviour, which established the null hypothesis that coopetition behaviour does not affect insider trading profitability. Based on prior studies (Bae et al., 2020; Rahman et al., 2021), we re-estimate the DID model under this setting by repeating it 1000 times. Panel A of Table 7 shows the simulated distribution of coefficients and *t*-statistics on placebo *POST*×*COOPETITION*. The simulated coefficients on placebo *POST*×*COOPETITION* present a mean and median around zero in all specifications, far from our actual estimation of coefficients from the DID model. Furthermore, the simulated *p*-value and corresponding actual estimates in all specifications are less than 5%. Consequently, there is a 5% chance or less that the influence of coopetition on insider trading is ineffective. Thus, the results provide additional support that our DID model results are not mechanical, and *POST*×*COOPETITION* is only statistically significant during the actual coopetition event.

[Insert Table 7 here]

Secondly, we construct a hypothetical treatment group from the non-coopetition firms. Here, we assume that the coopetition behavior has already occurred and randomly select non-coopetition firms as the treatment group (coopetition firms). We then conduct PSM for the placebo coopetition firms using the sample one year before coopetition participation to match all the firm-year observations in the control group (non-coopetition firms). We re-estimate the DID model 1000 times under this setting. The simulated distribution of coefficients and *t*-statistics of placebo *POST*×*COOPETITION* are shown in Panel B of Table 7. The results are

similar to the first placebo test. In terms of mean and median, the *t*-statistics of placebo *POST×COOPETITION* are considerably lower than our actual *t*-statistics. The simulated *p*-value with related *t*-statistics is less than 5% (excluding *CAR6MONTH* (-2/+2) at 10% level). Thus, the results indicate that our DID model results are not mechanical and *POST×COOPETITION* is only statistically significant for the coopetition firms.

By performing two placebo tests, we further eliminate any potential concern related to or DID estimations results, indicating that insider trading profitability decreases exclusively for treated firms (coopetition firms) in the year following coopetition engagement. Therefore, we demonstrate a causal relationship between coopetition and insider trading profitability.

6.3 Instrumental variable (IV) approach

In this section, we further test the causality between coopetition and insider trading by implementing an instrumental variable approach. The instrumental variable is constructed based on the policy change for coopetition organisations. As detailed in Section 2.1, the technical standard is created based on consensus of the voting result. The patent owner will share the standard-essential patent (SEP) with all organisation members by charging a licencing fee, which is referred to as fair, reasonable, and non-discriminatory (FRAND) or reasonable and non-discriminatory (RAND) royalties. The licensor will typically demand a minimum royalty rate to compensate for the disclosure of trade secrets that may result in the licensor's loss of market share in the downstream product market (Sidak, 2013). Some scholars argue that the adoption of a technical standard confers substantial market power to its owner, who may opportunistically abuse such power and charge excessively high royalty rates (Layne-Farrar et al., 2007; Sidak, 2013). Consequently, such a royalty rate might discourage firms from joining the coopetition relationship, especially small growth firms with capital constraints. The royalty burden on sales would erode profit margins and destroy firms' free cash flows. Thus, the firms would incur an adverse selection cost because of reduced public investment confidence,

resulting in a share price undervaluation. Consequently, the royalty charge might discourage firms from participating in the coopetition organisation.

Therefore, several coopetition organisations have begun to modify their licensing policies to "royalty-free" (RF) and "no assertion" (NA) in response to the licensor's potential opportunistic behavior regarding royalty rates and abuse of market power over their intellectual property rights (Sidak, 2013; Chen et al., 2021). Consequently, modifying the policy of coopetition organisations would encourage coopetition participation by lowering the cost of access to intellectual property rights (patents) from patent owners. Hence, the policy change in coopetition organisations would be an appropriate shock to coopetition participation.

We obtain data on this coopetition organisation policy change from the Searle Center Database on Technology Standards and Standard Setting Organizations. Following Chen et al. (2021), we use the number of relevant coopetition organisations that add 'royalty-free' or 'no assertion' as optional licensing terms in the past three years as our instrumental variable (*SEP_PC*). A relevant coopetition organization is defined as a coopetition organization in which a firm's industry peers participate but not the firm itself. If the firm engaged in coopetition behavior prior to the coopetition organization issuing the new policy (RF or NA), *SEP_PC* would be coded zero. Thus, *SEP_PC* captures a firm's willingness to join the coopetition relationship after the coopetition organisation reduces the cost of coopetition.

Following prior studies, we adopt Wooldridge's (2010) three-stage process to demonstrate the causality between coopetition and insider trading profitability. In the first stage, we estimate the probit model by regressing *COOPETITION* on firm-level control variables (shown in Panel C of Table 4) while adding *SEP_PC* as an instrument.

[Insert Table 8 here]

The results of the first stage regression are reported in column (1) of Table 8. The coefficients of *SEP_PC* are positive and statistically significant in each time window. The

results are consistent with our anticipation that firms will be attracted to join the coopetition relationship after the organisations reduce the cost of coopetition participation by issuing a SEP policy.

We then compute the fitted probability of coopetition involvement from the regression. In the second stage, we regress *COOPETITION* on the fitted probability of coopetition participation and all control variables in Equation (4). In the third stage, we regress *CAR3MONTH* and *CAR6MONTH* on the fitted value of coopetition engagement from the second stage regression and all control variables in Equation (4).

Column (3) and (4) in Table 8 report the results of the third stage. The results are negative and statistically significant for both *CAR3MONTH* and *CAR6MONTH*. Therefore, we can confirm that increased coopetition participation causes decreased insider trading profitability.

Overall, the results are consistent with our conjecture and main analysis when we plug the fitted value of coopetition participation into the model, demonstrating that even if the context changes, the conclusions still hold. Additionally, policy change within coopetition organisations is unlikely to be affected by firms or other memberships, as firms do not have the authority to modify the coopetition organisation policy, meaning that the exclusive restriction is not violated. Consequently, our instrumental variables indicate that our findings are unlikely to be driven by potential endogeneity issues.

6.4 Heckman two-stage model

We also adopt Heckman two-stage approach to address unobservable differences between coopetition and non-coopetition firms. In the first stage, we estimate a probit model by including all firm-level control variables in Equation (4) to compute the Inverse Mills Ratio (*IMR*), also known as the bias correction term. However, Heckman model requires an exclusion restriction, which is a variable that only impacts insider trading profitability through coopetition. Following Chen et al. (2021), the SEP policy change only impacts coopetition

participation. Thus, we include the *SEP_PC* in the first stage. The results of the first stage are reported in column (1) of Table 9.

[Insert Table 9 here]

In the second stage, we re-run Equation (4) while adding the Inverse Mills Ratio to control for selection bias. The results are shown in columns (2) and (3) in Table 9. The coefficients of coopetition are statistically significant, which provides strong support for our primary analysis.

7. Robustness tests

7.1 Alternative proxies

To test the robustness of our findings, we re-run our baseline model by choosing additional proxies for both coopetition and insider trading. First, we use the number of competitors that the coopetition firm cooperates with as an alternative proxy for coopetition to re-estimate the baseline model. The results, reported in Table 10, are consistent with the main findings.

