

Why can't the market add and subtract? Evidence from central firms in business groups

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March 2025

Woojin Kim

Seoul National University and ECGI

Shu-Feng Wang

Ajou University

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Keywords: Centrality, Free float, Law of one price, Korean business group

JEL Classifications: G12, G34

Woojin Kim*

Professor of Finance
Seoul National University
1 Gwanak-ro, Gwanak-gu
Seoul, 08826, Republic of Korea
phone: +822-880-5831
e-mail: wojinkim@snu.ac.kr

Shu-Feng Wang

Associate Professor
Ajou University
206 Worldcup-ro Yeongtong-gu
Suwon, 443-749, South Korea
e-mail: sfwang@ajou.ac.kr

*Corresponding Author

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Woojin Kim^{*}
Seoul National University, ECGI

Shu-Feng Wang^{**}
Ajou University Business School

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^{*} Samick Chaired Professor of Finance. Seoul National University Business School, Gwanak-gu, Seoul, Korea 08826, Seoul, Korea. e-mail: woojinkim@snu.ac.kr.

^{**} Associate Professor of Finance. Ajou University Business School, 206 Worldcup-Ro, Yeoungtong-Gu, 16499, Suwon, S. Korea: e-mail: sfwang@ajou.ac.kr.

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I. Introduction

Standard arbitrage argument stipulates that mispricing cannot persist in an efficient market since arbitrageurs would quickly step in to take advantage of the mispricing. Nevertheless, growing literature on behavioral finance presents many pieces of evidence on persistent mispricing based on various limits to arbitrage. A prominent example is the short sales constraint discussed in Ofek and Richardson (2003) among many others which is considered a key factor behind the prolonged overpricing during the tech bubble. Lamont and Thaler (2013) present some extreme cases of blatant mispricing, where carved out subsidiary prices are much higher than the prices of a synthetic portfolio that consists of parent shares which will be converted into carved-out shares at a later date. Such mispricing cannot persist in an efficient market since arbitrageurs can buy the cheap parent shares, short the overpriced carved-out shares, and lock in the profit at a later date by converting parent shares into carved-out shares and closing out the short position. Lamont and Thaler (2013) point out that such arbitrage trading strategy was not feasible at the time precisely because all available shares were already borrowed and shorted, limiting additional short sales.

In this paper, we document exactly the opposite pattern. While Lamont and Thaler (2013) show that overpricing may persist when there are limits to short sales, we show that underpricing may persist then there are limits to purchases of shares. In U.S. or other developed capital markets, especially those based on common law tradition, public firms are typically widely held with substantial free float. As such, investors may purchase these shares freely in the open market, or through a tender offer if the sought amount is substantial. So while overvaluation may persist due to short sales constraints, undervaluation is not likely to persist since there are no such constraints on purchases.

However, it is fairly well established by now that many firms around the world, especially those in civil law countries, are typically controlled by dominant families who hold

a substantial amount of voting rights (La Porta et al., 1999 etc). In these economies, controlling families generally enjoy high levels of private benefits (Dyck and Zingales, 2004; Nenova, 2003) so that they are very reluctant in relinquishing control either by selling their own shares or by selling new shares which would dilute their proportional ownership. Foley and Greenwood (2010) show that ownership is quickly diluted in countries with good investor protection following an IPO, while the controlling block stays in tact in countries with bad investor protection. Kim (2012) shows that most takeover targets in Korea are already bankrupt, implying that controlling shareholders cling to their control until they are ultimately removed by the creditors following a default. In these economies, a substantial number of publicly traded stocks are simply not for sale, regardless of the offer price. This implies that it may not be feasible to purchase a sufficient number of undervalued stocks necessary to remove any mispricing.

Almeida and Wolfenzon (2006) suggest a variable referred to as 'centrality' which measures how important a given firm is in maintaining control over other member firms within the business group. For example, if a firm is located at the top of the corporate pyramid, it would be relatively important in controlling other firms in the bottom and hence given a high value of centrality. In contrast, if a firm is located at the bottom of the pyramid, it would not be as central, since selling this firm does not affect control of other member firms. From the family's perspective, central firms are essential in maintaining control of the overall business group. As such, families would be less willing to sell shares in these central firms, especially when the level of private benefit is high. We argue that controlling family's holdings in these 'central' firms are essential and thus less likely to be sold. And if there is indeed more difficulty in purchasing these central stocks, underpricing, if any, may persist.

We test these predictions in Korea, which is widely known for concentrated family ownership and high levels of private benefits. We first document that there are a substantial

number of public firms in Korea whose market cap is less than the market value of the shares they hold in public affiliated firms, implying a blatant mispricing similar to those reported in Lamont and Thaler. A prominent example is Samsung C&T, the de-facto holding company of Samsung, the largest business group in Korea that consists of 16 publicly traded firms. The market cap of Samsung C&T as of 2024 is 24.1 trillion KRW¹. But the value of its holdings of 5.01% in Samsung Electronics, the largest public firm in Korea, amounts up to 24.16 trillion KRW. Samsung C&T holds shares in other public member firms as well, and engages in various businesses of its own, including construction, trading, fashion, and resorts. This implies that valuation of Samsung C&T's remaining businesses is negative, similar to the negative stubs documented in Lamont and Thaler (2013).

Such cases where the whole is valued *less* than, not *greater* than, the sum of its parts are also found elsewhere. A prominent example is Naspers, a South African conglomerate, which trades at 35-40% discount relative to its net asset value (NAV) which mostly consists of its holdings in Chinese big tech firm, Tencent. Closed-end fund discount is also somewhat similar to the mispricing we document. However, since the fund's asset only consists of its holdings in other unrelated stocks, they are fundamentally different from central firms engaging in its own business and holding shares in affiliated firms.

We identify a total of 80 firms in Korea that are similar to Samsung C&T, whose market cap is below the market value of the shares they hold. This situation cannot persist in an efficient market since an arbitrageur may buy up all stocks in the undervalued firm and sell shares of affiliated firms held by the undervalued firm, reaping an arbitrage profit. However, if these firms are central, there is no way that an arbitrageur can buy the controlling block, no matter how high a price they are willing to pay. As such, mispricing, in this case extreme

¹ As of 25th June, 2024.

underpricing, can persist in the market.² This phenomenon is related with “Korea discount”, a common term used by practitioners and regulators to imply that Korean stocks are generally undervalued relative to fundamentals. A popular metric in measuring the degree of this “discount” is market to book, or price to book ratio (PBR). Korean stocks are notorious for having a low PBR. On average, they are close to one, much lower than the levels found in U.S. or other developed capital markets. The undervaluation we document is an extreme version of Korea discount, sometimes referred to as ‘holding company discount’ in Korea.

We next explore cross-sectional variation in the degree of mispricing. Our conjecture is that the more central a firm is, the less the family is willing to sell shares, and thus arbitrage opportunity is less likely. To calculate centrality, we need detailed information on cross-firm ownership among member firms within a business group including private firms. Korea Fair Trade Commission (KFTC) provides a matrix of intercorporate ownership for all member firms for certain large business groups in Korea, which we utilize to calculate centrality as in Almeida and Wolfenzon (2006). As such, this measure is available only for member firms of *large* business groups, but not for regular public firms that do not belong to large business groups. For the subset of firms that we are able to obtain centrality, we explore whether the degree of centrality or how important that firm is in maintaining control over other member firms affects the degree of mispricing. We find that consistent with our conjecture, centrality is positively correlated with underpricing. That is, the more central a firm is, the more likely is the extreme underpricing.

