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International asset pricing with strategic business groups[1]

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A B S T R A C T

Firms in global markets often belong to business groups. We argue that this feature can have a profound influence on international asset pricing. In bad times, business groups may strategically reallocate risk across affiliated firms to protect core "central firms." This strategic behavior induces co-movement among central firms, creating a new intertemporal risk factor. Based on a novel data set of worldwide ownership for 2002–2012, we find that central firms are better protected in bad times and that they earn relatively lower expected returns. Moreover, a centrality factor augments traditional models in explaining the cross section of international stock returns.

1. Introduction

Traditional asset pricing models assume that the stocks of different companies are claims on assets of independent entities. While this premise holds for US-listed firms, it fails to capture the intricacies of the global market, in which multiple listed firms often belong to the same business group (e.g., Claessens et al., 2000; Faccio and Lang, 2002). The fraction of firms classified as group-affiliated ranges from about a fifth in Chile to two-thirds in Indonesia (Khanna and Yishay, 2007). In the US, the formation of business groups has been discouraged by regulators since the 1930s (see Kandel et al., 2018). Because US firms' independence is an exception rather than the rule, a fundamental question about the global market is the extent to which traditional asset pricing models, and related risk factors derived in the US, can adequately explain asset returns.

Our paper seeks to shed light on this issue by exploring the asset pricing implications of a critical feature of business groups that violates the independence assumption: strategic asset and risk reallocation. When a business group controls multiple firms, it has the flexibility to collect assets from each affiliated firm to build up the group's reserves and to reallocate them to those firms when needed.[1] When asset values are exposed to both systematic and idiosyncratic risk, the business group can benefit from two types of reallocation strategies. First, the group

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[1] In practice, this type of benefit can be easily achieved through internal capital markets and centralized treasury management, which could help explain the rise of business groups in the first place (see, among others, Stein, 1997; Johnson et al., 2000; Bertrand et al., 2002; Bae et al., 2002; Jiang et al., 2010). The value of the affiliated firms, in this case, would be affected by the value of assets reserved and reallocated by the group [in line with Merton (1974), when firms use leverage].

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can pool firm assets for risk-sharing purposes to diversify idiosyncratic risk, a common goal of group treasury management. This strategy resembles portfolio investments and does not change the systematic risk of affiliated firms.[2]

More interesting is the case in which business groups strategically respond to systematic risk or, more broadly speaking, economic situations that could threaten their control of group assets. A business group will not treat all affiliated firms equally because the failure of some can be much more costly to the ultimate owner of the group than others. Because a business group typically relies on a small number of central firms to control a large number of affiliated firms (e.g., Almeida and Wolfenzon, 2006a, 2006b), a failure of central firms could lead to the loss of ownership of the entire business group. In this case, the business group has incentives to reduce the risks to central firms, particularly in bad times, by allowing them to receive more from the group's reserves. This strategy essentially protects the equity value of central firms by reallocating risk to peripheral firms and resources to central firms.

Our key intuition is that such strategic behavior of business groups can profoundly shape the cross section of asset returns, allowing affiliated firms to differ from independent firms in an asset pricing perspective. To the extent that more important firms in a business group are better protected against risk, they should have a lower risk premium and a higher price. Because retaining control is arguably the most important consideration of business group owners, a testable prediction is that firms central to retaining control should be better protected and expected to earn lower returns.

Moreover, the strategy of redistributing risk could generate a new intertemporal risk factor (i.e., Merton, 1973) for affiliated assets. When business groups strategically respond to certain bad states, their redistribution of risk and resources between central and peripheral firms induces an additional source of uncertainty for investors. Their strategic behavior dynamically changes the risk profile of group assets and thus the investment opportunity set of investors. When investors want to hedge unfavorable shifts in this opportunity set in the spirit of Merton (1973), a new intertemporal risk factor arises, which can be proxied for by a central minus peripheral mimicking portfolio.[3] This factor arises in addition to the original (i.e., independent firm-based) asset pricing factors. Its economic origin, the strategic and intertemporal shifting of asset risk profiles by business groups, also highlights a fundamental difference between international and traditional US-based asset pricing models.[4]

We examine these predictions using a novel data set of the worldwide ownership structure of firms for the 2002–2012 period, which is the most extensive in the literature for both public and private firms (Aminadav and Papaioannou, 2020).[5] Because our goal is to understand the extent to which the strategic allocation of business group ultimate owners complements traditional US-based asset pricing models, our analysis focuses on the non-US sample, which contains 11,298 affiliated firms from 77 countries. For each business group, we identify its ownership structure and construct a new measure, that is, centrality, to describe the importance of each firm for retaining control of all group-controlled assets. Firm centrality is measured by the counterfactual loss in group assets if the business group loses the firm. Group assets include not only public firms but also private firms affiliated with the business group.

The first step in our analysis aims to provide evidence that central firms are protected in bad times. To achieve this goal, we examine whether central firms are less affected by unexpected negative shocks to their industry than peripheral firms. Although unexpected negative shocks undermine firm value in general, we find, using the framework of Bertrand et al. (2002), that central firms appear to be much less vulnerable to such shocks. A one standard deviation increase in centrality could offset between 11% and 12% of the negative impact of shocks on

[2] With this strategy, traditional asset pricing models and factors that explain the cross section of independent firms should apply to group-affiliated firms in the international market.

[3] Merton (1973) shows that long-term market investors want to hedge against unfavorable shifts in their investment opportunity set, which in equilibrium generates an intertemporal risk factor that can be proxied for by the returns of an asset that correlates with state shifts [i.e., the *n*th asset in Merton (1973)]. Merton (1973) demonstrates this intuition with a single state variable (the interest rate) that affects the return distribution of all assets and thus investors' opportunity set. We propose that the strategic behavior of business groups generates a similar effect. For instance, group control could be in greater danger in certain states when the bankruptcy risk for central firms is high or when they become too cheap to deter group raiders. Because the loss of group control can significantly affect business group owners, they do not want to give up the ownership of their core assets. Instead, given their substantial power over group firms (e.g., La Porta et al., 1999), the ultimate owners have incentives to strategically alter the risk profile of their controlled assets while holding their ownership stakes unchanged. In this way, their strategic behavior systematically affects the group asset returns and the opportunity set of the investors, similar to the influence of the interest rate on independent assets in the original Merton model. When investors want to hedge unfavorable shifts in this opportunity set à la Merton (1973), a new intertemporal risk factor arises to price group firms. Empirically, because the return spread of the central minus peripheral mimicking portfolio correlates with the strategic behavior of business groups, it can serve the role of the *n*th asset in Merton (1973) to proxy for the intertemporal risk factor.

[4] If business groups use resources to change the market exposure of the affiliated firms, the strategic behavior implies time-varying conditional capital asset pricing model betas, which the literature provides two ways to estimate. The first approach allows betas to load on observable lagged state variables (Shanken, 1990; Cochrane, 1996; Ferson and Schadt, 1996; Ferson and Harvey, 1991, 1999; Lettau and Ludvigson, 2001; Petkova and Zhang, 2005). The concern when using this method is the lack of the proper information set (Hansen and Richard, 1987), as strategic business group decisions are likely to involve important information unavailable to the public. The second approach directly measures time-varying realized betas from short-window regressions (Chan, 1988; Grundy and Martin, 2001; Lewellen and Nagel, 2006). However, as Boguth et al. (2011) point out, this approach could give rise to an overconditioning bias when asset returns are nonlinear in market returns. Asset pricing tests with strategic business groups are vulnerable to this bias because central firms are likely convex in market returns (when they are more protected in, all else equal, downside markets). Due to these concerns, we focus on the mimicking portfolio approach in our analysis and leave the examination of conditional betas to future research.

[5] We are grateful to Gur Aminadav for sharing the data with us and other assistance with our paper. The information on both public and private firms is crucial for us to properly assess the importance of each listed firm in business groups.

the firm's market-to-book value. Following the more recent work of Faccio et al. (2021), we find that centrality buffers the adverse impact of commodity shocks, consistent with central firms being protected from such shocks.

A potential concern with the above evidence is that some omitted variables simultaneously drive firm values and observed shocks in our analysis. Hence, we exploit an exogenous shock induced by sovereign downgrades. Almeida et al. (2017) show that the downgrade of a country's sovereign bonds exhibits a negative impact on firms' cost of financing when their credit rating is above the post-downgrade sovereign ceiling. We find that this impact is significantly mitigated for central firms, confirming that they are strategically protected against adverse shocks by their business groups.