[Insert Table 10 here]

Secondly, we use the buy-and-hold abnormal return as an alternative proxy for insider trading profitability to check the credibility and generalisability of the baseline results. The results, reported in Table 11, are consistent with our main analysis.

[Insert Table 11 here]

7.2 Additional control variables

Hillier et al. (2015) argue that insider trading behaviour is conducted individually, and that trade size will differ significantly according to insiders' characteristics. Thus, we include control variables for trade size and insiders' personal traits. The trade size is the number of shares traded by an insider on a certain transaction date over the firm's total number of outstanding shares. Insiders' attributes are captured by an indicator variable that equals 1 if the

insiders are CEOs, 2 for other top-level managers, 3 for directors and other managers, and 4 for blockholders.

In addition, insider profitability may be driven by a firm's internal corporate governance, as Roulstone (2003) demonstrates that a well-governed firm imposes restrictions on insider trading. These restrictions are measured by the percentage of stocks traded by insiders within one month following a firm's earnings announcement. According to Roulstone (2003), firms are considered to be self-imposed insider trading restriction companies if at least 75% of trade occurs within this time period. We use a dummy variable to account for this type of firm by following Roulstone (2003) and Rahman et al. (2021).

[Insert Table 12 here]

The tests for coopetition and insider trading by including additional control variables are presented in Table 12. The coefficients of *COOPETITION* remain negatively significant. Thus, our results are robust to the inclusion of additional control variables.

8. Economic Mechanism

In this section, to better understand the impact of coopetition on insider trading in terms of economic mechanism i.e., information asymmetry, we perform a series of cross-sectional tests. We use three proxies of information asymmetry i) analyst forecast error; ii) idiosyncratic volatility; and iii) voluntary management disclosure. We define 'High' and 'Low' of these variables based on the cut-off point at 50^{th} percentile.

8.1 Analyst forecast error

We find that corporate insiders generate lower abnormal returns from their trades in a coopetition firm. Aboody and Lev (2000) document that the research and development process plays an important role in determining information asymmetry, since outsiders cannot directly observe the value of a firm's R&D. Gnyawali and Park (2011) indicate that a firm's coopetition relationship reduces the uncertainty of firm performance and Bushee et al. (2021) suggest that

information sharing between coopetition firms enhances analysts' sales forecast accuracy. This points to the information asymmetry channel of coopetition. To identify the validity of this information asymmetry channel, we use analyst forecast errors as a proxy for information asymmetry by following past research (Glaeser, 2018; Rahman et al., 2021). Analyst forecast error is measured as the absolute difference between actual and means earnings per share.

We regress insider trading on coopetition by distinguishing the level of the information asymmetry of the coopetition firms. The results are presented in Panel A of Table 13. The coefficients of *COOPETITION* are negative only when analyst dispersion is low. Therefore, reduced information asymmetry renders the association between coopetition and insider trading more pronounced.

[Insert Table 13 here]

8.2 Idiosyncratic volatility

According to Morck et al. (2000), firms with a greater value of property rights have a high level of idiosyncratic volatility. They suggest that strong property rights promote information asymmetry, resulting in increased proprietary costs and, consequently higher idiosyncratic volatility. Additionally, Durnev et al. (2003) demonstrate that companies with a higher level of idiosyncratic volatility have a greater level of stock price informativeness. They argue that private information is reflected through stock price, with higher idiosyncratic volatility indicating higher information asymmetry. Thus, we use idiosyncratic volatility as another proxy to further explore the role of information asymmetry in coopetition firms. Panel B of Table 13 presents the results. The coefficients are negatively significant only in the sub-sample with low idiosyncratic volatility[10]. Thus, the results suggest that the relationship

[10] Note: the coefficients on the low level and high level of idiosyncratic volatility are statistically indistinguishable using the Chow-test. However, the significant coefficients only for the low group provides further support for the information asymmetry channel.

between coopetition and insider trading is more pronounced for firms with low idiosyncratic volatility.

8.3 Voluntary management disclosure

The proprietary cost of disclosing the information is unfavourable to the firm (Verrecchia, 1983). However, after coopetition participation, the superior patent information will no longer be exclusively owned by the possessor, as trade secrets are disclosed to competitors (e.g., Baron and Spulber, 2018; Ranganathan et al., 2018). Disclosing the patent information to the public to attract more potential investment would be favourable to a firm, since trade secrets become available to competitors through R&D cooperation activities. Chen et al. (2021) document that coopetition relationships drive a company to increase corporate R&D disclosure. Therefore, we anticipate a more pronounced association between coopetition and insider trading profitability for a firm with a high level of voluntary management disclosure. We collect management voluntary disclosure data from I/B/E/S guidance. The tests are reported in Panel C of Table 13. The coefficients of *COOPETITION* are negatively significant only for firms with a high level of voluntary management disclosure. This implies that coopetition reduces insider trading profitability to a greater degree when there is a high level of voluntary management disclosure.

9. Conclusion

This study develops an empirical mechanism to measure the impact of coopetition on insider trading profitability. We focus on insider trading throughout the period surrounding coopetition participation by performing event studies and regressions. We implement a range of tests to enhance the credibility of the baseline results. Firstly, we employ a difference in differences analysis in a quasi-experimental design to establish the causality between coopetition and insider trading profitability. We next use an instrumental variable approach to further demonstrate the causality and address endogeneity concerns. Alternate proxies for

insider trading and coopetition as well as additional control variables are used to confirm the robustness of the findings. In heterogeneity analysis, we further find that decreases in insider trading profitability are more pronounced for coopetition firms with a lower level of information asymmetry. Overall, we find plausible evidence that coopetition decreases information asymmetry, proprietary costs, and corporate insiders' rent-seeking activities.

More importantly, our study sheds light on a feasible corporate strategy for reducing information asymmetry among corporate insiders and outsiders. The results suggest that coopetition strategies enhance capital market transparency by reducing information-based trades/insider trading profitability, which protects capital market integrity, raises investor confidence, and enhances public approval of companies.