Since centrality is available only for a subset of our sample of mispriced firms, we resort to another measure that may proxy for centrality. Specifically, we identify those firms

² We use the terms underpricing, mispricing, undervaluation, or misevaluation, interchangeably, to largely denote a situation where the parent’s market cap is less than the sum of its’ subsidiaries’ market cap.

that reported themselves as formal 'holding company' in their filings to KFTC. According to KFTC regulations, all Korean firms that meet the following criterion must declare itself as a formal holding company; total assets over 500 billion KRW (roughly 400 million USD), at least half of which are used to hold shares in other affiliated companies. These formal 'holding' companies are subject to certain regulations, e.g. must directly hold at least 30% (50%) of public (private) subsidiaries' shares, and cannot incur leverage above 200% of equity. Since the primary purpose of creating these 'holding' companies are by construction to control other affiliated companies, they are likely to exhibit high centrality. In fact, the average centrality for holding companies in our sample are 26.27 while those for remaining non-holding companies are only 9.77.

Using this alternative measure of centrality, namely being a formal holding company, we examine whether they exhibit more extreme low valuation using the full sample of mispriced stocks. We find that being a holding company is highly correlated with extreme underpricing. For example, average parent market cap relative to the sum of its subsidiaries' market cap is 2.98 for holding companies while the corresponding number for non-holding companies is 13.74.

In our robustness tests, we consider various alternative explanations, including the degree of free float, illiquidity, and diversification of the parent, as well as the short-sales constraints of the target. We find that while these variables generally explain the degree of underpricing when used alone, they all lose their statistical significance when included together with centrality.

Overall, our findings suggest that family control of business groups may have implications not only for corporate finance but also asset pricing. Specifically, if their motivation to pursue private benefits is so high as to not sell their shares, especially those in central firms, then these stocks may be subject to extreme undervaluation which may persist.

Such blatant mispricing is not easily arbitrated away simply because arbitrageurs cannot buy these stocks, especially central stocks. This phenomenon provides a mirror image of Lamont and Thaler (2013) where limits on short sales generates prolonged overpricing. Our finding complement their results and suggest that limits on purchases or long positions may generate prolonged underpricing.

The remainder of the paper is as follows. Section 2 describes our data sources and sample construction process. Section 3 provides descriptive statistics of the sample, focusing on the degree of extreme mispricing. Section 4 examines the cross-sectional relationship between measures of centrality and the degree of underpricing. And section 5 concludes.

II. Sample and Summary statistics

II – 1. Data and Sample Construction

Our basic unit of observation is a publicly traded firm in Korea that holds shares in other public member firms within the same business group. This type of multiple listing is not common in U.S. or other developed markets mostly due to various legal complexities arising from potential conflict of interest. According to a report by Japanese government, multiple listings only account for less than 1% in U.S. and U.K, less than 3~4% in France and Germany, and 6 to 11% in Japan³. In contrast, such multiple listing is quite common in Korea. A report by Korea Capital Market Institute (KCMI) documents that 20% of IPO firms in Korea already

³ Group Governance (Studies by the Corporate Governance System Study Group), March 5, 2019, Ministry of Economy, Trade and Industry ([chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.fsa.go.jp/en/refer/councils/follow-up/material/20190305-3.pdf](https://www.fsa.go.jp/en/refer/councils/follow-up/material/20190305-3.pdf))

have another public member firm within the business group⁴.

Our definition of a business group consists of at least two publicly traded firms, following Baek et al. (2006). This definition is different from the popular KFTC designation of 'large' business groups in two respects. First, KFTC designates only 'large' business groups, whose gross total assets of all member firms exceeds 5 trillion KRW (roughly 4 billion USD). As such, this classification leaves out many smaller business groups whose size does not meet the minimum threshold, while our classification includes them. Second, KFTC designates large business groups even when there isn't any public member firm. For example, Booyoung, the 26th largest business group in 2024 according to KFTC designation, consists of 21 member firms, all of which are private.

Nevertheless, we do resort to KFTC's large business group data, since they provide detailed inter-corporate ownership information, including all private member firms, which is necessary in calculating the centrality measure. For all public firms that are not included in the KFTC dataset, we manually collect their ownership information from DART (Data Analysis, Retrieval, and Transfer System), an electronic disclosure system that allows companies to submit disclosures online, similar to EDGAR in U.S.⁵ From this data source, we manually create public parent – public subsidiary(ies) pairs⁶. Once we obtain these pairs or relationships, we calculate market capitalization of the parent as well as the combined market cap of all shares held in other public member firms by the parent. We then create a relative valuation measure of the parent, which we refer to as 'parent market cap (P) relative to the (sum of) subsidiary(ies)' market cap (S)' or simply 'P/S'. Since there could be many public firms in a large business group, a single business group may include multiple parent-subsidary(ies) relationships.

⁴ Kilnam Nam, 2022, Major Issues in Carve-outs and Multiple Listings, Issue Report 22-07, Korean Capital Market Institute (*in Korean*).

⁵ DART is operated by Financial Supervisory Service of Korea.

⁶ Note that a single parent may hold shares in more than one subsidiary.

Private firms are excluded from this ownership structure construction since they lack market capitalization information.

Figure 1 illustrates how we construct such pairs or relationships for Samsung, the largest business group in Korea. In this diagram, there are a total of 15 publicly traded firms, from which we are able to identify 5 unique parent-subsidary(ies) relationships. The first parent-subsidaries relationship starts from Samsung C&T, the de facto holding company of Samsung, which in turn has shares in five public member firms: Samsung Electronics (5%), Samsung SDS (17.1%), Samsung Biologics (43.4%), Samsung Life (19.30%), and Samsung E&A (6.97%), where percentage ownership is denoted in parentheses. We then calculate the market capitalization of Samsung C&T, and the sum of the market values of shares held by Samsung C&T in these five public subsidiaries as the end of 2021. Subsidiaries with less than 5% ownership are not included.

Table 1 provides detailed ownership and market capitalization calculations of Samsung C&T and its subsidiaries. The combined market value of shares held by Samsung C&T in these subsidiaries is 54 trillion KRW, while Samsung C&T's own market capitalization is only 22 trillion KRW, which indicates a clear mispricing. For this specific unit of observation, 'parent to subsidiaries' ratio or P/S is 0.403 (22,053 divided by 54,634).

[INSERT FIGURE 1 HERE]

[INSERT TABLE 1 HERE]

In Figure 1, we further identify the second layer of parent-subsidaries relationships, starting from the three public firms held by Samsung C&T, which also holds shares in other 3rd

layer public member firms.⁷ For example, Samsung Electronics has shares in three public subsidiaries: Cheil, Samsung Biologics, and Hotel Shilla. Samsung SDS has shares in one public subsidiary, Multi Campus. And Samsung Life has shares in four other public subsidiaries. Among the 3rd layer public firms, only Samsung SDI has shares in other public member firm, Samsung E&A, which we classify as our 5th and last parent-subsubsidiary(ies) relationship within Samsung.

Following Almeida and Wolfenzon (2006), we also calculate the centrality measure, whenever we can. Centrality of a given member firm is defined as the drop in critical threshold of other member firms when this firm is excluded from the group. Critical threshold is the minimum ownership required to control a firm or the weakest link under a hostile takeover situation. The idea is that if the critical threshold of other member firms drops a lot when a given firm is excluded, then this given firm must be important in controlling other member firms.

Since this measure requires full inter-corporate ownership matrix including private firms, we can only calculate this for member firms of large business groups where such information is available.⁸ Although our data is a single cross-section from 2021, the ownership structure and centrality do not vary much over time, as have been noted in other studies.⁹ Financial variables such as total assets, total liabilities, cash holdings, net income, and free float are obtained from FnDataguide, which is one of the major data vendors in Korea similar to Compustat.