We then move on to explore the asset pricing implications of strategic reallocation by business groups. To determine whether centrality implies a lower risk premium under strategic reallocation, we relate centrality to out-of-sample stock returns (Daniel et al. (1997) DGTW-adjusted returns) in the cross section. After controlling for firm-specific characteristics such as size, book-to-market, and momentum, we find a strong negative relation between centrality and future stock returns. In Fama and MacBeth (1973) (Fama-MacBeth) specifications, we find that a one standard deviation increase in centrality equates to a 14 (12) basis points (bps) lower out-of-sample monthly return (DGTW-adjusted).

To further gauge the economic magnitude of centrality-related risk premiums, we perform a portfolio analysis, constructing two types of centrality-based portfolios with or without conditioning on the business groups to which they belong. The first specification uses an unconditional sort based on the cross section of all the firms. The second sort captures the asset pricing influence of centrality among firms being of the highest centrality to their respective business group. For both specifications, high-centrality portfolios deliver lower four-factor adjusted returns. The economic magnitude of the risk-adjusted spread between high- and low-centrality portfolios for the two specifications is, respectively, 67 bps and 36 bps (per month). These are highly economically and statistically significant.

Next, we explore the extent to which group strategic allocation can create a new intertemporal risk factor that affects international asset pricing. For this purpose, we use a centrality factor based on the central minus peripheral mimicking portfolio and conduct tests to identify the incremental explanatory power it provides, in addition to that offered by traditional factor models such as the international capital asset pricing model (CAPM), the international Fama-French model (Fama and French, 2012), and models with variables to proxy for intermediary and uncertainty risk factors.

We perform the Bayesian asset pricing test introduced in Barillas and Shanken (2018) as well as the squared Sharpe ratio test introduced in Barillas et al. (2020), which does not rely on test assets to determine the best pricing model. The highest probability model chosen by the Bayesian asset pricing test includes the centrality factor. This specification dominates all other factor models based on the Sharpe ratio comparison tests. Across these different types of asset pricing tests, group strategic allocation clearly creates a new intertemporal risk factor that influences stock returns in the international market.

Finally, we conduct a battery of additional analyses to shed more light on the economics of the centrality factor. We assume that business groups rely on internal (i.e., within business group) resources to protect central firms in bad states. An important missing element is external funding. Could business groups, for instance, treat states with deteriorating external funding liquidity as bad states or use external capital to achieve the same goal? We find that known proxies of funding liquidity risk related to intermediary capital (He et al., 2017), Volatility Index (VIX), and the default spread neither explain the centrality factor nor affect its significance in Bayesian asset pricing tests. These results reject funding liquidity risk as the main driving force of the new factor.

If the protection of group control is the main economic incentive for strategic reallocation, our results should be robust using alternative measures of group control. Consistent with this notion, our robustness checks show that top firms, in which ultimate owners have the highest ownership stakes, can generate similar, albeit weaker, results. We base our analysis on centrality as it better captures the strategic behavior of the ultimate owners. Centrality quantifies what an owner would lose (of group assets) if he or she loses a given firm. This counterfactual vulnerability provides business group owners the incentives to strategically reallocate resources to protect central firms in bad states.

A remaining question about our analysis arises from the observation that business groups often expropriate investors via asset tunneling.[6] Could our results on central firms reflect a time-varying expropriation incentive instead of a dynamic risk reallocation by group owners? To address this issue, we follow the literature (e.g., Almeida and Wolfenzon, 2006b; Almeida et al., 2011; Bertrand et al., 2002; Bae et al., 2002) to identify extractors, i.e., firms that are most likely to receive tunneled assets or other cash flows for expropriation purposes. We find that the influence of central firms is distinct from extractors, suggesting that expropriation and related cash flow considerations are not the main driving force for the intertemporal risk factor proposed in our analysis.

Our study is related to several strands of the literature. First are studies exploring the economic grounds of international asset pricing.[7] Our novel contribution is to pro-

[6] Asset tunneling reflects the agency issue of business groups, as the ultimate owners can use this channel to directly transfer wealth from the investors of other group firms. In contrast, risk reallocation does not imply expropriation. If the intertemporal risk is properly priced in the market, peripheral firms receiving risk would be compensated with a higher risk premium. Hence, investors of the peripheral firms do not experience wealth loss.

[7] A long literature on international asset pricing, for instance, has focused on the issue of market integration and the set of factors driving global stock returns (see, e.g., Bekaert and Harvey, 1995; Bekaert et al., 2002; Bekaert et al., 2007; Bekaert et al., 2011; Bekaert et al., 2009; Carrieri et al., 2007; Chan et al., 2000; Chan et al., 1992; Doidge et al., 2007; Ferson and Harvey, 1993, Griffin, 2002; Griffin et al., 2003; Griffin and Stulz, 2001; Hou et al., 2011; Kang and Stulz, 1997;Karolyi and Stulz, 2003).

pose that international asset pricing can differ profoundly from that in the US market due to the strategic behavior of business groups. Regardless of the set of factors necessary to expand the cross section of stock returns for independent firms, the strategic risk reallocation of business groups (to protect their central firms in bad times) is likely to introduce an additional intertemporal risk factor to shape stock returns in the spirit of Merton (1973).[8]

We build on and extend the literature on business groups and pyramids (Johnson et al., 2000; Bertrand et al., 2002). Whereas existing studies mainly focus on either why pyramids exist or the financing implications thereof, we explore the asset pricing implications of strategic business groups. In doing so, we extend the emerging literature on the asset pricing impact of organizational structure (e.g., Eisfeldt and Papanikolaou, 2013).

Our findings can also be compared with studies on institutional (co-)ownership, as the ultimate owner of business groups can be regarded as a common owner of affiliated firms. Both types of ownership can influence asset prices. The economic channel to influence asset prices, however, differs. Bartram et al. (2015) and Anton and Polk (2014) show that co-ownership of institutional investors can propagate crises and create price contagion in the presence of market frictions such as trading impacts. In contrast, we show that group ownership can affect asset prices by altering risk distribution among affiliated firms.

The remainder of the paper is organized as follows. Section 2 presents the data that we employ and the main variables constructed for the analysis. Section 3 examines whether central firms are strategically protected by business groups. The cross-sectional asset pricing implications of such strategic behavior are discussed in Section 4. Section 5 examines whether a centrality factor should be included in international factor models. Section 6 provides additional tests and robustness checks, and a brief conclusion follows in Section 7.

2. Data and main variables

We first describe the data sources and then explain how we construct our identifiers of business groups and our measures of centrality and the other control variables.

2.1. Ownership data

Data on ownership come from the Orbis database of Bureau van Dijk, covering worldwide privately and publicly listed firms over the period 2001–2013. The centrality data are available for some firms in 2001, but we have comprehensive centrality data only from 2002 to 2012. We start with ownership data on 150,343 unique firms, of which 48,461 are unique publicly listed firms from 134 countries and 101,882 are unique private firms from 190 countries. These firms are held by 535,088 unique shareholders. The type distribution is 4612 insurance companies; 9223 banks, 180,648 industrial firms (all companies that are not banks, financial companies, or insurance companies), 58,566 mutual or pension funds, nominees, trusts, or trustees, 40,117 financial companies, 212,337 single private individuals or families, 3275 foundations or research institutes, 2465 employees, managers, or directors, 1058 private equity firms, 4181 public authorities, states, or governments, 884 venture capital firms, 30 hedge funds, and 17,692 for which type is unidentified.

We use this ownership data to determine the controlled firms (as opposed to noncontrolled or widely held firms) and their ultimate owners. From these, we identify the public and private firms that are affiliated with business groups (as opposed to stand-alone firms) by examining common ultimate ownership. We define a business group as an entity with at least two publicly listed firms (and any number of private firms) that are controlled by the same ultimate owner. A detailed description of the methodology is given in Appendix A. The final sample for our tests has 11,298 publicly listed group-affiliated firms and 5443 business groups from 77 countries (46,483 firm-year observations).