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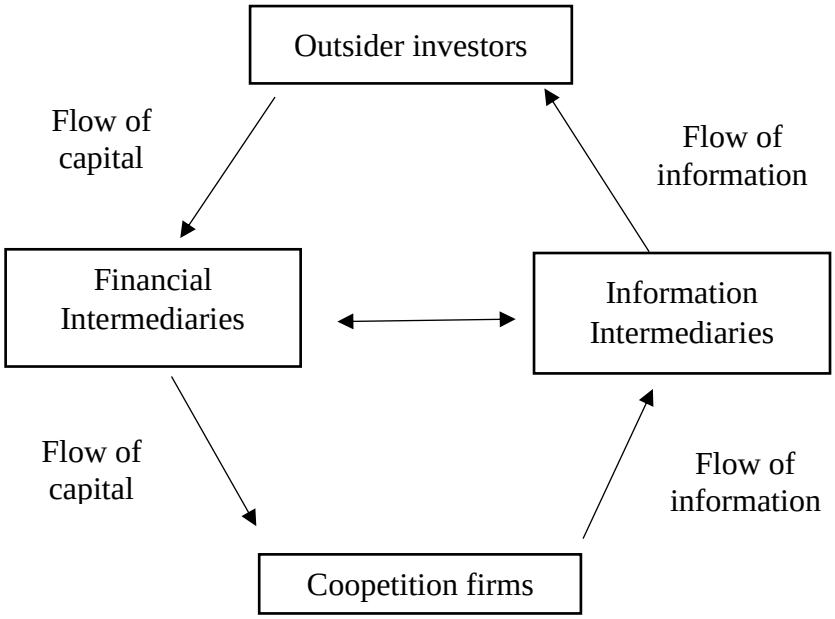

Figure 1. Financial and information flows for coopetition firms

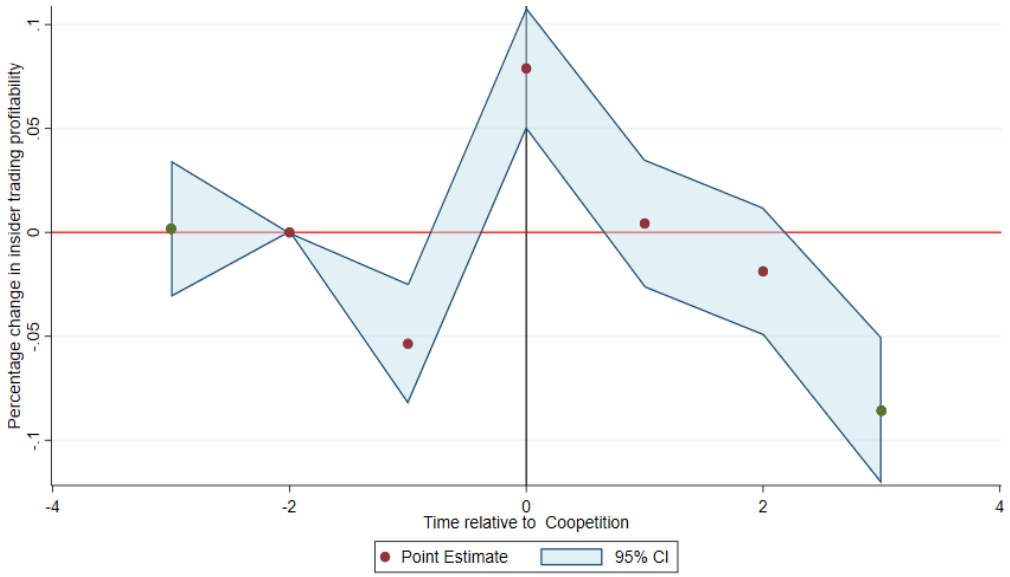

Figure 2: Percentage change in insider trading profitability (CAR3MONTH) surrounding coopetition participation.

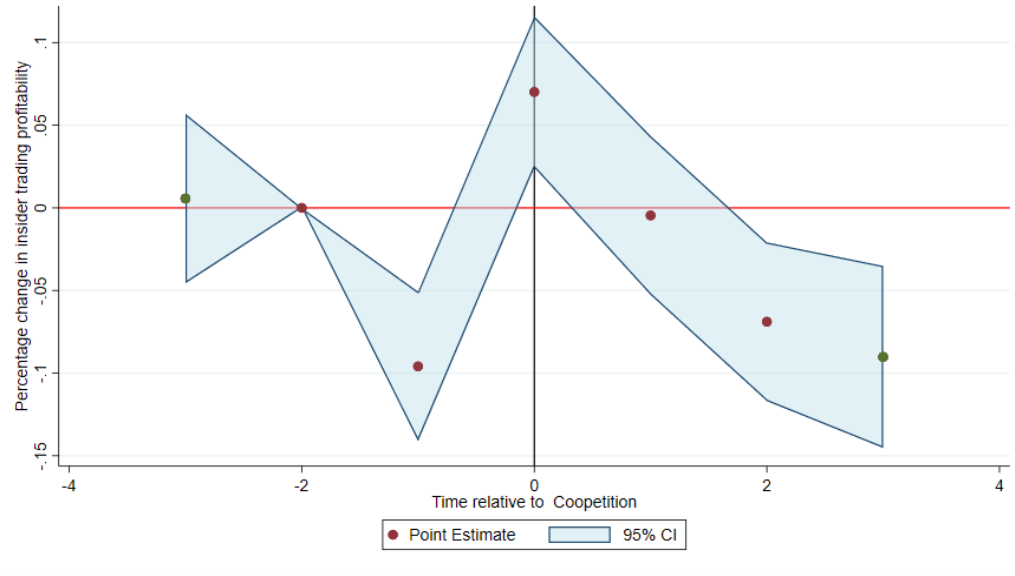

Figure 3: Percentage change in insider trading profitability (CAR6MONTH) surrounding coopetition participation.

Table 1: Sample Selection and Industry Distribution

Panel A: Sample Selection of Coopetition Firms

Restriction	Observations
Number of unique coopetition firms in the Searle Center Database	74,898
Less: The firms that cannot be matched with Compustat and CRSP Merged	(73,121)
Number of unique coopetition firms matched with Compustat and CRSP Merged	1,777
Less: The firms in SIC 4900 to 4999 and 6000 to 6999	(81)
Less: Observations with missing values in calculating control variables	(1,371)
Number of unique coopetition firms in the pre-matched treatment group	325
Less: Observations that cannot be matched with the control group	(3)
Number of unique coopetition firms in the post-matched treatment group	322

Panel B: Industry Distribution of Coopetition firms

Fama-French 12 Industry Classification	Frequency	Percentage
Business Equipment	119	36.96%
Chemicals and Allied Products	18	5.59%
Consumer Durables	15	4.66%
Consumer Non-Durables	17	5.28%
Energy	8	2.48%
Healthcare, Medical Equipment, and Drugs	33	10.25%
Manufacturing	43	13.35%
Telephone and Television Transmission	17	5.28%
Wholesale, Retail, and Some Services	30	9.32%
Other	22	6.83%

This table reports the sample selection process and industry distribution of the coopetition firms. Panel A shows the selection process of our treatment group. Panel B presents the frequency of coopetition firms' industry distribution by Fama-French 12 industry classification. The data for industry classification comes from their own website: https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library/det_12_ind_port.html.

Table 2: Variable Definitions

Variable	Definition
Panel A: Coopetition variables	
COOPETITION	A dummy variable equal to one if a firm in a coopetition group engaged in a coopetition relationship during the year, and zero otherwise.
Panel B: insider trading variables	
CAR3MONTH	Average daily abnormal return estimated using Carhart's (1997) four-factor model over 63 trading days subsequent to the insider trading date.
CAR6MONTH	Average daily abnormal return estimated using Carhart's (1997) four-factor model over 126 trading days subsequent to the insider trading date.
Panel C: Firm characteristics	
ANALYST	The natural logarithm of 1 plus number of analysts following the firm at time t-1.
BTM	The book-to-market ratio for the firm at time t-1.
AGE	The natural logarithm of firm age at time t-1 since its first appearance in CRSP.
SIZE	The natural logarithm of total assets at time t-1.
LOSS	An indicator variable equal to 1 if a firm reports a loss in year t-1 and 0 otherwise.
PASTRETRUN	We evaluate cumulative abnormal return for each insider transaction prior to one month (21 days) of the transaction using an event study approach and Carhart's four-factor model (Carhart, 1997).
PROFIT	The ratio of income before extraordinary items to total assets at time t-1.
RESEARCH	Calculated by dividing income before extraordinary items by total assets.
SALES_GROWTH	The average of the previous five years of sales growth at time t-1.
TURNOVER	The average of the trading volume to the number of outstanding shares during a one-year period at time t-1.
VOLATILITY	The standard deviation of daily stock returns over a one-year period at time t-1.