⁷ Samsung Biologics and Samsung E&A are not defined as parent companies in our sample, since they do not hold shares in other public member firms.

⁸ A large business group is defined as a collection of affiliated domestic companies with total assets amounting to 5 trillion KRW or more in the previous fiscal year. Each May, KFTC publishes the list of such large business groups.

⁹ Refer to Almeida and Wolfenzon (2006).

II – 2. Summary Statistics

Our initial dataset comprises 666 parent-subsubsidiary(ies) relationships. After excluding observations without ownership data, 410 pairs remain. As mentioned previously, formal centrality measure is available for only a subset of all parent firms, 84 out of 410, since we need intercorporate shareholding information including all private member firms, which are provided by the KFTC for large business groups.

Table 2 presents summary statistics for the variables used in this paper. In Panel A of Table 2, “All” refers to the entire sample, while “Mispriced ($P/S < 1$)” refers to pairs where the market capitalization of the parent relative to the market value of all subsidiaries held is less than 1. We first note that in 76 out of 410 P-S relationships, close to 20% of the full sample, we observe an extreme mispricing where the whole is less than sum of its parts.

We next present various characteristics of the parent-subsubsidiary(ies) relationships for the full sample as well as the mispriced subsample. Layer reflects the distance of the parent from the controlling shareholder; for example, in Figure 1, if the parent company is Samsung C&T, its layer equals 1. If the parent company is Samsung Electronics, the layer equals 2. On average, the layer is 1.310, indicating that some parent firms are not directly held by the controlling shareholders. For the full sample, average number of subsidiaries is 1.612, whereas the corresponding number for the mispriced sample is 2.355, indicating that parent companies tend to be discounted more when they have more subsidiaries. Both the market capitalization of parent companies (Parent Mktcap) and the value of subsidiary shares is higher for the mispriced sample than for the full sample, which suggests that mispricing is a non-trivial phenomenon in the Korean capital market. Free float represents the shares of a company that can be publicly traded without restriction scaled by the total number of outstanding shares.¹⁰

¹⁰ Free float shares exclude those held by the controlling shareholders, the government, treasury stock, employee

The average free float in Table 2 is 56.3% slightly lower than the 69.3% found by Ding et al. (2016) for the period from 2003 to 2011 of the Korean stock market. Our free float number aligns closely with Kim and Wang (2024) who report an average free float of 56.27% (mean) and 56.32% (median) in the Korean stock market. The last row in Table 2, Holding Company, is a dummy variable that equals 1 if the company is a formal holding company as designated by the KFTC. Holding companies constitute 21% of the overall sample and 56.6% of the mispriced sample, indicating a higher likelihood of mispricing among formal holding companies.

Panel B of Table 2 presents similar characteristics for the centrality subsample where this measure is available. Among this subsample of 84 pairs or relationships, the average centrality (of the parent) is 14.480, which increases up to 24.245 for the mispriced group, consistent with the notion that centrality could be one of the determinants of such mispricing.

[INSERT TABLE 2 HERE]

Next, we provide summary statistics of the parent company, including the mean and median tests of various financial variables for the mispriced group ($P/S < 1$) and others ($P/S > 1$) in Table 3. Panel A presents the results for the full sample, while Panel B reports those for the centrality subsample. TA represents total assets, expressed in 10 billion KRW (roughly 8 million USD). ROA is the return on assets, defined as net income divided by total assets. Cash holding is the cash held by the company, scaled by total assets. ΔPPE is the change in property, plant, and equipment, defined as the change in tangible assets scaled by the previous year's sales. Leverage is total liabilities divided by total assets. Cashflow is earnings before interest

stock ownership, and locked-up shares from the total number of shares outstanding.

and tax, plus depreciation and amortization, scaled by sales. Volatility is the standard deviation of daily stock returns over a given year. All variables are calculated as of the end of 2021.

Panel A of Table 3 indicates that extremely undervalued parent companies ($P/S < 1$) tend to exhibit smaller total assets, higher ROA, less cash holdings, less investment in PPE, less use of debt, lower cashflow, small return volatility, and higher stock liquidity compared to those with $P/S > 1$. The differences in means tests show that except for ΔPPE and Cashflow, all variables are statistically significantly different at least at the 10% level, suggesting that extreme undervaluation may reflect different parent company characteristics.

Panel B of Table 3 shows the financial characteristics of the parent firms in the centrality subsample. Since this measure is available only for member firms of large business groups, the total assets of centrality subsample (17,992 billion KRW) are much larger than those of the full sample (4,749 billion KRW). For mean and median tests, only total assets and leverage exhibit significant results, suggesting that firm characteristics are similar between mispriced and non-mispriced group in large business groups.

[INSERT TABLE 3 HERE]

III. Empirical Results

In this section, we formally test whether the degree of the controlling family's incentive to not sell certain shares is related with the degree of severe underpricing. Our first key measure is centrality, which measures how important this firm is in maintaining control over other member firms. Since this measure is available for only a subset of the sample, we also utilize a dummy for formal holding companies as designated by the KFTC as a proxy for centrality.

III-1. Centrality

We first use centrality to investigate the severe underpricing in the parent. Our hypothesis is that since central firms are essential in maintaining control of the overall business group for the controlling family members, they would be less willing to sell shares in these central firms, resulting in a limit to arbitrage, namely to purchase all shares in the parent, and eliminate such discount in the parent company.

[INSERT TABLE 4 HERE]

Table 4 shows the results of logit regressions, where the dependent variable is mispricing, a dummy variable that equals 1 if the market capitalization of the parent relative to the total market value of the subsidiaries held by the parent is less than one ($P/S < 1$). In equation (1), we document a positive relationship between centrality and mispricing, which suggests that firms with high centrality values are more likely to suffer deep discounts, confirming our main hypothesis. In equation (2), we also add parent market cap and the number of subsidiary in the regression. Again the centrality measure is positively correlated with undervaluation measures. We also find that the number of subsidiaries is also positively correlated with the degree of undervaluation. We next control for other financial variables that may affect undervaluation in equation (3), and find that centrality is positively related to undervaluation supporting our hypothesis.

An important result is that we find a significantly negative coefficient on cash flow rights of the controlling families. Since central firms are more likely to be held directly by the family, families tend to have more direct financial interest or higher cash flow rights in these companies. Standard theory on cash flow - control disparity or ‘wedge’ would predict that firms

directly held by controlling families would exhibit higher valuation. Instead, our analysis suggests rather an opposite result. This suggests that incentives for maintaining control over other member firms may be first order priority while exercising cash flow rights in central firms may be of only second order.

III-2. Holding Company Dummy

Above analysis resorts to centrality as the key explanatory measure, but this is available for only a subset of the sample. To fully utilize all parent-subsidiaries relationships in our sample, we next resort to a holding company dummy. Under Korean regulations, all firms whose total assets exceeds 500 billion KRW (roughly 400 million USD) and spends more than 50% of its assets in holding other subsidiaries shares are required to declare themselves as formal holding companies and report to the KFTC. These formal holding companies are subject to certain regulations¹¹. As of 2024, there are a total of 88 formal holding companies identified by the KFTC. Not all holding companies belong to our sample, since some holding companies are privately held, and some holding companies hold shares in private subsidiaries only. Note that we require both the parent and the subsidiary to be public to be included in our sample.