Data on accounting variables come from Bureau van Dijk (especially for the private firms), Datastream/Worldscope, and Compustat. Stock market information is from Datastream/WorldScope. To correctly measure the assets and profitability of each individual-affiliated firm, we need to ensure that the reported figures are not affected by equity stakes held by a firm in other firms. Whenever the reported figures are consolidated or are subject to the equity method, we use the equity stakes from Bureau van Dijk and the accounting information of the held firms to back out the exact amount by which these accounting figures have been adjusted (see Almeida et al., 2011).[9]

2.2. Group ownership structure and centrality of control

We rely on the measure of centrality in Almeida et al. (2011), augmented with the game theoretic method of identifying voting power as adopted in Aminadav and Papaioannou (2020), to introduce our own measure of the importance of a firm for group control, which is referred to as "centrality for group control" or simply "centrality" when appropriate. It is based on the structure of the business group and the value of the equity of affiliated firms.[10]

[8] This effect does not apply to independent firms because firms do not have extra assets to hedge in bad states of the economy (or such assets are very costly to obtain). Instead, independent firms use financial instruments, such as derivatives, to manage risk. See, e.g., Pérez-González and Yun (2013) as a recent example. On the theory side, Kim (2003) provides a model of intertemporal production based on the duality theory of Cochrane (1996). However, there is no strategic asset reallocation in the Kim (2003) model.

[9] That is, recording Firm A's share of Firm B's equity as an asset of Firm A and Firm A's share of Firm B's profits as a source of nonoperating income for Firm A.

[10] Almeida et al. (2011) define centrality as the average decrease in voting rights when a focal firm is excluded from the group. They also use critical control thresholds to compute the voting rights. Our measure adopts the same intuition of inferring the importance of a firm based on the counterfactual loss when it is excluded from the group. It differs in computing voting rights. We use the game theoretic method adopted in Aminadav and Papaioannou (2020) based on the Shapley and Shubik (1954) voting power index. The benefit of this method is that, as ex-

We define the centrality of an affiliate firm as the fraction of the entire group's (market) value that the owner loses control over if control of that particular firm is lost. Formally, if by losing control over firm F the ultimate owner of group G loses control over the set of firms G_{-F} (which includes F), then

$$Centrality_F = \frac{1}{Value_{UO}} \sum_{i \in G_{-F}} Value_i, \quad (1)$$

where $Value_i$ is the market value of equity of firm i and $Value_{UO} = \sum_{i \in GroupG} Value_i$ is the sum over the values of all the firms in group G.

By construction, the *Centrality* measure of a firm is a number between zero and one (mathematically, $Centrality_F \in (0, 1]$). The centrality of a particular firm represents the counterfactual loss in group value if the business group loses control over that firm. In other words, a higher value of firm centrality means the ultimate owner would lose a greater portion of the group if control over that firm was lost. For instance, if the ultimate owner loses control of a firm with a centrality of 0.5, he or she would lose control over firms that comprise 50% of the entire group value. A hypothetical example of a business group is shown in Fig. 1. Appendix B further describes how we compute the measure of centrality for this case.

The economic meaning of *Centrality* can perhaps be more clearly demonstrated when we compare it with two traditional types of firms in a business group: top and apex firms. The first is a firm in which the ultimate owner has the highest ownership stake. We define a dummy variable called *E1* that equals one for such a firm and zero otherwise (e.g., Almeida and Wolfenzon, 2006a; Almeida et al., 2011). The second is the firm that is entitled to the highest amount of cash flow rights of the group due to its direct or indirect stake in other group firms, which we capture by another dummy variable, *E2 (*e.g., Bertrand et al., 2002; Bae et al., 2002,).Because *E1* is a traditional proxy for business group control, we use it as an alternative centrality measure for robustness tests. *E2* differs from *E1* due to the separation of control and cash flow rights and is often used by group owners as an extractor to receive tunneled assets (i.e., for the purpose of expropriation).[11] It provides a reasonable measure to examine the role of expropriation or other related cash flow considerations in our analysis.

The economic difference between *Centrality* and these traditional measures is illustrated in the example in Fig. 2

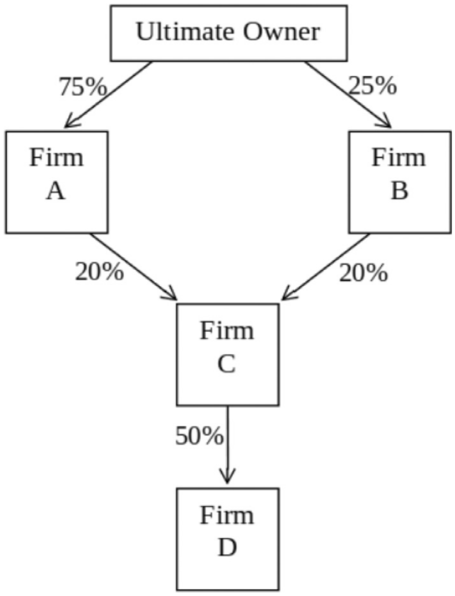

Fig. 1. An illustration of a hypothetical business group. The top box is the ultimate owner (e.g., a family) and the arrows represent control relations, such that an arrow points from the direct controlling shareholders to the controlled firm. The other boxes represent individual group firms. The percentages over the arrows show the voting rights that each controlling entity (ultimate owner or a firm) holds in other firms. The ultimate owner owns a direct stake of 75% in Firm A and 25% in Firm B. In addition, Firm A owns 20% in Firm C, Firm B also owns 20% in Firm C, and Firm C owns 50% in Firm D. We assume that in each firm the ownership distribution of the other (not controlling and not illustrated) minority shareholders is so dispersed that 20% stake is enough to control a corporation.

(Appendix D provides more details). In Panel A, we report the Italian group De Benedetti controlled by the Italian tycoon Carlo De Benedetti and his family. The extractor firm (i.e., *E2*) is Cofide—Gruppo De Benedetti SpA, from which the ultimate owner receives 38% of group cash flow rights with a centrality of 20%. The latter number means that losing control over this firm would cause the ultimate owner (the Carlo De Benedetti family) to lose control over firms that comprise 20% of the total group value. In this example, *E1* also coincides with *E2*. However, Cofide is not the most central firm to the ultimate owner.

The most central firm is CIR SpA, with 35% cash flow rights and 56% centrality. If the family loses its current control over CIR SpA, it would lose 56% of the group assets. Hence, CIR SpA is critical for the family to retain group control. The two firms are also connected. CIR SpA is jointly controlled by Cofide and another firm (Carlo De Benedetti & Figli S.a.p.a. Siglabile Cdb & F). Both are controlled by the De Benedetti family. If the family loses control over Cofide, it would not lose CIR SpA (and thus the 56% stake of the group assets), because the family still holds 24% of CIR SpA via the second firm, and, critically, the other shareholders of CIR SpA are not effective rivals of group control.[12]

plained in Appendix A, all important rival information is considered when we compute the coalitions of all pivotal shareholders. Aminadav and Papaioannou (2020) use the index to identify the ultimate owner of a business group, whereas we use it to compute the centrality measure of each firm, which allows us to calculate centrality as the counterfactual loss incurred by losing a specific firm while taking into consideration potential rivals for control. As discussed in Aminadav and Papaioannou (2020), this methodology has been computationally challenging for business groups with complex ownership structures and has only recently become computationally feasible.

[11] The value of control through ownership typically differs from the value of cash flow rights in the global market. Dyck and Zingales (2004), for instance, estimate an average control premium of 14% across 39 countries. Although their setup differs from ours, their results imply that group owners can have stronger incentives to protect control.