The time t-1 denotes the recent past, end-of-the-calendar year observations.

Table 3: Relevant summary statistics

Variable	Observations	Mean	SD	P25	Median	P75
Panel A: Insider Trading Profitability						
CAR3MONTH	5196	0.060	0.310	-0.100	0.040	0.200
CAR6MONTH	5196	0.080	0.490	-0.160	0.050	0.300
Panel B: Coopetition						
COOPETITION	5196	0.310	0.460	0	0	1
Panel C: Firm characteristics						
SIZE	5196	7.290	1.940	5.940	7.270	8.540
BTM	5196	0.560	0.450	0.270	0.430	0.730
LOSS	5196	0.240	0.430	0	0	0
PROFIT	5196	0.020	0.110	0	0.040	0.070
AGE	5196	3.030	0.740	2.510	3.030	3.590
SALES_GROWTH	5196	0.200	0.350	0.050	0.120	0.220
VOLATILITY	5196	0.030	0.020	0.020	0.030	0.040
TURNOVER	5196	1.670	0.870	1.080	1.690	2.330
ANALYST	5196	4.370	0.990	3.780	4.530	5.160
RESEARCH	5196	0.870	0.340	1	1	1
PASTRETURN	5196	-0.050	0.190	-0.130	-0.030	0.050

This table summarises the statistics for the study's primary variables. Profitability of insider trading is the main dependent variable (CAR3MONTH and CAR6MONTH). CAR3MONTH is the cumulative abnormal return three months (63 days) and CAR6MONTH is the cumulative abnormal return six months (126 days) from the transaction date. COOPETITION is a dummy variable that equals one if the firm engaged in a coopetition relationship during the year and zero otherwise. We construct a collection of control variables at the firm level in the manner described by Rahman et al. (2021). All variables are defined in Table 2.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) CAR3MONTH	1													
(2) CAR6MONTH	0.801***	1												
(3) COOPETITION	-0.069***	-0.058***	1											
(4) SIZE	-0.090***	-0.052***	0.093***	1										
(5) BTM	0.204***	0.172***	0.055***	-0.167***	1									
(6) LOSS	0.032**	0.001	0.010	-0.287***	0.223***	1								
(7) PROFIT	-0.047***	-0.029**	-0.037***	0.292***	-0.304***	-0.659***	1							
(8) AGE	-0.083***	-0.048***	0.181***	0.481***	-0.126***	-0.164***	0.169***	1						
(9) SALES_GROWTH	-0.011	0.007	-0.069***	-0.071***	-0.020	0.0120	-0.039***	-0.354***	1					
(10) VOLATILITY	0.175***	0.102***	-0.015	-0.478***	0.342***	0.428***	-0.433***	-0.395***	0.168***	1				
(11) TURNOVER	-0.015	-0.002	0.107***	0.046***	-0.192***	0.052***	-0.035**	-0.080***	0.103***	0.259***	1			
(12) ANALYSIT	-0.075***	-0.036**	0.060***	0.708***	-0.361***	-0.218***	0.300***	0.255***	0.131***	-0.313***	0.283***	1		
(13) RESEARCH	-0.008	-0.004	0.043***	-0.131***	-0.079***	0.023*	0.052***	0.072***	-0.201***	0.008	-0.097***	-0.134***	1	
(14) PASTRETURN	0.058***	0.090***	-0.012	0.020	0.145***	0.040***	-0.077***	0.011	-0.029**	0.001	-0.147***	-0.036***	-0.054***	1
VIF			1.07	2.95	1.46	1.88	1.98	1.60	1.27	1.98	1.4	2.76	1.11	1.05

Note: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

Table 4: Correlation matrix

Table 5: Coopetition and insider trading baseline regressions

Independent variables	Dependent variables: CAR3MONTH and CAR6MONTH			
	CAR3MONTH		CAR6MONTH	
	(1)	(2)	(3)	(4)
COOPETITION	-0.050***	-0.039**	-0.073***	-0.063**
	(-3.08)	(-2.15)	(-2.69)	(-2.19)
SIZE	-0.010	-0.015*	-0.019	-0.030*
	(-1.57)	(-1.95)	(-1.54)	(-1.94)
BTM	0.128***	0.153***	0.202***	0.245***
	(4.93)	(6.04)	(4.67)	(5.91)
LOSS	-0.039	-0.027	-0.075	-0.058
	(-0.95)	(-0.74)	(-1.11)	(-0.91)
PROFIT	0.096	0.077	0.029	-0.004
	(0.33)	(0.35)	(0.06)	(-0.01)
AGE	-0.006	-0.015	0.005	-0.009
	(-0.40)	(-1.10)	(0.20)	(-0.40)
SALE_GROWTH	-0.047	-0.066*	-0.019	-0.077
	(-1.31)	(-1.74)	(-0.32)	(-1.40)
VOLATILITY	3.183***	1.633	1.919	0.275
	(2.83)	(1.31)	(1.40)	(0.13)
TURNOVER	-0.007	-0.002	0.012	0.006
	(-0.47)	(-0.16)	(0.80)	(0.30)
ANALYST	0.026**	0.022	0.045**	0.046*
	(2.26)	(1.59)	(2.06)	(1.83)
RESEARCH	0.002	0.038	0.029	0.121
	(0.05)	(0.98)	(0.42)	(1.58)
PASTRETURN	0.058	0.040	0.194*	0.170
	(1.14)	(0.68)	(1.74)	(1.42)
Constant	-0.089	-0.104	-0.156	-0.261*
	(-1.28)	(-1.08)	(-1.40)	(-1.71)
Industry Fixed Effects	No	Yes	No	Yes
Year Fixed Effects	No	Yes	No	Yes
Observations	5,196	5,196	5,196	5,196
Adjusted R-squared	0.068	0.099	0.047	0.091

This table reports the baseline results for the relationship between coopetition and insider trading. CAR3MONTH is the cumulative abnormal returns 3 months (63 days) and CAR6MONTH is the cumulative abnormal returns six months (126 days) from the transaction date. The independent variable is COOPETITION, a dummy variable that equals one if the firm is a coopetition firm and zero otherwise. Following Rahman et al. (2021), we include a range of control variables: SIZE, ANALYST, BTM, RESEARCH, PROFIT, SALES_GROWTH, VOLATILITY, TURNOVER, and PASTRETURN. Firm and year fixed effects are included to control time-invariant industry-level potential influences and time-variant macro-level factors. Standard errors are clustered at the firm level to address heteroscedasticity. The t-statistics are reported in parentheses. The symbols ***, **, and * imply significance at the 1%, 5%, and 10% levels, respectively. All variables are defined in Table 2.