[INSERT TABLE 5 HERE]

¹¹ Formal holding companies are subject to the following regulations. First, debt ratio (= debt/equity) should be less than 200%. Second, the ownership of subsidiaries (or 2nd tier subsidiaries) by holding companies (or 1st tier subsidiaries) must be at least 20% for listed companies and 40% for unlisted companies. Third, 2nd tier holding companies are prohibited from owning shares of 3rd tier subsidiaries, except when the 3rd tier subsidiary is wholly owned by the 2nd tier subsidiary. Fourth, industrial holding companies are prohibited from owning financial subsidiaries. Last, holding companies are prohibited from owning more than 5% of shares in domestic non-affiliated companies.

We may indirectly check the validity of this holding company dummy variable by looking at the correlation between the holding company dummy and centrality in our centrality subsample. The correlation between the two variables turns out to be 0.587, which suggests that formal holding companies are likely to exhibit high values of centrality.

The results from Table 5 suggest that holding company dummy is significantly positively correlated with the severe mispricing dummy. This suggests that being a holding company, which is similar to being more central, adversely affects the company's stock price, again consistent with our main hypothesis. Furthermore, consistent with centrality results, parents with more subsidiaries are subject to severe underpricing.

IV. Alternative Hypotheses

IV-1. Less free float in the parent

So far, we have documented that shares that are less likely to be sold by the controlling family members are subject to severe underpricing. An alternative hypothesis is that perhaps mispricing may simply reflect less free float in the market, regardless of being central. That is, a stock may be more difficult to buy if there is less free float in the market regardless of its holdings in other member firms' shares. In contrast, our hypothesis emphasizes the importance of holdings in *other* member firms' shares, rather than its *own* liquidity of free float. To some extent, our hypothesis argues that free float may be affected by centrality. Since central firms are less likely to be traded, they may be less free float. On the other hand, this alternative hypothesis suggests that liquidity and free float, independent of centrality, may affect the degree of severe mispricing.

To formally test this conjecture, we consider measures of free float as an alternative explanatory variable. We first run specifications with free float without including centrality or

holding company variables. We then sequentially include either centrality or holding company to verify whether free float is still significant when considered together with centrality or holding company dummy.

Equation (1) of Table 6 suggests that low free float, i.e. less shares traded in the market, explains extreme underpricing when used alone. That is, stocks with less free float are more likely to experience extreme underpricing, as suggested in the alternative hypothesis.

[INSERT TABLE 6 HERE]

However, once we include either centrality or holding company in columns (2) and (3), free float is no longer significant, while both centrality and holding company remain significant. This suggests that it is the relative importance of a firm in a business group that determines the reluctance to sell and subsequent underpricing, rather than free float per se. To the extent that centrality is a more acute measure than holding company dummy, we continue to interpret this result as being more consistent with our main reluctant to sell hypothesis.

To further account for the possibility that free float may be affected by centrality, we first run free float on centrality or holding company to extract orthogonal components of the former that is independent of the latter. Once we obtain the orthogonalized free float, we include them in our baseline specification. Specifically, we regress free float on centrality or holding company dummy and calculate the residual as the orthogonalized free float.

[INSERT TABLE 7 HERE]

The results from Table 7 suggests that after orthogonalizing, free float still cannot explain extreme underpricing (equation (1)). When we add orthogonalized free float together

with centrality, orthogonalized free float still does not explain extreme underpricing while centrality does. We observe a similar pattern when holding company is used as the key explanatory variable. Since centrality is our key measure and holding company is an auxiliary, supplementary explanatory variable, we put more weight on the results based on centrality.

IV-2 Short-selling constraints of subsidiary(ies)

Our results suggest that the mispricing observed in our sample cannot be easily arbitrage away, primarily because arbitrageurs are unable to buy central stocks. However, one may argue that the short-sale constraints on subsidiary stocks could also drive this mispricing. To investigate this hypothesis, we examine whether short-sale constraints exist for these subsidiary stocks. The results are presented in Table 8.

[INSERT TABLE 8 HERE]

Since March 16, 2020, short-selling was prohibited in the Korean stock market due to heightened volatility caused by the COVID19 pandemic. Accordingly, we analyze short-selling activity for the year 2019 and 2020. *relss* represents relative short-selling activity, defined as the daily shorted shares divided by the daily trading volume. *SSval* denotes the dollar volume of daily short-selling activity, and *SSvol* refers to the daily number of shorted shares. In Panel A, the *relss* for all, $P/S > 1$, and $P/S < 1$ are 2.688%, 2.144%, and 4.919%, respectively, for 2019. In Panel B, the *relss* values for all stocks listed on the stock market, the KOSPI market, and the KOSDAQ market are 2.408%, 3.941%, and 1.554%, respectively. Although short-selling activity in the Korean stock market is not as active as in the U.S. market, a comparison between Panel A and Panel B reveals that the average *relss* is higher in our sample than in the overall market. This suggests that short-selling constraints are not a significant factor that affects

mispricing. Furthermore, the *relss* for firms with $P/S < 1$ (mispriced sample) is nearly twice as larger as for firms with $P/S > 1$. These findings imply that arbitrageurs actively engage in short-selling potentially to exploit mispricing, yet their activity is insufficient to fully eliminate the arbitrage opportunity. In conclusion, we attribute the mispricing observed in our study to long constraints than short constraints. Specifically, the arbitrage opportunity persists because arbitrageurs are unable to buy shares of the parent company, particularly those classified as central firms.

IV-3 Diversification discount of the parent

A large body of previous literature has examined the effect of corporate diversification on firm value. For instance, Lang and Stulz (1995), Berger and Ofek (1995), Servaes (1996) demonstrate that corporate diversification reduces firm value. Similarly, Bae et al. (2011), using data on Korean chaebols, find that unrelated diversification decreases firm value, while related diversification does not negatively affect firm value. This line of research suggests that our results may be driven by diversification discount rather than centrality.

To test this alternative hypothesis, we construct two measures of diversification: Herfindahl-Hirschman Index (HHI) and Entropy. HHI, as modified for this study, is based on the firm's product sales and is calculated as the sum of the squared proportions of sales across the firm's products. The equation is as follow:

$$HHI = \sum_{i=1}^N p_i^2 \quad (1)$$

where p_i represents the proportion of the firm's total sales attributed to product i . A higher HHI value indicates that a firm's sales are concentrated in few products. Entropy, derived from Jacquemin and Berry (1979), is defined as follows:

$$\text{Entropy} = \sum_{i=1}^N p_i \ln \left(\frac{1}{p_i} \right) \quad (2)$$

[INSERT TABLE 10 HERE]

A higher Entropy value suggests that a firm has a more diversified product portfolio. Table 9 reports summary statistics of the HHI and Entropy index. Panel A presents results for the full sample, while Panel B focuses on the centrality sample. In both panels, the average HHI is higher for mispriced firms, suggesting that these firms are less diversified and their sales are concentrated in a few products. Similarly, the entropy index is lower for mispriced firms, reinforcing the idea that they are less diversified. These findings indicate that the discounting effect observed in central firms is not driven by a diversification discount. We further confirm this result using regression analysis in Table 10.

[INSERT TABLE 10 HERE]

Table 10 presents the results of a logit regression, where dependent variable is the undervalued measure ($P/S < 1$), and the independent variables include the diversification indices, free float, centrality, holding company dummy, and other control variables. In Panel A of Table 10, the first column shows a positive correlation between HHI and undervaluation, implying that the more concentrated a firm's product portfolio is, the more likely it is to be undervalued. This is actually opposite of what diversification discount hypothesis predicts. That is, while the theory predicts more discount for diversified firms, we report more discount for concentrated firms. This finding holds across different specifications. The sign and significance of the free float, centrality, and holding company measures remain consistent.