[12] This example illustrates that, unlike more traditional measures based on a fixed percentage of ownership, centrality accounts for the ability to control group assets based not only on the ownership held by an ultimate

Fig. 2. Two real examples of apex firms versus central firms This figure illustrates two real examples of business groups for which the listed central firm (in red) differs from the listed *E1* and *E2* firms (in blue). In Panel A, the *E1* and *E2* firm is Cofide—Gruppo De Benedetti SpA with ultimate owner direct and indirect cash flow rights (voting rights) of 38% and centrality measure of 20%. The central firm is CIR SpA–Compagnie Industriali Riunite with cash flow rights (voting rights) of 35% and centrality measure of 56%. Even though the firm Cofide is part of the controlling concert of shareholders that controls CIR SpA–Compagnie Industriali Riunite, it is not a critical shareholder for control. The reason is that CIR Spa–Compagnie Industriali Riunite is jointly controlled by two shareholders of the firm Cofide and the firm Carlo de Benedetti & Figli S.a.p.a. Siglabile Cdb & F. Both controlling shareholders are ultimately controlled by the De Benedetti family. If the family losses control over Cofide, it would not lose control over CIR SpA–Compagnie Industriali Riunite as it still holds a stake of 24% via Carlo de Benedetti & Figli S.a.p.a. Siglabile Cdb & F, which allows it to maintain control over CIR Spa–Compagnie Industriali Riunite. Consequently, it would not lose the part of the group that is below CIR SpA–Compagnie Industriali Riunite. This is not the case if the family loses control over CIR SpA–Compagnie Industriali Riunite, when it would lose control over everything below that firm. This explains why CIR SpA–Compagnie Industriali Riunite has a higher centrality than Cofide—Gruppo De Benedetti SpA, even if Cofide—Gruppo De Benedetti SpA has higher cash flow rights and is one of controlling shareholders of CIR SpA–Compagnie Industriali Riunite. In Panel B, the *E1* and *E2* firms are Austevoll Seafood ASA with ultimate owner direct and indirect cash flow rights (voting rights) of 56% and centrality measure of 9%. The central firm is DOF ASA with cash flow rights (voting rights) of 48% and centrality measure of 39%. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Between the two firms, CIR SpA plays a more critical role for the family to control group assets. It subsequently has higher centrality. The other firm, Cofide, has higher cash flow rights because it receives cash flows from the central firm and other firms (and, hence, is *E2* of the group), and is even among the controlling shareholders of the first firm (which helps explain why Cofide is *E1* of the group).[13] Because the potential loss of CIR SpA can generate much larger counterfactual damage to its group control, the De Benedetti family has a higher incentive to protect this firm in bad states. This example intuitively illustrates how the strategic behavior of business groups can arise for central firms.

2.3. Control variable measurement

We control for firm characteristics known to influence returns in our cross-sectional analysis. These are firm size, measured as the natural log of market equity; growth opportunities, proxied by the book-to-market ratio (i.e., the book value of common equity divided by the market value of common equity); momentum, measured by past twelve-month stock returns, leaving out the most recent month; and the one month lagged return. As per the standard literature, we employ data screening and cleaning following Hou et al. (2011), Ince and Porter (2006), and others.[14]

In the panel regressions, we further control for firm risk using leverage and size using (the log of) the firm assets. We also control for (the log of) the sum of the book value of equity of all the firms in the group and the (log of) the book value of the total number of group firms (we exclude the focal firm from both measures).

Finally, we include dummy variables for each group (to control for group effects), dummy variables for each country (to capture country effects), dummy variables for each industry (which correspond to the four-digit Standard Industrial Classification code of the primary industry of each firm) to account for industry effects, and dummy variables to capture time effects. In some specifications, we control for firm fixed effects. Appendix C provides a description of the variables used in our analysis.

2.4. Summary statistics

Table 1 provides the summary statistics, Panel A for firm-level variables and Panel B for business group characteristics. Our sample contains 46,843 firm-year observations from 2002 to 2012.

Panel A reports that our measure of centrality has a mean of 0.37 in our sample and wide distribution across firms. We split the sample by the median value of centrality to assess differences in characteristics between central and noncentral firms. The last three columns show that the average centrality is 0.71 for the sample of most central firms and 0.04 for the rest. The difference between the two groups is highly significant, both statistically (with a p-value of virtually zero) and economically. Hence, if an owner loses the central firm in our sample, it equates to a loss of 71% of the value of the entire group. This observation confirms that central firms are major building blocks of business groups that the owners cannot afford to lose.

Also, central firms are typically larger and older, five to six times larger than noncentral firms. They have five more years of operation and a lower valuation. These patterns further illustrate the importance of central firms, consistent with Almeida et al. (2011). The distribution of these variables is in general consistent with the literature.[15] Panel B reports that a typical business group has about 14 affiliated firms (public and private), albeit substantial cross-group variations exist in the number of affiliated firms as well as group assets and book equity. Also shown in the panel is the within group distribution of centrality. In addition to the maximum and median value of within group centrality, we calculate the centrality difference between the most central firm and the most peripheral firm within the group. The centrality difference, reported in "Difference: within group maximum centrality - minimum centrality," amounts to an average of 0.6. This value is on a par with the centrality difference reported in Panel A between the group of central and noncentral firms (the Panel A difference is not conditioning on the same business group). The difference between the dollar value of total assets controlled (both directly and indirectly) by the most central firm and that of the most peripheral firm is reported in "Difference: within group value maximum centrality – minimum centrality (billions of dollars)." On average, the central firm within a group controls about 60% more value than the least central firm.

From the two panels, it is evident that central firms play a pivotal role in controlling the assets within business

owner but also on that of other rival owners who could compete for control. Economically speaking, the counterfactual loss implied by centrality provides a better proxy for the real controlling power when the business groups have multiple large shareholders or dispersed ownership and blocks.

[13] Because *E1* and *E2* are different for many business groups, they also play different roles in our later analysis. We use this example to illustrate the economic role of centrality. Another example of similar spirit, the Møgster family group from Norway, is given in Panel B, where the extractor firm is Austevoll Seafood ASA with ultimate owner cash flow rights of 56% and centrality of 10%. The central firm is DOF ASA with cash flow rights of 48% and centrality of 39%.

[14] We winsorize size and book-to-market equity at the bottom 0.5% and top 99.5% of the distribution. We employ screens that include the removal of padded zeros, non-primary exchange listings, non-equity securities, and extreme return reversals. Extreme reversals, which suggest data issues, are accounted for using the following method: If the stock return, or the one month lagged stock return, is greater than 300% and the product of the return and the lagged return is less than 50% [i.e. $(1 + r_t) \times (1 + r_{t-1}) - 1 < 50\%$], then both r_t and r_{t-1} are set to missing. We also winsorize returns at the bottom 0.1% and top 99.9% of the distribution in each market.

[15] For example, mean total assets (billions of dollars) is 11.5 in our sample, compared with 7.33 in Anderson et al. (2012). The international average of leverage is 0.25 in Ferreira and Matos (2008), compared with 0.22 in our sample. In Lau et al. (2010), the market-to-book ratio averages around 1.7 across stocks in different countries, compared with the mean of 2.1 in our sample. Mean idiosyncratic volatility (scaled by total volatility) in Durnev et al. (2003) is between 0.923 (for high) and 0.610 (for low) compared with a mean of 0.82 in our sample.

Table 1
Summary statistics.
The table reports the summary statistics for the main variables used in the paper. Panel A shows the mean, standard deviation, 5th, 50th (median) and 95th percentiles, and number of observations for the centrality measure, ownership measures, firms *E1* and *E2*, financial variables, and the difference of mean tests between central and noncentral firms (*Centrality* is a dummy variable equal to one if centrality is above the median and zero otherwise). Panel B reports group-level statistics (we add the 25th and 75th percentiles). The sample consists of worldwide public firms that are affiliated with business groups in the 2002–2012 period.

Panel A: Summary statistics for firm-level variables

Variable	Mean	Standard deviation	5%	50%	95%	Number of observations	Central versus noncentral firms: Noncentral (mean)	Central (mean)	*t*-test (*p*-value)
Centrality	0.37	0.40	0.00	0.16	1.00	46,483	0.04	0.71	(0.00)
Ownership stake of the ultimate owner	0.47	0.23	0.11	0.49	0.90	46,483	0.43	0.50	(0.00)
E1 (dummy for highest stake of ultimate owner)	0.36	0.48	0.00	0.00	1.00	46,483	0.12	0.60	(0.00)
E2 (dummy for highest value owned)	0.42	0.49	0.00	0.00	1.00	46,483	0.39	0.45	(0.00)
Total assets (billions of dollars)	11.54	50.55	0.03	0.69	38.90	46,483	2.94	20.13	(0.00)
Market capitalization (billions of dollars)	3.93	15.45	0.01	0.39	16.33	46,483	1.26	6.61	(0.00)
Market-to-book	2.12	2.62	0.27	1.36	6.51	46,483	2.35	1.88	(0.00)
Leverage	0.22	0.20	0.00	0.19	0.60	46,483	0.20	0.25	(0.00)
Age in years since incorporation	41.94	40.97	4.00	29.00	118.00	43,904	41.10	42.77	(0.00)
Idiosyncratic volatility (scaled by total volatility)	0.82	1.74	0.51	0.83	0.97	39,676	0.85	0.77	(0.00)