Table 6: Coopetition and insider trading DID regression

Independent variables	Dependent variables: CAR3MONTH and CAR6MONTH					
	CAR3MONTH			CAR6MONTH		
	(1) (-1/+1)	(2) (-2/+2)	(3) (-3/+3)	(4) (-1/+1)	(5) (-2/+2)	(6) (-3/+3)
POST×COOPETITION	-0.089**	-0.057*	-0.081***	-0.113*	-0.095**	-0.102**
	(-2.36)	(-1.87)	(-2.84)	(-1.86)	(-1.97)	(-2.32)
COOPETITION	0.042	0.001	0.000	0.064	0.005	0.002
	(1.46)	(0.03)	(0.01)	(1.29)	(0.17)	(0.06)
POST	0.106***	0.077***	0.066***	0.146**	0.083*	0.060
	(3.06)	(2.72)	(2.60)	(2.48)	(1.81)	(1.48)
SIZE	0.007	-0.015	-0.012*	0.005	-0.023	-0.028*
	(0.44)	(-1.64)	(-1.70)	(0.17)	(-1.17)	(-1.85)
BTM	0.163***	0.133***	0.148***	0.297***	0.247***	0.241***
	(4.93)	(4.55)	(5.95)	(5.30)	(5.11)	(5.80)
LOSS	-0.179***	-0.026	-0.028	-0.321***	-0.061	-0.059
	(-3.23)	(-0.56)	(-0.77)	(-3.20)	(-0.75)	(-0.93)
PROFIT	-0.556*	0.021	0.074	-1.191***	-0.031	-0.008
	(-1.88)	(0.07)	(0.34)	(-3.15)	(-0.07)	(-0.02)
AGE	-0.024	-0.016	-0.016	-0.028	-0.018	-0.010
	(-1.43)	(-1.05)	(-1.16)	(-0.88)	(-0.69)	(-0.44)
SALES_GROWTH	-0.105***	-0.049	-0.070*	-0.103**	-0.070	-0.081
	(-2.69)	(-1.44)	(-1.93)	(-2.02)	(-1.37)	(-1.52)
VOLATILTIY	5.286**	2.728*	1.741	3.803	1.076	0.371
	(2.48)	(1.71)	(1.41)	(1.06)	(0.40)	(0.18)
TURNOVER	-0.014	-0.009	-0.002	0.011	0.007	0.007
	(-0.48)	(-0.48)	(-0.13)	(0.25)	(0.28)	(0.32)
ANALYST	-0.002	0.013	0.018	0.014	0.022	0.042*
	(-0.07)	(0.79)	(1.33)	(0.35)	(0.70)	(1.71)
RESEARCH	-0.041	0.055	0.050	-0.014	0.156*	0.132*
	(-0.89)	(1.15)	(1.30)	(-0.18)	(1.91)	(1.69)
PASTRETURN	0.025	0.036	0.035	0.125	0.196	0.165
	(0.25)	(0.52)	(0.59)	(0.69)	(1.39)	(1.38)
Constant	-0.048	-0.037	-0.113	-0.200	-0.170	-0.268*
	(-0.33)	(-0.30)	(-1.21)	(-0.82)	(-0.95)	(-1.80)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,582	4,145	5,196	2,582	4,145	5,196
Adjusted R-squared	0.165	0.114	0.105	0.145	0.099	0.093

This table reports the results of the DID specification that accounts for the relationship between coopetition and insider trading. CAR3MONTH is the cumulative abnormal returns 3 months (63 days) and CAR6MONTH is the cumulative abnormal returns six months (126 days) from the transaction date. POST is a period dummy variable, which equals one for a company after coopetition participation. The effective year for firms in the coopetition group is the year they began coopetition behaviour, whereas the effective year for firms in the control group is the year they were matched using the PSM technique. COOPETITION is a categorical variable that is equal to one if the firm established a coopetition relationship throughout our sample period and zero otherwise. POST×COOPETITION is the interaction variable, representing insider trading profitability of coopetition firms after the coopetition behaviour. PASTRETURN is the one-month cumulative raw returns prior to insider transactions (day 21 to day 1). All other control variables are the same as in the PSM process. Standard errors are clustered at the firm level to address heteroscedasticity. The t-statistics are reported in parentheses. The symbols ***, **, and * imply significance at the 1%, 5%, and 10% levels, respectively. All variables are defined in Table 2.

Panel A: 'Coopetition firms' in non-coopetition year											
		Distribution of estimates									
	Actual	Mean	1%	5%	10%	25%	50%	75%	90%	95%	99%
CAR3MONTH											
(+1/-1)											
COOPETITION × POST	-0.089	0.022	-0.077	-0.045	-0.028	-0.004	0.023	0.05	0.075	0.089	0.113
	(-2.36)	(0.65)	(-2.12)	(-1.30)	(-0.79)	(-0.12)	(0.66)	(1.43)	(2.17)	(2.52)	(3.24)
(+2/-2)											
COOPETITION × POST	-0.057	0.017	0.058	-0.036	-0.025	-0.005	0.174	0.038	0.059	0.072	0.096
	(-1.87)	(0.59)	(-2.12)	(-1.30)	(-0.93)	(-0.18)	(0.61)	(1.36)	(2.02)	(2.46)	(3.39)
(+3/-3)											
COOPETITION × POST	-0.081	0.008	-0.057	-0.037	-0.027	-0.100	0.008	0.027	0.043	0.053	0.066
	(-2.84)	(0.33)	(-2.45)	(-1.51)	(-1.09)	(-0.42)	(0.32)	(1.09)	(1.79)	(2.15)	(2.86)
CAR6MONTH											
(+1/-1)											
COOPETITION × POST	-0.113	0.031	-0.115	-0.076	-0.051	-0.124	0.029	0.071	0.114	0.14	0.196
	(-1.86)	(0.55)	(-2.12)	(-1.30)	(-0.89)	(-0.20)	(0.51)	(1.30)	(2.09)	(2.48)	(3.45)
(+2/-2)											
COOPETITION × POST	-0.095	0.021	-0.107	-0.064	-0.048	-0.015	0.020	0.055	0.090	0.109	0.145
	(-1.97)	(0.45)	(-2.12)	(-1.44)	(-0.92)	(-0.30)	(0.42)	(1.16)	(1.90)	(2.31)	(3.13)
(+3/-3)											
COOPETITION × POST	-0.102	0.002	-0.057	-0.037	-0.027	-0.100	0.008	0.027	0.043	0.053	0.066
	(-2.32)	(0.05)	(-2.39)	(-1.62)	(-1.28)	(-0.69)	(0.10)	(0.78)	(1.39)	(1.75)	(2.50)