Panel B shows the results using the Entropy index, which largely align with the findings from Panel A. The results presented in Table 10 provide robust evidence that diversification discount hypothesis does not explain the observed underpricing.

IV-4 Cashflow right

Controlling shareholders hold equity stakes in business group member firms either directly or indirectly. A typical ownership structure in these groups is a pyramid, where a controlling shareholder directly controls one firm, which in turn controls other firms. In this structure, controlling shareholders have significantly higher cashflow rights in central firms than in subsidiary firms. We use cashflow rights as an additional robustness measure to validate our results. Table 11 shows the findings.

[INSERT TABLE 11 HERE]

Table 11 reports the logit regression of P/S on cashflow rights, centrality, and other control variables. Cashflow rights represent shareholders' claim on the dividends. Column 1 of Table 11 shows that higher cashflow rights are associated with greater mispricing, suggesting that firms directly held by controlling shareholders are more likely to experienced mispricing. This result remains robust after controlling other variables. However, in Column 4, when we include the centrality measure in the regression, cashflow rights lose significance, while centrality remains significant. The findings confirm that centrality is a more appropriate measure of a firm's important within a business group.

V. Conclusion

Business groups in emerging markets have been mostly analyzed in the corporate finance or governance contexts. Various agency problems of the controlling families which results in a loss of firm value have been documented in extant literature. In this paper, we take a slightly different, but related perspective on central firms and its asset pricing implications in terms of limits of arbitrage. When some asset is undervalued, arbitrageurs can simply purchase or take ‘long’ position in the asset which would eliminate such underpricing. Since there is no ‘purchase’ constraint in general, limits of arbitrage have been discussed in the context of ‘short’ sales constraints, which may result prolonged overvaluation.

In this paper, we argue that undervaluation may also be prolonged if there are certain ‘long’ purchase constraints, which generates a mirror image of Lamont and Thaler (2013). Such constraint on purchases may be found for ‘central’ firms in business groups, where the controlling family is extremely averse to selling share. We document 76 cases of blatant mispricing where market cap of the parent company is less than the total market value of the shares held in its subsidiaries. This mispricing cannot exist in U.S. or other developed markets since an arbitrageur – a hedge fund or a private equity firm – could simply buy out the parent, sell the subsidiary shares and reap the arbitrage profit. But such arbitrage is not feasible if a substantial number of shares are held by the controlling family. The reluctance to sell shares would be most pronounced in central firms.

Such extreme underpricing is a serious issue for investors in the Korean stock market. One reason why controlling families allow such underpricing may be related with a very high inheritance tax rate in Korea, up to 60% for controlling shareholders. This incentivizes the controlling family to keep the stock price at a low level, which would reduce their inheritance tax. The incentives for the family to allow extreme low valuation for central firms would be an interesting topic for future research.

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Figure 1. Samsung Group's Ownership Structure

The figure illustrates the ownership structure of Samsung Group, focusing exclusively on listed companies. The numbers 1, 2, and 3 indicate the layers within the Samsung Group. Layer is defined as the position within the group.

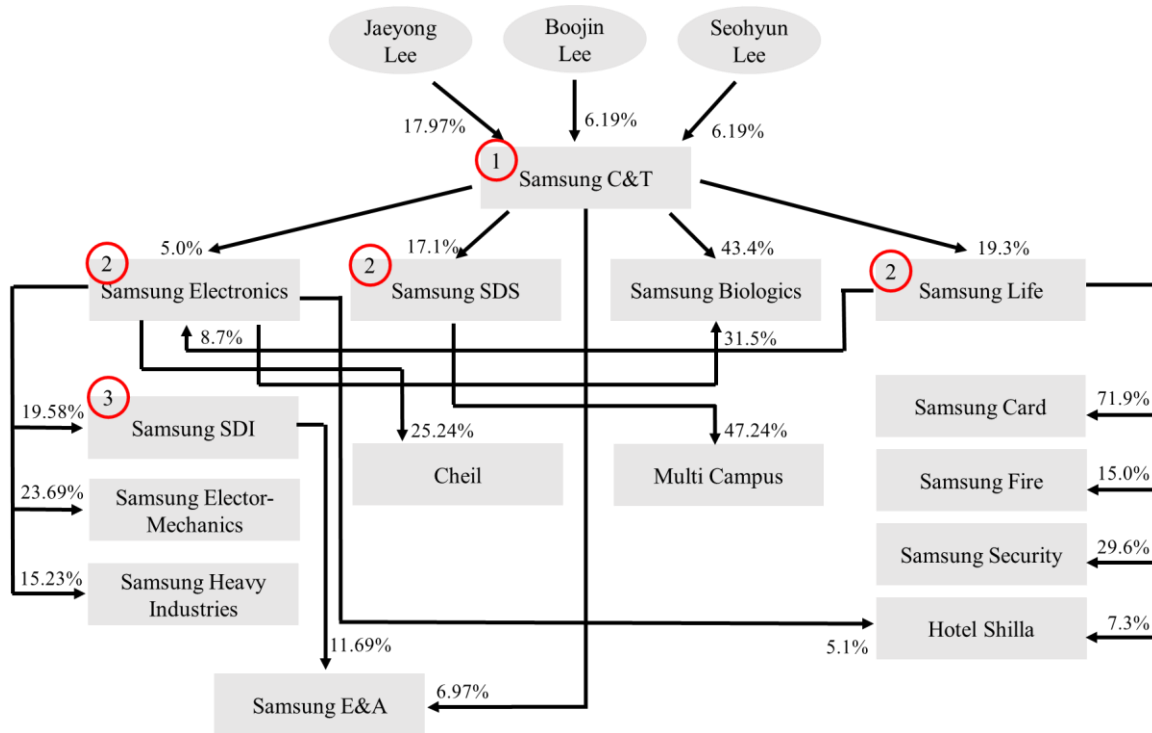


Table 1. The degree of mispricing: Samsung C&T case.

This table presents the degree of mispricing for Samsung C&T. Parent refers to the parent company. Public subsidiary denotes the subsidiary firms listed on the stock market. Ownership by holding represents the percentage of ownership held by the holding company. The Market cap of the subsidiary is the firm's size at the end of 2021, measured in billion KRW. The value of subsidiary shares is calculated as the ownership percentage multiplied by the market cap of the subsidiary. P/S is defined as the market capitalization of the parent relative to the total market value of the subsidiaries held by the parent.

Parent	Public subsidiary	Ownership by Parent	Market cap of subsidiary	Value of subsidiary shares
Samsung C&T (market cap.22,053)	Samsung Electronics	5.00%	479,374	23,969
	Samsung SDS	17.10%	12,497	2,137
	Samsung Biologics	43.40%	58,953	25,586
	Samsung Life	19.30%	13,700	2,644
	Samsung E&A	6.97%	4,292	299
Sum of Subsidiaries				54,634
P/S				0.403

Table 2. Summary Statistic of Sample Firms

The table shows summary statistics of the sample firms. Panel A includes full sample, while Panel B focuses on firms with centrality measures. N of parent-subsidiaries indicates the number of such relationships, which is the basic unit of observations. Layer is the position in the pyramid structure relative to controlling shareholders, or the distance from the controlling shareholder. N of subsidiaries is the number of subsidiaries per each parent company. Parent Mktcap (P) is the market capitalization of the parent company at the end of 2021, measured in billion KRW. The value of subsidiary shares (S) is calculated as the sum of the products between parent's proportional ownership and market cap of each subsidiary. P/S is defined as the market capitalization of the parent relative to the total market value of the subsidiaries held by the parent. Free float is the shares of a company that can be publicly traded without restriction, scaled by the total number of outstanding shares. Holding company is a dummy variable that equals 1 if the firm is a formal holding company as designated by the KFTC. Centrality is based on the measure from Almeida and Wolfenzon (2006).