Panel B: Summary statistics for business groups

Statistic	Mean	Standard deviation	5%	25%	50%	75%	95%	Number of observations
Total number of group firms	13.97	26.34	2.00	2.00	4.55	13.00	58.05	17,120
Group total assets (billions of dollars)	31.32	102.34	0.05	0.38	2.13	12.98	153.31	17,120
Group total book value (billions of dollars)	14.29	43.29	0.03	0.25	1.50	8.37	70.43	17,120
Within group maximum centrality	0.81	0.29	0.12	0.67	1.00	1.00	1.00	17,120
Within group median centrality	0.49	0.35	0.01	0.14	0.50	0.80	1.00	17,120
Difference: within group maximum centrality - minimum centrality	0.46	0.41	0.00	0.00	0.46	0.90	1.00	17,120
Difference: within group value maximum centrality - minimum centrality (billions of dollars)	6.05	22.05	−0.12	0.00	0.07	2.20	32.73	17,120

groups. The loss of the central firm in our sample could, moreover, mean the loss of the group. However, other affiliated firms with a high centrality score are also important to maintaining group control. Hence, our remaining analysis explores a cross section of the centrality score to understand the impact of the potential strategic behavior of business groups.

3. Centrality and sensitivity to shocks

Because business groups rely on central firms to control assets, we need to investigate the extent to which central firms are strategically protected by business groups in bad times. We will test this by assessing the sensitivity of central firms to industry shocks and to sovereign downgrade shocks.

3.1. Sensitivity to industry shocks

We address this issue by investigating the influence of unexpected negative industry shocks. We consider two ways. First, we follow Bertrand et al. (2002) to assess the help from the low-centrality firms to the high-centrality firms. We consider the following panel specification:

$$MB_{i,t} = \alpha + \beta_1 NegShock_{i,t} + \beta_2 Centrality_{i,t} + \beta_3 Centrality_{i,t} \times NegShock_{i,t} + c \times \Delta x_{i,t} + \epsilon_{i,t}, \quad (2)$$

where $MB_{i,t}$ refers to the market-to-book ratio; our proxy of firm valuation, $NegShock_{i,t}$, denotes the unexpected negative shocks of the industry for which the firm operates in; and $\Delta x_{i,t}$ represents a vector of firm characteristics defined in Appendix C. We control for changes in these characteristics. We also control for serial correlation and heteroskedasticity using the Huber-White sandwich estimator (clustered by group-level identifier) for the standard errors. We control for time fixed effects. In alternative specifications, we include firm fixed effects. The unexpected yearly shocks for each industry are measured as the residual term $\eta_{i,t}$, from the following AR specification (Anderson et al., 2012):

$$ROA_{i,t} = \alpha + \beta_1 ROA_{i,t-1} + \beta_2 ROA_{i,t-2} + \beta_3 ROA_{i,t-3} + \eta_{i,t}, \quad (3)$$

where $ROA_{i,t}$ is the realized size-weighted mean return on assets (ROA) of industry i in year t. In our estimation, we use the one-year lag of this residual. In robustness tests, we also use mean industry sales growth (Mitchell and Mulherin, 1996) or the size-weighted mean industry earnings per share (Anderson et al., 2012) instead of ROA to compute the residual in regression Eq. (2). Alternatively, following Jian and Wong (2010), we define the shock to the industry as the difference between each industry's mean ROA (or the mean return on sales) in a specific year and the past three years moving average ROA (or return on

Table 2
Sensitivity to shocks.
This table reports the results of how unexpected shocks influence the valuation and returns of central and noncentral firms. In Columns 1–3, we report how yearly industry return on asset (ROA) shocks influence the valuation of central firms. Following Anderson et al. (2012), unexpected industry shock is measured by the residuals of an AR(3) process of industry ROAs. We then regress market-to-book on unexpected industry shock as well as its interaction with *Centrality*. We control for log assets, log number of group firms, and lag capital expenditures, as well as *E1* and *E2*. In Columns 4–6, we report how weekly firm-level commodity shocks influence the idiosyncratic returns of central firms. Following Faccio et al. (2021), we match commodities to industries using a statistical matching method. We then regress the weekly idiosyncratic firm-level stock returns on unexpected commodity shocks as well as its interaction with *Centrality* using a Fama-MacBeth specification. We control for log market value equity, log book-to-market equity, and momentum, measured by past twelve-month stock returns, leaving out the most recent month. ***, **, and * represent the significance level at 1%, 5%, and 10%, respectively, using robust standard errors with *t*-statistics given in parentheses.

Variable	Market-to-book (1)	Market-to-book (2)	Market-to-book (3)	Idiosyncratic return (4)	Idiosyncratic return (5)	Idiosyncratic return (6)
Centrality	0.26***	0.26***	0.23**	−0.17***	−0.16***	−0.08**
	(2.92)	(2.91)	(2.56)	(−3.80)	(−3.49)	(−1.91)
Shock	0.081***	0.11***	0.10***	1.84**	3.15***	2.51***
	(3.27)	(4.03)	(3.78)	(2.21)	(3.07)	(2.55)
Centrality × *Shock*		−0.37**	−0.35**		−3.97**	−3.27**
		(−2.45)	(−2.38)		(−2.82)	(−2.27)
Controls	Yes	Yes	Yes	No	No	Yes
Firm fixed effects	Yes	Yes	Yes	–	–	–
Time fixed effects	No	No	Yes	–	–	–
R-squared	0.011	0.012	0.037	0.012	0.014	0.058
Number of observations	9,405	9,405	9,405	200,127	200,127	200,127

sales). Our results are robust to these alternative measures of unexpected industry shocks.

The results are reported in Columns 1, 2 and 3 of Table 2. Central firms appear to be much less vulnerable to shocks as the interaction term between centrality and industry shock has a significantly negative coefficient. In Model 2, with firm fixed effects, for instance, a one standard deviation increase in centrality could offset approximately 12% of the negative impact (i.e., $\sigma \times \frac{\beta_3}{\beta_1} = 12\%$, where $\sigma = 0.40$ is the magnitude of the one standard deviation change in centrality), and, in the case of both firm and time fixed effects, the effect is around 11%. The economic magnitude estimated from the first model is about the same (though slightly smaller). This observation is consistent with the notion that central firms are highly protected by business groups in bad times. These results should be considered suggestive given the non-normality in the distribution of the centrality variable. While not affecting the results of the portfolio analysis, it may make more difficult the economic interpretation of the results of this section.

To examine how general the protection is, we follow the approach taken by Faccio et al. (2021), who match commodities to industries using a statistical matching method and then regress the weekly idiosyncratic firm-level stock returns on unexpected commodity shocks as well as the interaction of unexpected commodity shocks with business group affiliation. While their goal is to assess the degree by which firms affiliated with business groups are sensitive to shocks, ours is to investigate whether, within business groups, certain firms (the central firms) are less sensitive to shocks. Thus, we interact the unexpected commodity shocks with centrality instead of business group affiliation.

We define shocks for a given firm as unexpected weekly returns of the commodity matched to the firm's industry, as in Faccio et al. (2021).[16] We follow their analysis and adopt a Fama-MacBeth specification and regress idiosyncratic returns, defined as the residual of the firm's weekly returns on the local market return, on shock, centrality, and their interaction.

The results reported in Columns 4–6 show that, again, central firms are much less sensitive to unexpected negative industry shocks. Central firms' returns are less sensitive to industry shocks as the interaction term between centrality and industry shock has a significantly negative coefficient. In Model 5, for instance, a one standard deviation increase in centrality could offset approximately 32% of the negative impact [i.e., 0.40 × (3.15/3.97), where 0.40 is the magnitude of the one standard deviation change in centrality].

In brief, our results show that central firms are protected by business groups in bad times. The message about valuation and default risk is clear. The use of unexpected negative industry shocks could be subject to concerns about a spurious correlation. For instance, if central firms adopt different strategies compared with their industry competitors, then a negative shock to their competitors could directly benefit them.

3.2. Sensitivity to the exogenous shock of sovereign downgrades

Sovereign downgrades offer a natural experiment that can help to identify the protection received by central firms in bad times. For example, Almeida et al. (2017) show that a country downgrade has a direct and exogenous impact on companies' (or groups') cost of financing in that

[16] We thank M. Faccio, R. Morck, and M. D. Yavuz for kindly making these data available to us. We use commodity shocks matched using the statistical method.