Panel B: 'Non-coopetition firms' in coopetition year											
		Distribution of estimates									
	Actual	Mean	1%	5%	10%	25%	50%	75%	90%	95%	99%
CAR3MONTH											
(+1/-1)											
COOPETITION × POST	-0.089	0.009	-0.111	-0.071	-0.055	-0.025	0.008	0.044	0.078	0.093	0.127
	(-2.36)	(0.18)	(-2.50)	(-1.64)	(-1.32)	(-0.59)	(0.18)	(0.993)	(1.62)	(1.99)	(2.75)
(+2/-2)											
COOPETITION × POST	-0.057	-0.002	-0.071	-0.052	-0.041	-0.022	-0.003	0.018	0.040	0.051	0.078
	(-1.87)	(-0.083)	(-2.69)	(-1.87)	(-1.48)	(-0.80)	(-0.12)	(0.62)	(1.34)	(1.77)	(2.74)
(+3/-3)											
COOPETITION × POST	-0.081	-0.009	-0.078	-0.058	-0.048	-0.029	0.010	0.012	0.029	0.038	0.061
	(-2.84)	(-0.36)	(-3.02)	(-2.28)	(-1.81)	(-1.16)	(-0.39)	(0.47)	(1.12)	(1.49)	(2.21)
CAR6MONTH											
(+1/-1)											
COOPETITION × POST	-0.113	0.019	-0.190	-0.118	-0.087	-0.036	0.017	0.078	0.125	0.158	0.213
	(-1.86)	(0.27)	(-2.19)	(-1.60)	(-1.18)	(-0.52)	(0.24)	(1.08)	(1.76)	(2.09)	(2.95)
(+2/-2)											
COOPETITION × POST	-0.095	-0.015	-0.145	-0.107	-0.086	-0.053	-0.017	0.024	0.059	0.079	0.116
	(-1.97)	(-0.30)	(-2.87)	(-2.09)	(-1.75)	(-1.04)	(-0.34)	(0.47)	(1.23)	(1.59)	(2.28)
(+3/-3)											
COOPETITION × POST	-0.102	-0.02	-0.137	-0.103	-0.085	-0.056	-0.023	0.011	0.041	0.057	0.086
	(-2.32)	(-0.50)	(-3.07)	(-2.29)	(-1.86)	(-1.26)	(-0.52)	(0.24)	(0.92)	(1.24)	(1.99)

Table 7: Placebo tests

This table reports the falsification tests for the association between coopetition and insider trading. COOPETITION (Placebo) is a categorical variable equal to one if the firm established a coopetition relationship throughout our sample period and zero otherwise; POST (Placebo) is a period dummy variable, which equals one for the year after the coopetition behaviour and zero otherwise. POST×COOPETITION (Placebo) is the interaction variable representing the insider trading profitability of treated firms after the coopetition behaviour. We include windows of one, two, and three years of observations before and after the coopetition event in our regression sample. In Panel A, we randomly assign the treated year for coopetition firms when the coopetition behaviour did not occur. In Panel B, we randomly select non-coopetition firms as the treatment group (coopetition firms). We conduct the PSM process as per the baseline sample and re-estimate the DID model 1000 times under this setting for both panels. CAR3MONTH is the cumulative abnormal returns 3 months (63 days) and CAR6MONTH is the cumulative abnormal returns six months (126 days) from the transaction date. We also include firm-level control variables, defined in Table 2. Standard errors are clustered at the firm level to address heteroscedasticity. All regressions include industry and year fixed effects.

Table 8: Instrumental variable approach

	First-Stage Model	Second-Stage Model	Third-Stage Model	
VARIABLES	COOPETITION	COOPETITION	CAR3MONTH	CAR6MONTH
	(1)	(2)	(3)	(4)
SEP_PC	0.035***			
	(2.67)			
Fitted_Participation		0.947***		
		(3.55)		
Fitted_Coopetition			-0.214**	-0.423**
			(-2.31)	(-2.43)
SIZE	0.008	0.001	-0.016**	-0.031**
	(0.12)	(0.04)	(-2.02)	(-1.98)
BTM	0.532***	0.003	0.177***	0.295***
	(2.75)	(0.05)	(6.06)	(5.98)
LOSS	-0.235	0.001	-0.037	-0.076
	(-1.15)	(0.01)	(-0.98)	(-1.17)
PROFIT	-1.117	-0.013	-0.022	-0.195
	(-1.25)	(-0.05)	(-0.09)	(-0.52)
AGE	0.561***	0.007	0.011	0.047
	(4.83)	(0.15)	(0.56)	(1.39)
SALES_GROWTH	0.306*	-0.000	-0.061	-0.053
	(1.84)	(-0.01)	(-1.49)	(-0.88)
VOLATILTIY	-4.097	0.113	1.198	-0.397
	(-0.48)	(0.05)	(0.90)	(-0.18)
TURNOVER	0.164	-0.003	0.004	0.017
	(1.34)	(-0.08)	(0.23)	(0.73)
ANALYST	0.107	0.001	0.030**	0.060**
	(0.83)	(0.03)	(1.97)	(2.20)
RESEARCH	1.080***	0.016	0.074*	0.199**
	(3.29)	(0.16)	(1.69)	(2.24)
PASTRETRUN	0.135	0.002	0.035	0.159
	(0.73)	(0.04)	(0.58)	(1.31)
Constant	-2.379**	-0.036	-0.226*	-0.555***
	(-2.15)	(-0.10)	(-1.88)	(-2.77)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Model of fits				
Test of weak instrument (Kleibergen-Paap rk LM statistic):	9.202***	9.202***	9.202***	9.202***
Test of under indenfication (Kleibergen-Paap rk Wald F statistic):	11.27***	11.27***	11.27***	11.27***
Over idenfitfiation	No	No	No	No
Test of endogeneity (Wu-Hausman)			6.663***	10.304***
Observations	4,874	4,874	4,874	4,874
Adjusted R-squared		0.237	0.099	0.092

This table presents the results of the instrumental variable test to further alleviate endogeneity concerns. We use Wooldridge's (2010) three-stage approach to conduct the regressions. Following Chen et al. (2021), SEP_PC represents the number of a firm's industry peers that have engaged in coopetition relationships over the preceding three years after the relevant coopetition organisation reduced the cost of coopetition. The relevant coopetition organisation is defined as one that adds RF or NA as optional licence terms within the calendar year. Industry peers are defined as firms under the same two-digit SIC code. Fitted_coopetition is calculated from the fitted value of COOPETITION after the coopetition organisation issued new regulation to reduce the cost of coopetition. All variables are defined in Table 2. Standard errors are clustered at the firm level to address heteroscedasticity. All regressions include industry and year fixed effects. The t-statistics are reported in parentheses. The symbols ***, **, and * imply significance at the 1%, 5%, and 10% levels, respectively