	All	Mispriced (P/S<1)	All	Mispriced (P/S<1)
	Mean		Median	
Panel A: Full sample				
N of parent-subsidiaries	410	76		
Layer	1.310	1.184	1.000	1.000
N of subsidiaries per parent	1.612	2.355	1.000	2.000
Parent Mktcap (P)	3,041.39	1,500.77	294.97	351.86
Value of subsidiary shares (S)	979.50	2,837.73	89.03	542.52
P/S	11.506	0.603	2.873	0.584
Free Float	0.563	0.466	0.554	0.480
Holding Company	0.207	0.566	0.000	1.000
Panel B: Centrality subsample				
N of parent-subsidiaries	84	25		
Centrality	14.480	24.245	10.689	24.274
Layer	1.560	1.160	1.000	1.000
N of subsidiaries per parent	2.262	2.920	2.000	3.000
Parent Mktcap (P)	11,880.90	3,433.39	2,082.99	906.20
Value of subsidiary shares (S)	3,594.97	6,525.30	569.93	2,012.02
P/S	15.646	0.594	2.754	0.548
Free Float	0.503	0.433	0.510	0.485
Holding Company	0.286	0.600	0.000	1.000

Table 3. Summary Statistics of Financial Variables

The table reports the summary statistics of financial variables of full sample stocks in Panel A and the centrality subsample in Panel B. The table also presents the difference in mean and median test for P/S < 1 sample and P/S > 1 sample. P/S is defined as the market capitalization of the parent relative to the total market value of the subsidiaries held by the parent. TA is total assets, expressed in billion KRW. ROA is net income divided by total assets. Cash holding is cash held by the company scaled by total assets. Δ PPE is a change in property, plant, and equipment, defined as the change in tangible assets scaled by the previous year's sales. Leverage is total liabilities divided by total assets. Cashflow refers to earnings before interest and tax plus depreciation and amortization, scaled by sales. Volatility is the standard deviation of daily stock return over a given year. Amihud is Amihud's (2002) illiquidity measure, defined as the absolute value of daily return divided by the trading amount and average over a given year. tv is turnover, defined as the number of daily trading volume divided by number of share outstanding. N of parent-subsidiaries indicates the number of such relationships, which is the basic unit of observations. All the variables are constructed using 2021 data.

	All	P/S<1	P/S>1	t-value	All	P/S<1	P/S>1	p-value
	Mean				Median			
	Panel A: Full sample							
TA	4,749.22	2,294.25	5,309.51	-1.94	369.36	552.82	313.26	0.000
lnTA	20.092	20.449	20.011	2.53	19.727	20.130	19.563	0.000
ROA	0.007	0.050	-0.002	2.37	0.029	0.030	0.028	0.587
Cash holding	0.073	0.042	0.081	-5.16	0.047	0.021	0.053	0.000
ΔPPE	-0.025	-0.264	0.028	-0.85	0.000	-0.001	0.000	0.217
Leverage	0.341	0.285	0.353	-2.74	0.326	0.301	0.336	0.010
Cashflow	1.379	0.386	1.602	-0.92	0.089	0.222	0.076	0.000
Volatility	2.962	2.587	3.048	-3.44	2.689	2.365	2.796	0.001
Amihud	0.015	0.019	0.014	1.83	0.008	0.010	0.008	0.052
tv	0.024	0.014	0.027	4.57	0.013	0.007	0.015	0.000
N of parent-subsidiaries	409	76	333					
	Panel B: Centrality subsample							
TA	17,991.72	5,624.51	23,232.06	-2.41	4,053.95	1,903.78	6,032.35	0.016
lnTA	22.229	21.581	22.503	-2.47	22.123	21.367	22.520	0.016
ROA	0.041	0.041	0.041	0.03	0.032	0.031	0.034	0.913
Cash holding	0.047	0.045	0.047	-0.13	0.022	0.022	0.021	0.582
ΔPPE	0.013	-0.008	0.022	-0.79	-0.001	-0.001	-0.001	0.549
Leverage	0.406	0.331	0.437	-2.08	0.402	0.376	0.436	0.053
Cashflow	0.327	0.420	0.288	1.14	0.116	0.216	0.112	0.103
Volatility	2.410	2.304	2.454	-1.10	2.235	2.194	2.272	0.445
Amihud	0.005	0.010	0.003	1.49	0.002	0.004	0.001	0.010
tv	0.009	0.007	0.009	1.22	0.006	0.006	0.006	0.235
N of parent-subsidiaries	84	25	59					

Table 4. Logit Regression: Centrality

The table reports logistic regression, where the dependent variable, P/S, is regressed on centrality and control variables. P/S is defined as the market capitalization of the parent relative to the total market value of the subsidiaries held by the parent. If the P/S is less than 1, the dependent variable is set to 1; otherwise, it is set to 0. Centrality is based on the measure from Almeida and Wolfenzon (2006). Parent Mktcap (P) is the market capitalization of the parent company at the end of 2021, measured in billion KRW. N of subsidiary is the number of subsidiary companies for each holding company. N of subsidiary is the number of subsidiaries for each holding company. lnTA is the log total assets. ROA is net income divided by total assets. Cash holding is cash held by the company scaled by total assets. ΔPPE is a change in property, plant, and equipment, defined as the change in tangible assets scaled by the previous year's sales. Leverage is total liabilities divided by total assets. Cashflow refers to earnings before interest and tax, plus depreciation and amortization, scaled by sales. Volatility is the standard deviation of daily stock return over a given year. Amihud is Amihud's (2002) illiquidity measure, defined as the absolute value of daily return divided by the trading amount and average over a given year. N of parent-subsubsidiaries indicates the number of such relationships, which is the basic unit of observations. All the variables are constructed using 2021 data. The z-statistics are in parentheses and ***, **, and * are significance levels at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)
Centrality	0.095*** (3.96)	0.067*** (2.89)	0.103*** (2.83)
Parent Mktcap		-0.685** (-2.53)	-0.571 (-0.91)
N of Subsidiary		0.577** (2.40)	0.766** (2.38)
lnTA			-0.289 (-0.48)
ROA			7.157 (0.74)
Cash holding			5.021 (0.76)
ΔPPE			-4.012 (-1.64)
Leverage			-1.308 (-0.63)
Cashflow			-1.366* (-1.72)
Volatility			-0.092 (-0.14)
Amihud			56.967 (0.79)
Constant	-2.405*** (-4.88)	15.936** (2.19)	18.446* (1.70)
N of parent-subsubsidiaries	84	84	84
Pseudo R ²	0.207	0.297	0.411