Table 3
Sensitivity to the exogenous sovereign downgrades.
This table contains linear regression estimates of the differential effect of an exogenous downgrade shock on stock returns between firms with different levels of centrality. The dependent variable is the annual return in year t (in percent). *Bound* is a dummy variable that takes the value of one if a firm has a credit rating equals to or above the sovereign rating in year $t-1$, and *Downgrade* is a dummy variable that takes the value of one if a firm's country rating is downgraded in year t. The control variables are the natural logarithm of firm size, the natural logarithm of book-to-market equity, and leverage. Regressions also include year, country, and business group fixed effects. The sample consists of Wharton Research Data Services FactSet Fundamentals annual fiscal (international) nonfinancial firms in the 2002–2012 period. Robust standard errors clustered by country event are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Centrality × *Downgrade* × *Bound*	1.24***	1.20***	1.31***	1.15***	1.67***	1.28***
	(5.84)	(5.70)	(5.57)	(6.18)	(5.63)	(5.01)
Centrality	−0.06	−0.04	−0.04	−0.03	0.01	0.07
	(−1.67)	(−1.29)	(−1.12)	(−1.07)	(0.13)	(0.93)
Downgrade	−0.13	−0.12	0.17	−0.08	0.12	−0.11
	(−1.66)	(−1.67)	(1.04)	(−0.66)	(0.73)	(−0.92)
Bound	0.05	0.04	−0.09*	−0.06	0.02	0.13*
	(0.89)	(0.80)	(−1.93)	(−1.02)	(0.31)	(1.90)
Bound × *Centrality*	0.06	0.06	0.09	0.12*	−0.07	−0.20
	(0.69)	(0.76)	(1.23)	(1.85)	(−0.68)	(−1.52)
Downgrade × *Centrality*	0.04	0.02	−0.04	0.03	−0.01	0.00
	(0.22)	(0.08)	(−0.18)	(0.20)	(−0.03)	(0.02)
Bound × *Downgrade*	−0.62***	−0.59***	−0.71***	−0.63***	−0.88***	−0.54***
	(−6.72)	(−7.25)	(−4.30)	(−4.98)	(−3.13)	(−4.00)
Controls	No	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	No	Yes	No	Yes
Country fixed effects	No	No	Yes	Yes	No	Yes
Business group fixed effects	No	No	No	No	Yes	Yes
R-squared	0.52	0.53	0.08	0.57	0.18	0.66
Number of observations	964	964	963	963	842	842

country. We therefore examine whether the downgrade would have a less negative impact on central firms, via a less severe stock price drop than on peripheral firms.

We provide a brief description of the experiment. Details can be found in Almeida et al. (2017). The key intuition is that when a sovereign nation gets downgraded, a firm domiciled therein with a rating higher than the post-downgrade sovereign ceiling (i.e., bound firms) also is downgraded, even when everything about the firm remains the same. In practice, the ratings of bound firms deteriorate after a sovereign downgrade. This introduces a source of exogenous variation into the risk measures of affected firms. Whereas Almeida et al. (2017) focus on a difference-in-differences (DiD) specification to understand the different outcomes of bound firms versus non-bound firms in a downgraded sovereign setting, we use a triple difference specification that measures the differential effect of centrality conditional on this known DiD treatment effect. That is, we want to understand if centrality has a differential effect on a sample of treated firms conditional on an exogenous treatment effect.

The unit of observation for our tests is firm-year. The dependent variable is the annual return in year t (the year after the downgrade event). (Unreported) results using characteristic-adjusted returns and local market adjusted-returns are similar. *Bound* is a dummy variable that takes the value of one if a firm has a credit rating equal to or above the sovereign rating in year $t-1$. *Downgrade* is a dummy variable that takes the value of one if a firm's country rating is downgraded in year t. Our sample of treated firms contains 36 unique firms that experience shocks to their ability to finance over the period 2002–2012 as a result of exogenous downgrades due to sovereign downgrades.[17] The control firms consist of firms in countries with a sovereign downgrade that are not bound by the sovereign ceiling.

The results are presented in Table 3. The coefficient on the interaction term *Bound* × *Downgrade* is negative and significant, confirming that bound firms suffer negative cumulative annual returns after a sovereign downgrade. The coefficient on the triple interaction term *Centrality*× *Downgrade*× *Bound* is positive and significant, suggesting that central firms are insulated from this exogenous shock. The results are robust to the inclusion of control variables and fixed effects at the year, country, and business group level. The effect is also economically significant. For the last model, which controls for the year, country, and business group fixed effects, a one standard deviation increase in centrality absorbs about 90% of the negative price impact of sovereign downgrades (i.e., $\sigma \times \beta_{tripple} \ / \ \beta_{interaction} = 0.40 \times 1.279 \ / \ 0.544 = 94.0\%$). Consistent with our findings in Section 3.1 central firms are strategically protected in bad times.

4. Centrality and the cross-section of stock returns

If business groups strategically protect central firms in bad times, we expect centrality to affect the cross-section of asset prices. This section examines this prediction.

[17] The sovereign downgrades occurred in Argentina, Egypt, Greece, Japan, Mexico, and Portugal.

Table 4
The return predictability of centrality in Fama-MacBeth regressions.
This table presents the results of univariate and multivariate Fama and MacBeth regressions of monthly firm-level excess returns on firm-level characteristics. The dependent variable in Panel A is the raw return. The dependent variable in Panel B is the Daniel et al. (1997) (DGTW)-adjusted return, which is the raw return minus the return on the corresponding size, book-to-market, and momentum portfolio. ***, **, and * represent the significance level at 1%, 5%, and 10%, respectively, with *t*-statistics given in parentheses.

Panel A: Predicting out-of-sample stock returns

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Centrality	−0.47***	−0.51***	−0.32**	−0.38**	−0.51***	−0.37***
	(−2.86)	(−3.22)	(−2.02)	(−2.37)	(−3.34)	(−2.71)
Log market value of equity			−0.11***			−0.063*
			(−3.02)			(−1.68)
Log book-to-market				0.45***		0.38***
				(4.40)		(3.72)
Momentum					0.13	0.01
					(0.27)	(0.03)
Lag return		−2.03*				−2.80***
		(−1.93)				(−2.84)
R-squared	0.00	0.02	0.01	0.01	0.02	0.05
Number of observations	292,236	292,236	292,236	292,236	292,236	292,236

Panel B: Predicting out-of-sample DGTW-adjusted stock returns

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Centrality	−0.27**	−0.31***	−0.25*	−0.26**	−0.32***	−0.31**
	(−2.29)	(−2.67)	(−1.85)	(−2.12)	(−2.82)	(−2.49)
Log market value of equity			−0.02			−0.02
			(−0.90)			(−0.96)
Log book-to-market				0.06		0.05
				(1.16)		(0.80)
Momentum					−0.08	−0.12
					(−0.18)	(−0.28)
Lag return		−2.45**				−3.01***
		(−2.56)				(−3.26)
R-squared	0.00	0.01	0.00	0.00	0.01	0.03
Number of observations	292,236	292,236	292,236	292,236	292,236	292,236

4.1. A multivariate analysis

We start by performing a multivariate analysis at the stock level. Following Hou et al. (2011), we run a series of Fama-MacBeth estimates of the loading of stock returns on stock centrality, as well as a set of stock-specific characteristics such as size, book-to-market, momentum, lagged return. We regress the returns in month *t* on last-quarter centrality and standard control variables. We consider both raw returns and DGTW-adjusted returns.

The results are reported in Table 4. In Panel A, we use as a dependent variable the raw returns; in Panel B, the DGTW-adjusted returns. Column 1 considers only centrality, Columns 2–5 consider specifications in which the control variables are incrementally added, and Column 6 jointly considers all the control variables. The results suggest that centrality is always negatively related to returns across all the specifications. For the specification in Column 6 with all the control variables, a one standard deviation higher centrality is related to 14 (12) bps lower monthly return (DGTW-adjusted return). This effect is highly robust when we use alternative specifications or control for the influence of institutional investors (see Tables OA1 and OA2 in the Online Appendix for more details).