Table 9: Heckman-two stage model

	First-Stage Model	Second-Stage Model	
VARIABLES	COOPETITION	CAR3MONTH	CAR6MONTH
	(1)	(2)	(3)
COOPETITION		-0.039**	-0.063**
		(-2.14)	(-2.17)
Inverse Mills Ratio		0.031	0.038
		(0.73)	(0.46)
SEP_PC	0.035***		
	(2.67)		
SIZE	0.008	-0.016**	-0.032**
	(0.12)	(-2.08)	(-2.07)
BTM	0.532***	0.165***	0.260***
	(2.75)	(5.98)	(5.62)
LOSS	-0.235	-0.031	-0.061
	(-1.15)	(-0.85)	(-0.97)
PROFIT	-1.117	0.014	-0.100
	(-1.25)	(0.06)	(-0.27)
AGE	0.561***	-0.001	0.009
	(4.83)	(-0.07)	(0.24)
SALES_GROWTH	0.306*	-0.064	-0.064
	(1.84)	(-1.50)	(-1.00)
VOLATILTIY	-4.097	1.180	-0.372
	(-0.48)	(0.92)	(-0.17)
TURNOVER	0.164	0.001	0.008
	(1.34)	(0.08)	(0.37)
ANALYST	0.107	0.026*	0.051*
	(0.83)	(1.76)	(1.88)
RESEARCH	1.080***	0.056	0.144
	(3.29)	(1.26)	(1.51)
PASTRETURN	0.135	0.035	0.157
	(0.73)	(0.59)	(1.30)
Constant	-2.379**	-0.228	-0.438
	(-2.15)	(-1.13)	(-1.17)
Industry Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Observations	4,874	4,874	4,874
Adjusted R-squared		0.100	0.091

This table shows presents the results of the Heckman two stage model to correct for selection bias. Column (1) reports the selection model. SEP_PC represents the number of a firm's industry peers that have engaged in coopetition relationships over the preceding three years after the relevant coopetition organisation reduced the cost of coopetition. COOPETITION is a dummy variable that is equal to one if the firm is a coopetition firm and zero otherwise. For dependent variables in column (2), CAR3MONTH is the cumulative abnormal returns 3 months (63 days) and CAR6MONTH is the cumulative abnormal returns six months (126 days) from the transaction date. The Inverse Mills Ratio is a correction term in the second stage. All variables are defined in Table 2. The standard errors are clustered at the firm level to address heteroscedasticity. All regressions include industry and year fixed effects. The t-statistics are reported in parentheses. The symbols ***, **, and * imply significance at the 1%, 5%, and 10% levels, respectively.

Table 10: Alternative measure of coopetition (number of competitors)

Independent variables	Dependent variables: CAR3MONTH and CAR6MONTH			
	CAR3MONTH		CAR6MONTH	
	(1)	(2)	(3)	(4)
COOPETITION_PEER	-0.011**	-0.008*	-0.026***	-0.020**
	(-2.41)	(-1.68)	(-3.57)	(-2.55)
SIZE	-0.011***	-0.016***	-0.020***	-0.029***
	(-2.89)	(-3.29)	(-2.88)	(-3.36)
BTM	0.128***	0.156***	0.202***	0.242***
	(8.36)	(9.92)	(8.18)	(9.31)
LOSS	-0.032*	-0.024	-0.043	-0.028
	(-1.88)	(-1.41)	(-1.57)	(-1.06)
PROFIT	0.087	0.077	0.114	0.087
	(0.90)	(0.88)	(0.76)	(0.69)
AGE	-0.007	-0.015*	-0.003	-0.021
	(-1.08)	(-1.86)	(-0.23)	(-1.48)
SALES_GROWTH	-0.059***	-0.081***	-0.044*	-0.102***
	(-3.71)	(-4.16)	(-1.75)	(-3.42)
VOLATILTIY	2.039***	1.193*	1.753**	1.266
	(4.11)	(1.71)	(1.97)	(1.01)
TURNOVER	-0.003	-0.003	0.002	-0.021
	(-0.49)	(-0.31)	(0.22)	(-1.57)
ANALYST	0.025***	0.027***	0.049***	0.058***
	(3.75)	(3.36)	(4.38)	(4.34)
RESEARCH	0.038***	0.059***	0.079***	0.156***
	(2.94)	(3.00)	(3.78)	(4.86)
PASTRETURN	0.073**	0.070*	0.273***	0.259***
	(2.08)	(1.95)	(4.38)	(4.17)
Constant	-0.094***	-0.133**	-0.190***	-0.303***
	(-2.70)	(-2.30)	(-3.51)	(-3.23)
Industry Fixed Effects	No	Yes	No	Yes
Year Fixed Effects	No	Yes	No	Yes
Observations	4,688	4,688	4,688	4,688
Adjusted R-squared	0.057	0.080	0.051	0.102

This table presents the results regarding the association between coopetition and insider trading using an alternative measure of coopetition, namely COOPETITION_PEER, which is the number of industry peers in the same coopetition organisation. Industry peers are defined as firms under the same two-digit SIC code. CAR3MONTH (CAR6MONTH) is the cumulative abnormal returns 3 months (6 months) after the transaction date. All variables are defined in Table 2. Firm and year fixed effects are included to control time-invariant industry-level potential influences and time-variant macro-level factors. The t-statistics are reported in parentheses. The symbols ***, **, and * imply significance at the 1%, 5%, and 10% levels, respectively.

Table 11: Alternative measure of insider trading (BHAR)

Independent variables	Dependent variables: BHAR3MONTH and BHAR6MONTH			
	BHAR3MONTH		BHAR3MONTH	
	(1)	(2)	(3)	(4)
COOPETITION	-0.051***	-0.039*	-0.094**	-0.086**
	(-2.67)	(-1.94)	(-2.46)	(-2.26)
SIZE	-0.010	-0.011	0.006	-0.006
	(-1.32)	(-1.30)	(0.20)	(-0.17)
BTM	0.161***	0.188***	0.331***	0.409***
	(4.44)	(5.27)	(4.02)	(4.36)
LOSS	-0.039	-0.027	-0.122	-0.110
	(-0.78)	(-0.62)	(-1.21)	(-1.12)
PROFIT	0.072	0.041	0.183	0.164
	(0.21)	(0.15)	(0.28)	(0.32)
AGE	0.002	-0.017	-0.006	-0.041
	(0.11)	(-0.99)	(-0.13)	(-0.84)
SALES_GROWTH	-0.062	-0.078*	-0.123	-0.203**
	(-1.42)	(-1.67)	(-1.21)	(-2.04)
VOLATILTIY	3.033*	1.098	2.450	1.456
	(1.82)	(0.67)	(0.83)	(0.37)
TURNOVER	-0.011	-0.012	0.025	-0.001
	(-0.57)	(-0.59)	(1.08)	(-0.04)
ANALYST	0.031**	0.023	0.019	0.024
	(2.13)	(1.29)	(0.40)	(0.50)
RESEARCH	-0.004	0.027	0.046	0.151
	(-0.08)	(0.64)	(0.50)	(1.47)
PASTRETURN	0.052	0.023	0.321	0.283
	(0.79)	(0.29)	(1.26)	(1.14)
Constant	-0.142	-0.122	-0.310**	-0.389*
	(-1.64)	(-1.05)	(-2.06)	(-1.78)
Industry Fixed Effects	No	Yes	No	Yes
Year Fixed Effects	No	Yes	No	Yes
Observations	5,196	5,196	5,196	5,196
Adjusted R-squared	0.061	0.099	0.057	0.095

This table presents the results regarding the association between coopetition and insider trading using an alternative measure of insider trading. BHAR3MONTH and BHAR6MONTH are buy-and-hold abnormal returns over 3 month (63 trading days) and 6 months (126 trading days), respectively. COOPETITION is a dummy variable that is equal to one if the firm is a coopetition firm and zero otherwise. All variables are defined in Table 2. Firm and year fixed effects are included to control time-invariant industry-level potential influences and time-variant macro-level factors. Standard errors are clustered at the firm level to address heteroscedasticity. The t-statistics are reported in parentheses. The symbols ***, **, and * imply significance at the 1%, 5%, and 10% levels, respectively.