Table 5. Logit Regression: Holding

The table reports logistic regression, where the dependent variable, P/S, is regressed on centrality and control variables. P/S is defined as the market capitalization of the parent relative to the total market value of the subsidiaries held by the parent. If the P/S is less than 1, the dependent variable is set to 1; otherwise, it is set to 0. Holding company is a dummy variable that equals 1 if the firm is a formal holding company as designated by the KFTC. Parent Mktcap (P) is the market capitalization of the parent company at the end of 2021, measured in billion KRW. N of subsidiary is the number of subsidiary companies for each holding company. N of subsidiary is the number of subsidiaries for each holding company. lnTA is the log total assets. ROA is net income divided by total assets. Cash holding is cash held by the company scaled by total assets. ΔPPE is a change in property, plant, and equipment, defined as the change in tangible assets scaled by the previous year's sales. Leverage is total liabilities divided by total assets. Cashflow refers to earnings before interest and tax, plus depreciation and amortization, scaled by sales. Volatility is the standard deviation of daily stock return over a given year. Amihud is Amihud's (2002) illiquidity measure, defined as the absolute value of daily return divided by the trading amount and average over a given year. N of parent-subsidiaries indicates the number of such relationships, which is the basic unit of observations. All the variables are constructed using 2021 data. The z-statistics are in parentheses and ***, **, and * are significance levels at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)
Holding company	2.204*** (7.75)	2.004*** (6.61)	1.900*** (5.02)
Parent Mktcap		-0.294** (-2.51)	-0.572** (-2.30)
N of Subsidiary		0.582*** (4.33)	0.478*** (3.41)
lnTA			0.254 (1.09)
ROA			3.627* (1.68)
Cash holding			-3.490 (-1.22)
ΔPPE			-0.054 (-0.30)
Leverage			0.352 (0.37)
Cashflow			-0.098 (-0.54)
Volatility			-0.257 (-1.54)
Amihud			0.481 (0.06)
Constant	-2.180*** (-11.87)	4.704 (1.57)	7.936** (1.97)
N of parent-subsidiaries	410	410	401
Pseudo R ²	0.157	0.211	0.245

Table 6. Logit Regression: Freefloat

The table reports logistic regression, where the dependent variable, P/S, is regressed on free float, centrality, holding, and control variables. P/S is defined as the market capitalization of the parent relative to the total market value of the subsidiaries held by the parent. If the P/S is less than 1, the dependent variable is set to 1; otherwise, it is set to 0. Free float is the shares of a company that can be publicly traded without restriction, scaled by the total number of outstanding shares. Centrality is based on the measure from Almeida and Wolfenzon (2006). Holding company is a dummy variable that equals 1 if the firm is a formal holding company as designated by the KFTC. Parent Mktcap (P) is the market capitalization of the parent company at the end of 2021, measured in billion KRW. N of subsidiary is the number of subsidiary companies for each holding company. N of subsidiary is the number of subsidiaries for each holding company. lnTA is the log total assets. ROA is net income divided by total assets. Cash holding is cash held by the company scaled by total assets. ΔPPE is a change in property, plant, and equipment, defined as the change in tangible assets scaled by the previous year's sales. Leverage is total liabilities divided by total assets. Cashflow refers to earnings before interest and tax, plus depreciation and amortization, scaled by sales. Volatility is the standard deviation of daily stock return over a given year. Amihud is Amihud's (2002) illiquidity measure, defined as the absolute value of daily return divided by the trading amount and average over a given year. N of parent-subsidiaries indicates the number of such relationships, which is the basic unit of observations. All the variables are constructed using 2021 data. The z-statistics are in parentheses and ***, **, and * are significance levels at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)
Free float	-2.671*** (-2.65)	-1.176 (-0.37)	-1.427 (-1.29)
Centrality		0.099*** (2.64)	
Holding company			1.758*** (4.48)
Parent Mktcap (P)	-0.546** (-2.26)	-0.554 (-0.87)	-0.551** (-2.20)
N of Subsidiary	0.601*** (4.45)	0.767** (2.37)	0.497*** (3.51)
lnTA	0.254 (1.11)	-0.286 (-0.47)	0.218 (0.94)
ROA	2.991 (1.44)	7.188 (0.74)	3.360 (1.50)
Cash holding	-5.509* (-1.90)	5.378 (0.81)	-3.064 (-1.08)
ΔPPE	-0.012 (-0.08)	-4.087* (-1.69)	-0.036 (-0.20)
Leverage	-0.967 (-1.11)	-1.339 (-0.64)	0.478 (0.50)
Cashflow	-0.009 (-0.30)	-1.394* (-1.73)	-0.098 (-0.44)
Volatility	-0.157 (-0.95)	-0.054 (-0.08)	-0.220 (-1.30)
Amihud	-0.428 (-0.06)	45.829 (0.60)	-2.087 (-0.27)
Constant	9.249** (2.41)	18.481* (1.71)	8.722** (2.11)
N of parent-subsidiaries	401	84	401
Pseudo R ²	0.194	0.412	0.250

Table 7. Logit regression: Orthogonalized Freefloat

The table reports logistic regression, where the dependent variable, P/S, is regressed on orthogonalized free float, centrality, holding, and control variables. P/S is defined as the market capitalization of the parent relative to the total market value of the subsidiaries held by the parent. If the P/S is less than 1, the dependent variable is set to 1; otherwise, it is set to 0. Orth_Freefloat is orthogonalized free float, we regress free float on centrality or holding and the residual is orth_freefloat. Free float is the shares of a company that can be publicly traded without restriction, scaled by the total number of outstanding shares. Centrality is based on the measure from Almeida and Wolfenzon (2006). Holding company is a dummy variable that equals 1 if the firm is a formal holding company as designated by the KFTC. Parent Mktcap (P) is the market capitalization of the parent company at the end of 2021, measured in billion KRW. N of subsidiary is the number of subsidiary companies for each holding company. N of subsidiary is the number of subsidiaries for each holding company. lnTA is the log total assets. ROA is net income divided by total assets. Cash holding is cash held by the company scaled by total assets. ΔPPE is a change in property, plant, and equipment, defined as the change in tangible assets scaled by the previous year's sales. Leverage is total liabilities divided by total assets. Cashflow refers to earnings before interest and tax, plus depreciation and amortization, scaled by sales. Volatility is the standard deviation of daily stock return over a given year. Amihud is Amihud's (2002) illiquidity measure, defined as the absolute value of daily return divided by the trading amount and average over a given year. N of parent-subsidiaries indicates the number of such relationships, which is the basic unit of observations. All the variables are constructed using 2021 data. The z-statistics are in parentheses and ***, **, and * are significance levels at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)
Orth_Freefloat	-0.357 (-0.40)	-1.196 (-0.38)	-1.240 (-1.15)
Centrality		0.105*** (2.80)	
Holding company			1.974*** (5.09)
Parent Mktcap (P)	-0.592** (-2.46)	-0.553 (-0.87)	-0.555** (-2.21)
N of Subsidiary	0.584*** (4.32)	0.766** (2.37)	0.494*** (3.50)
lnTA	0.326 (1.43)	-0.285 (-0.47)	0.225 (0.96)
ROA	3.391* (1.69)	7.179 (0.73)	3.385 (1.52)
Cash holding	-6.812** (-2.31)	5.386 (0.81)	-3.149 (-1.10)
ΔPPE	-0.035 (-0.25)	-4.085* (-1.69)	-0.034 (-0.19)
Leverage	-1.408 (-1.64)	-1.337 (-0.64)	0.456 (0.47)
Cashflow	-0.010 (-0.23)	-1.394* (-1.73)	-0.098 (-0.45)
Volatility	-0.220 (-1.33)	-0.051 (-0.08)	-0.220 (-1.29)
Amihud	4.114 (0.56)	4.566 (0.60)	-1.752 (-0.23)
Constant	7.958** (2.15)	17.772 (1.62)	7.867* (1.94)
N of parent-subsidiaries	401	84	401
Pseudo R ²	0.175	0.412	0.249

Table 8. Short-selling activity of subsidiary firms

The table presents the short-selling activity of subsidiary firms. Panel A reports the sample stocks analyzed in this paper, while Panel B includes all stocks listed on the Korean stock market. *relss* represents relative short selling activity, defined as the daily shorted shares divided by the daily trading volume, expressed as a percentage. SSval denotes the dollar volume of daily short-selling activity, measured in millions of Korean Won. SSvol refers to the daily number of shorted shares.