4.2. A portfolio analysis

The previous results provide preliminary evidence that centrality is related to out-of-sample stock returns in the cross-section. We now perform a portfolio analysis to further examine the extent to which the relation between centrality and returns is economically significant and unexplained by traditional international asset pricing factors.

In the main analysis, we sort stocks into high- and low-centrality portfolios. We consider three alternative portfolio constructions to capture overall, within, or across business group effects. First, we sort stocks into high- and low-centrality portfolios without conditioning on business group membership. This overall sort aims to create a general mimicking portfolio for centrality. In the first sorting, we rank stock, for each quarter, as a function of their degree of centrality across all stocks in the prior quarter. Then, we select the stocks with the 25% highest and 25% lowest degree of centrality (i.e., top and bottom quartile, respectively) and group them in high- and low-centrality portfolios.

Second, we sort stocks into high- and low-centrality portfolios using only the most central firm from each business group. We select the most central firm from all business groups with more than two publicly traded companies and then classify these firms into high- and low-centrality portfolios. This between sort aims to further explore the power of centrality by zooming in on the subgroup of most central firms. This subgroup test could help mitigate the concern that central firms could systematically differ from peripheral firms in characteristics (noticeably, size) instead of group control.[18]

Third, we sort stocks into high and low centrality within each group to control for the potential influence of business groups. Here, we take the most and least central firm from each business group and then classify them into high- and low-centrality portfolios. Because the empirical results of the third methodology are very similar to the first, we focus on the first two sorts in the main text and report the returns of the third sort in the Online Appendix (Table OA3).

In all cases, we define the portfolio returns as the equal-weighted average of the stock returns with the highest or lowest centrality. Next, we take the difference between the high-centrality and the low-centrality portfolios. Then, we regress the returns of such portfolios on factors from an international asset pricing model.

The results are reported in Panels A and B of Table 5 for, respectively, the first and second sorting. Across all the specifications and portfolio sorts, we observe a strong negative alpha. For the four-factor model, the high-centrality portfolios deliver 67 bps per month lower risk-adjusted returns than the low-centrality firms in the case of the unconditional sorting. The high minus low performance amounts to 36 bps per month in the case of the between-group sort. These results lend initial support to the notion that the central minus peripheral mimicking portfolio could capture a new source of intertemporal risk in the presence of strategic business groups.

Because understanding the role played by external funding liquidity in centrality-based effects is important, we next include in our analysis a list of proxies for funding liquidity risk related to changes in intermediary capital, VIX, and the default spread. Based on He et al., 2017, the risk of intermediary capital is proxied for by the intermediary capital risk factor (ICRF) and intermediary value-weighted investment return (IVVW). We also follow the literature (e.g., Lu and Qin, 2021; Hahn and Lee, 2006) to proxy for the risk of VIX and default spread by their innovations (i.e., ΔVIX and ΔDefault Spread). The results are tabulated in Panels C and D of Table 5. The centrality mimicking portfolio is in general unrelated to funding risk. The only variable that is marginally correlated with our (between-sort) centrality portfolio is ICRF. It does not, however, absorb the average return generated by the centrality portfolio.

Overall, these results are consistent with the previous multivariate analysis and show that centrality helps to span the cross section of stock returns over and above the explanatory power of the traditional factors. But, can we interpret centrality-linked return dispersion as an intertemporal risk factor in the global market?

5. Asset pricing tests of centrality as an additional risk factor

The results in Section 4 suggest that a centrality factor could be important for summarizing the cross-section of international stock returns. We perform a series of tests to compare factor models and determine if the centrality factor should be included for international stock returns. A common criticism of such tests is that they are sensitive to the choice of test assets. We therefore use the insight of test-asset irrelevance proposed in Barillas and Shanken (2017) and directly compare potential factors. We start with the test of Barillas et al. (2020) to demonstrate how the centrality factor could help increase the squared Sharpe ratios of portfolios of existing factors. Next, we use the Barillas and Shanken (2018) procedure to identify a parsimonious factor model that spans the maximum Sharpe ratio portfolio for the traded factors without retaining redundant factors and verify that it selects our centrality factor. We then compare the squared Sharpe ratios of optimal models with and without our centrality factor. Finally, we perform Bayesian asset pricing tests that compare the posterior probability of optimal models chosen from a series of potential base factors with and without including centrality.[19]

Table 6 contains pairwise tests of equality of the squared Sharpe ratios of nine asset pricing models. The squared Sharpe ratio changes and their corresponding *p*-values are, respectively, presented in Panel A and Panel B. This test was introduced in Barillas et al. (2020). The models use the CAPM (MKT), the Fama and French (1993) three-factor model (3F), and the Carhart model with the additional momentum factor (Carhart 4F). The model (3F + CMP) adds the general central minus peripheral mimicking portfolio (i.e., CMP) to the three-factor model, the model (3F + ICRF) adds the intermediary capital risk factor to the three-factor model, and the model (FF5 + ICRF) adds the Fama and French (2015) five-factor model (5F) to the intermediary capital risk factor. We include ICRF to capture the influence of funding risk because it exhibits the highest (albeit still marginal) relation with centrality in our previous test. Our later tests show that including other funding risk proxies does not change our main conclusions. The model (FF5 + CMP) adds the central minus peripheral portfolio to the 5F model.

[18] Size could be a concern when business groups allow central firms to directly control more assets than peripheral firms. Our previous multivariate analyses explicitly control for size. Untabulated results confirm that neither the relative size within a business group nor an interaction of centrality with relative size reduces the effect of centrality.

[19] We thank an anonymous referee for suggesting this test.

Table 5
Portfolio analysis.
This table presents the results of univariate and multivariate regressions of central minus peripheral portfolios returns on common explanatory factors. Panel A contains the results using the central minus peripheral portfolio construction across all firms (overall sort). Panel B contains portfolios constructed using variation between only the most central firms in each group (between sort). All central minus peripheral portfolios are constructed using a one-quarter lag of centrality for which returns are equal weighted. Columns 1–5 of Panels C and D contain results from Panels A and B with additional control variables for the intermediary capital risk factor, the intermediary value-weighted investment return, the change in Volatility Index (VIX), and the change in default spread, respectively. ***, **, and * represent the significance level at 1%, 5%, and 10%, respectively, with *t*-statistics given in parentheses.

Panel A: Performance of high- minus low-centrality portfolios (overall sort)

Factor	(1)	(2)	(3)	(4)
Intercept	−0.57***	−0.72***	−0.71***	−0.67***
	(−2.87)	(−4.88)	(−4.95)	(−4.67)
Market factor		31.57***	30.90***	28.28***
		(10.37)	(10.48)	(8.74)
Size factor			−29.96***	−27.26***
			(−3.50)	(−3.17)
Value factor			19.65**	18.91**
			(2.27)	(2.21)
Momentum factor				−7.36*
				(−1.87)
R-squared	0.00	0.45	0.51	0.53
Number of observations	132	132	132	132

Panel B: Performance of high- minus low-centrality portfolios (between sort)

Factor	(1)	(2)	(3)	(4)
Intercept	−0.36***	−0.37***	−0.39***	−0.36**
	(−2.62)	(−2.69)	(−2.72)	(−2.52)
Market factor		2.49	2.12	0.35
		(0.88)	(0.73)	(0.11)
Size factor			0.08	1.99
			(0.01)	(0.23)
Value factor			5.15	4.39
			(0.60)	(0.51)
Momentum factor				−5.11
				(−1.30)
R-squared	0.00	0.01	0.01	0.02
Number of observations	129	129	129	129

Panel C: Centrality portfolios from Panel A with alternative controls

Factor	(1)	(2)	(3)	(4)	(5)
Intercept	−0.70***	−0.67***	−0.67***	−0.66***	−0.69***
	(−4.76)	(−4.68)	(−4.61)	(−4.60)	(−4.58)
Intermediary capital risk factor	−3.71				−4.17
	(−0.94)				(−0.70)
Intermediary value-weighted investment return		−4.05			−0.32
		(−0.76)			(−0.04)
ΔVIX			−0.02		−0.01
			(−0.47)		(−0.26)
ΔDefault Spread				−0.37	−0.55
				(−0.54)	(−0.76)
Market factor	31.48***	32.64***	26.52***	27.58***	30.18***
	(6.72)	(4.94)	(5.35)	(7.88)	(3.67)
Size factor	−28.31***	−28.67***	−26.75***	−29.14***	−31.04***
	(−3.26)	(−3.25)	(−3.08)	(−3.13)	(−3.15)
Value factor	22.25**	23.26**	19.54**	19.20**	23.82**
	(2.40)	(2.25)	(2.24)	(2.23)	(2.26)
Momentum factor	−9.36**	−9.35*	−7.49*	−7.18*	−9.56**
	(−2.10)	(−1.97)	(−1.89)	(−1.81)	(−2.00)
R-squared	0.53	0.53	0.53	0.53	0.53
Number of observations	132	132	132	132	132