Table 12: Alternative measures: Additional control variables

Independent variables	Dependent variables: CAR3MONTH and CAR6MONTH			
	CAR3MONTH		CAR6MONTH	
	(1)	(2)	(3)	(4)
COOPETITION	-0.058***	-0.046**	-0.089***	-0.072**
	(-3.09)	(-2.09)	(-2.77)	(-2.17)
Trade Size	-0.076	0.077	-0.023	0.190
	(-0.39)	(0.30)	(-0.16)	(0.86)
Restriction	0.037	0.090**	0.027	0.066
	(0.76)	(2.21)	(0.29)	(0.76)
All other controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	No	Yes	No	Yes
Year Fixed Effects	No	Yes	No	Yes
Insider Fixed Effects	No	Yes	No	Yes
Observations	6,099	6,099	6,099	6,099
Adjusted R-squared	0.067	0.113	0.053	0.115

This table presents the results regarding the association between coopetition and insider trading by include self-imposed insider trading restrictions and insider fixed effects. CAR3MONTH (CAR6MONTH) is the cumulative abnormal returns 3 months (6 months) after the transaction date. COOPETITION is a dummy variable that is equal to one if the firm is a coopetition firm and zero otherwise. Following Rahman et al. (2021), we include a range of control variables: SIZE, ANALYST, BTM, RESEARCH, PROFIT, SALES_GROWTH, VOLATILITY, TURNOVER, and PASTRETURN. Firm and year fixed effects are included to control time-invariant industry-level potential influences and time-variant macro-level factors. Standard errors are clustered at the firm level to address heteroscedasticity. The t-statistics are reported in parentheses. The symbols ***, **, and * imply significance at the 1%, 5%, and 10% levels, respectively. All variables are defined in Table 2.

Panel A: Analyst forecast error

Independent variables	Dependent variables: CAR3MONTH and CAR6MONTH			
	CAR3MONTH		CAR6MONTH	
	Low	High	Low	High
	(1)	(2)	(3)	(4)
COOPETITION	-0.049**	0.006	-0.104***	0.004
	(-2.22)	(0.23)	(-2.80)	(0.11)
Constant	-0.053	-0.531**	-0.375**	-1.098**
	(-0.47)	(-2.03)	(-2.14)	(-2.21)
Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	2,193	2,194	2,193	2,194
Adjusted R-squared	0.099	0.153	0.154	0.168

Panel B: Idiosyncratic volatility

Independent variables	Dependent variables: CAR3MONTH and CAR6MONTH			
	CAR3MONTH		CAR6MONTH	
	Low	High	Low	High
	(1)	(2)	(3)	(4)
COOPETITION	-0.028**	-0.040	-0.038*	-0.058
	(-2.28)	(-0.96)	(-1.89)	(-0.98)
Constant	0.083	-0.068	-0.025	-0.025
	(0.90)	(-0.45)	(-0.20)	(-0.09)
Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	2,600	2,578	2,600	2,578
Adjusted R-squared	0.109	0.133	0.112	0.145

Panel C: Management voluntary disclosure

Independent variables	Dependent variables: CAR3MONTH and CAR6MONTH			
	CAR3MONTH		CAR6MONTH	
	Low	High	Low	High
	(1)	(2)	(3)	(4)
Coopetition	0.018	-0.066**	-0.057	-0.078*
	(0.49)	(-2.44)	(-0.96)	(-1.80)
Constant	0.117	-0.124	0.295	0.060
	(0.19)	(-0.24)	(0.29)	(0.06)
Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,682	1,881	1,682	1,881
Adjusted R-squared	0.406	0.284	0.414	0.321

Table 13: Heterogeneity analysis

This table presents the heterogeneity analysis results regarding analyst forecast error (Panel A), idiosyncratic volatility (Panel B), and management voluntary disclosure (Panel C). We include a range of control variables: SIZE, ANALYST, BTM, RESEARCH, PROFIT, SALES_GROWTH, VOLATILITY, TURNOVER, and PASTRETURN. Standard errors are clustered at the firm level to address heteroscedasticity. The t-statistics are reported in parentheses. The symbols ***, **, and * imply significance at the 1%, 5%, and 10% levels, respectively. All variables are defined in Table 2. Note: the coefficients on the low level and high level of idiosyncratic volatility are statistically indistinguishable using the Chow-test. However, the significant coefficients only for the low group provide further support for the information asymmetry channel.

Online Appendix

PSM procedure and ex-ante summary statistics

To examine the impact of coopetition on insider trading, we include a range of firm-level variables in the PSM process by referring to prior literature (Rahman et al., 2021). These variables include the natural log of the market value of the asset (SIZE), book-to-market-ratio (BTM), a dummy variable for negative earnings (LOSS), return on assets before extraordinary earnings (PROFIT), average past five years of sales growth (SALES_GROWTH), the standard deviation of daily stock return over a one-year period (VOLATILITY), the stock turnover ratio (TURNOVER), log analyst following (ANALYST), and firm age (AGE). We also require firms are matched by year and Fama-French 48 industry classification to ensure the matched firms are under the same information environment before coopetition participation.

Supplementary Table 1: Comparison of firm characteristics one year prior to first-time coopetition behaviour

	Coopetition firm	Matched non-coopetition firm	Difference
	(1)	(2)	(3)
SIZE	7.618	8.091	-0.473
BTM	0.494	0.556	-0.062
PROFIT	0.180	0.143	0.037
LOSS	0.273	0.375	-0.102
AGE	2.939	3.258	-0.319
SALES_GROWTH	0.212	0.263	-0.051
VOLATILITY	0.031	0.040	-0.009
TURNOVER	1.856	2.231	-0.375
ANALYST	4.471	4.473	-0.002
RESEARCH	0.929	0.857	0.072

This table reports the results of a balance check by comparing the differences in the means of the control variables following the PSM procedure. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Table 2.

Supplementary Table 1 compares coopetition and non-coopetition firms' firm-level characteristics in the year prior to coopetition participation. All variables are defined in Table 2. We find that all variables in the ex-ante summary of statistics for coopetition and non-coopetition firms are statistically and insignificantly different from zero, suggesting the treatment group (coopetition firms) and control group (non-coopetition firms) are "equal" prior to coopetition participation in terms

of firm-level characteristics, which enables us to concentrate on the influence of the main independent variable (coopetition) on insider trading.