		<i>relss</i>	SSval	SSvol	<i>relss</i>	SSval	SSvol
		Mean			Median		
Panel A: Full sample							
2019	All	2.668	211.29	12,274.97	1.784	25.24	4,021.09
	P/S>1	2.144	135.14	11,373.30	1.284	17.83	3,160.65
	P/S<1	4.919	538.72	16,152.15	4.284	139.39	6,249.40
2020	All	0.665	71.88	4,284.03	0.439	6.98	1,042.30
	P/S>1	0.543	38.82	3,855.55	0.326	5.50	848.36
	P/S<1	1.194	215.29	6,142.78	0.994	39.59	2,205.73
Panel B: All stocks listed in the Korean stock market							
2019	All	2.408	197.22	9,902.09	1.230	14.97	2,410.13
	KOSPI	3.941	414.79	15,391.56	2.289	30.39	3,320.67
	KOSDAQ	1.554	75.93	6,841.94	0.922	11.23	2,057.68
2020	All	0.602	64.10	3,531.72	0.295	3.84	610.91
	KOSPI	1.061	138.23	5,460.91	0.665	8.32	971.21
	KOSDAQ	0.357	24.37	2,497.89	0.189	2.70	484.94

Table 9. Summary Statistics of Diversification index

The table presents the summary statistics of the diversification indices. Panel A reports the results for the full sample, while Panel B focuses on the centrality sample. The Herfindahl-Hirschman Index(HHI), as modified in this study, is used to measure the degree of diversification in a firm's product sales. The HHI is calculated as the sum of the squared proportions of sales across a firm's products, where p_i represents the proportion of the firm's total sales attributed to product i . The formula is as follow:

$$HHI = \sum_{i=1}^N p_i^2$$

Entropy is from Jacquemin and Berry (1979), which is defined as:

$$\text{Entropy} = \sum_{i=1}^N p_i \ln \left(\frac{1}{p_i} \right)$$

	All	Mispriced P/S<1	All	Mispriced P/S<1
	Mean		Median	
	Panel A: Full sample			
HHI	0.520	0.542	0.477	0.486
Entropy	0.882	0.835	0.939	0.903
N of parent-subsidiaries	398	74		
	Panel B : Centrality Sample			
HHI	0.509	0.562	0.462	0.484
Entropy	0.897	0.811	0.955	0.817
N of parent-subsidiaries	84	25		

Table 10. Logit regression: diversification index

The table reports logistic regression, where the dependent variable, P/S, is regressed on HHI, free float, centrality, holding, and control variables. P/S is defined as the market capitalization of the parent relative to the total market value of the subsidiaries held by the parent. If the P/S is less than 1, the dependent variable is set to 1; otherwise, it is set to 0. Panel A shows the results of HHI, while Panel B reports the results of Entropy. The Herfindahl-Hirschman Index(HHI), as modified in this study, is used to measure the degree of diversification in a firm's product sales. The HHI is calculated as the sum of the squared proportions of sales across a firm's products, where p_i represents the proportion of the firm's total sales attributed to product i . The formula is as follow:

$$HHI = \sum_{i=1}^N p_i^2$$

Entropy is from Jacquemin and Berry (1979), which is defined as:

$$\text{Entropy} = \sum_{i=1}^N p_i \ln \left(\frac{1}{p_i} \right)$$

Free float is the shares of a company that can be publicly traded without restriction, scaled by the total number of outstanding shares. Centrality is based on the measure from Almeida and Wolfenzon (2006). Holding company is a dummy variable that equals 1 if the firm is a formal holding company as designated by the KFTC. Parent Mktcap (P) is the market capitalization of the parent company at the end of 2021, measured in billion KRW. N of subsidiary is the number of subsidiary companies for each holding company. N of subsidiary is the number of subsidiaries for each holding company. We use lnTA, ROA, Cash holding, Δ PPE, Cashflow, Volatility, and the Amihud illiquidity measure as control variables, consistent across Tables 4 to 7. The z-statistics are in parentheses and ***, **, and * are significance levels at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)
Panel A: Herfindahl Index					
HHI	1.210*	1.315	0.986	1.476	1.011
	(1.87)	(0.82)	(1.47)	(0.89)	(1.51)
Free float	-2.428**			-1.666	-1.457
	(-2.31)			(-0.51)	(-1.29)
Centrality		0.105***		0.101***	
		(2.83)		(2.62)	
Holding company			1.819***		1.684***
			(4.64)		(4.20)
Parent Mktcap (P)	-0.474*	-0.522	-0.546**	-0.489	-0.534**
	(-1.93)	(-0.83)	(-2.16)	(-0.76)	(-2.10)
N of Subsidiary	0.585***	0.777**	0.483***	0.776**	0.505***
	(4.32)	(2.37)	(3.44)	(2.35)	(3.56)
Control	Yes	Yes	Yes	Yes	Yes
N of parent-subsidiaries	395	84	395	84	395
Pseudo R ²	0.206	0.417	0.248	0.420	0.252
Panel B: Entropy Index					
Entropy	-0.607*	-0.628	-0.505	-0.697	-0.513
	(-1.77)	(-0.72)	(-1.43)	(-0.78)	(-1.45)
Free float	-2.416**			-1.544	-1.439
	(-2.30)			(-0.48)	(-1.28)
Centrality		0.103***		0.100***	
		(2.81)		(2.60)	
Holding company			1.823***		1.690***

			(4.66)		(4.22)
Parent Mktcap (P)	-0.478*	-0.544	-0.551**	-0.516	-0.539**
	(-1.95)	(-0.87)	(-2.18)	(-0.81)	(-2.13)
N of Subsidiary	0.583***	0.787**	0.482***	0.788**	0.503***
	(4.31)	(2.41)	(3.43)	(2.40)	(3.55)
Control	Yes	Yes	Yes	Yes	Yes
N of parent-subsidiaries	395	84	395	84	395
Pseudo R ²	0.205	0.416	0.248	0.418	0.252

Table 11. Logit regression: Cashflow right

The table reports logistic regression, where the dependent variable, P/S, is regressed on cashflow right, centrality, and control variables. P/S is defined as the market capitalization of the parent relative to the total market value of the subsidiaries held by the parent. If the P/S is less than 1, the dependent variable is set to 1; otherwise, it is set to 0. Centrality is based on the measure from Almeida and Wolfenzon (2006). Parent Mktcap (P) is the market capitalization of the parent company at the end of 2021, measured in billion KRW. N of subsidiary is the number of subsidiary companies for each holding company. N of subsidiary is the number of subsidiaries for each holding company. We use lnTA, ROA, Cash holding, Δ PPE, Cashflow, Volatility, and the Amihud illiquidity measure as control variables, consistent across Tables 4 to 7. The z-statistics are in parentheses and ***, **, and * are significance levels at 1%, 5%, and 10%, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Cashflow right	5.402*** (3.43)	3.851* (1.95)	4.178* (1.72)	2.619 (1.34)	0.899 (0.36)	-1.171 (-0.36)
Centrality				0.068** (2.41)	0.057* (1.94)	0.108** (2.40)
Parent Mktcap (P)		-0.508* (-1.79)	-0.717 (-1.31)		-0.613** (-2.01)	-0.593 (-0.97)
N of Subsidiary		0.654*** (2.84)	0.885*** (3.09)		0.560** (2.36)	0.759** (2.41)
Control	No	No	Yes	No	No	Yes
N of parent-subsidiaries	81	81	81	81	81	81
Pseudo R ²	0.145	0.246	0.331	0.213	0.287	0.408

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