(*continued on next page*)

Table 5
(*continued*)

Panel D: Centrality portfolios from Panel B with alternative controls

Factor	(1)	(2)	(3)	(4)	(5)
Intercept	−0.42***	−0.37**	−0.35**	−0.38***	−0.41***
	(−2.90)	(−2.57)	(−2.41)	(−2.64)	(−2.78)
Intermediary capital risk factor	−7.63*				−6.60
	(−1.97)				(−1.13)
Intermediary value-weighted investment return		−7.08			1.18
		(−1.33)			(0.15)
ΔVIX			−0.05		−0.04
			(−1.12)		(−0.92)
ΔDefault Spread				1.01	0.79
				(1.47)	(1.10)
Market factor	6.94	7.94	−3.88	2.28	2.73
	(1.50)	(1.21)	(−0.78)	(0.66)	(0.34)
Size factor	−0.37	−0.62	3.27	7.01	5.35
	(−0.04)	(−0.07)	(0.38)	(0.77)	(0.55)
Value factor	11.19	12.18	6.13	3.54	9.77
	(1.22)	(1.17)	(0.70)	(0.41)	(0.93)
Momentum factor	−9.19**	−8.49*	−5.37	−5.61	−8.68*
	(−2.09)	(−1.82)	(−1.37)	(−1.43)	(−1.86)
R-squared	0.05	0.04	0.03	0.04	0.07
Number of observations	129	129	129	129	129

The squared Sharpe ratio changes and their corresponding *p*-values are presented, respectively, in Panels A and B of Table 6. Our main finding is that the centrality factor (CMP) increases the squared Sharpe ratio of models to which it is added. We have no result in which a model without the centrality factor has a statistically significantly higher squared Sharpe ratio than a model with centrality.

Although these tests do not depend on test assets, they still rest on a somewhat arbitrary decision about which factor models to compare. In light of this, we use the method of Barillas and Shanken (2018) to calculate the posterior probability of every single factor model that can be constructed given our set of factors.[20] Barillas and Shanken (2018) derive a closed-form solution for the posterior probability of a given factor model of the form

$$P(M_i|D) = \frac{ML(M_i|D) \times P(M_i)}{\sum_{j=1}^{J} ML\left(M_j|D\right) \times P\left(M_j\right)}, \quad (4)$$

where the subscript i represents the model for which one wants a posterior probability; $j \in J$, the set of models; $P(M)$, the prior probability of a given model; and $ML(MD)$, the marginal likelihood of each model.

In the last column of the two panels, we use the above methodology to identify the highest probability model (OptBS) from the following set of potential factors: the five Fama-French factors, ICRF, and our centrality factor (CMP). The highest probability model uses four out of the five Fama-French factors [market (MKT), high minus low (HML), robust minus weak (RMW), and conservative minus aggressive (CMA)], ICRF, and CMP. Hence, the Barillas and Shanken (2018) test confirms the importance of the centrality factor. Moreover, the optimal model has a statistically significantly higher Sharpe ratio than all models, except for the CMP-augmented FF5 factor model. These observations lend support to the notion that CMP provides a new and powerful factor that is unexplained by known factors.

In Panel C, we further generalize the results by conducting model comparisons based on various potential factors. We first generate a series of subsets of potential factors with and without the centrality factor and refer to them as, respectively, Model A and Model B in the first two columns of the panel. Next, we apply the Barillas and Shanken (2018) methodology to identify the optimal model within each subset. Here we consider the question: To what extent is the centrality factor selected when it is included as a potential factor in Model B?

We then compare the squared Sharpe ratios of the two portfolios. The difference in squared Sharpe ratios (optimal Model B minus optimal Model A) and its *p*-value are tabulated in the next two columns of the table. Finally, the last column reports the posterior probability for the optimal Model B to be selected (over optimal Model A) based on the Bayesian asset pricing tests of Barillas and Shanken (2018).

Our main findings are as follows. Although the Barillas and Shanken methodology typically selects only a subset of factors in their optimal model, the centrality factor is always chosen as part of the optimal model when included in the set of potential factors. Information about other selected factors is tabulated in the Online Appendix (Table OA4). Moreover, optimal Model B (with our centrality factor) always has significantly higher squared Sharpe ratios than optimal Model A (without centrality). For each factor model we consider, the posterior probability of the factor model augmented with the centrality factor is overwhelmingly in favor of including the centrality factor. This observation confirms and generalizes the main finding of the previous two panels that other factors are unable to span the centrality factor.

[20] We use an alternative prior on the nuisance parameters, as suggested by Chib et al. (2020).

Table 6
Model comparisons.
This table contains pairwise tests of equality of the squared Sharpe ratios of nine asset pricing models. The models are the capital asset pricing model (CAPM) (MKT), the Fama and French (1993) three-factor model (3F), the 3F model augmented with the momentum factor (Carhart 4F), the 3F model augmented with the central minus peripheral mimicking portfolio (3F + CMP), the 3F model augmented with the intermediary capital risk factor (3F + ICRF), the Fama and French (2015) five-factor model (5F), the 5F model augmented with the intermediary capital risk factor (FF5 + ICRF), and the 5F model augmented with the central minus peripheral portfolio (FF5 + CMP). We include the highest probability model from Fig. 3 [OptBS is the optimal model using the method of Barillas and Shanken (2018)], which combines the market factor, the HML (high minus low) and RMW (robust minus weak) factors from the 5F model, the intermediary capital risk factor, and the CMP. The sample period is January 2002–December 2012. Panel A reports the difference between the (bias-adjusted) sample squared Sharpe ratios of the models in column i and row j, and Panel B reports the associated *p*-value for the test of equality of the squared Sharpe ratios. Panel C reports a series of model comparison tests for which we recalculate the optimal model using a series of different potential factor subsets that exclude and include the centrality factor (CMP). Online Appendix Table OA4 details the optimal model for each subset of factors. IVVW = intermediary value-weighted investment return; VIX = Volatility Index; ΔVIX = change in the VIX, Δ(Default Spread) = change in the default spread.

Panel A: Difference in squared Sharpe ratios

Model	3F	Carhart 4F	3F + ICRF	5F	3F + CMP	FF5 + ICRF	FF5 + CMP	OptBS
MKT	0.06	0.11	0.13	0.20	0.27	0.26	0.40	0.39
3F		0.04	0.05	0.14	0.20	0.19	0.34	0.32
Carhart 4F			0.00	0.10	0.16	0.14	0.29	0.27
3F + ICRF				0.12	0.11	0.13	0.25	0.26
5F					0.06	0.02	0.19	0.15
3F + CMP						0.02	0.13	0.15
FF5 + ICRF							0.11	0.13
FF5 + CMP								0.02

Panel B: *p*-values for difference in squared Sharpe ratios

Model	3F	Carhart 4F	3F + ICRF	5F	3F + CMP	FF5 + ICRF	FF5 + CMP	OptBS
MKT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3F		0.01	0.01	0.00	0.00	0.00	0.00	0.00
Carhart 4F			0.95	0.13	0.07	0.10	0.00	0.00
3F + ICRF				0.16	0.21	0.00	0.02	0.00
5F					0.60	0.08	0.00	0.02
3F + CMP						0.85	0.00	0.07
FF5 + ICRF							0.15	0.04
FF5 + CMP								0.29

Panel C: Bayesian model comparisons

Model A	Model B	Squared Sharpe ratio difference Model B-Model A	*p*-value	Posterior probability, Model B versus Model A
Fama-French 3 factor	Model *A* + Centrality	0.18	0.00	100%
Carhart 4 factor	Model *A* + Centrality	0.41	0.00	100%
Fama-French 5 factor (FF5)	Model *A* + Centrality	0.14	0.04	99%
FF5 + Mom + ICRF	Model *A* + Centrality	0.17	0.00	100%
FF5 + Mom + IVVW	Model *A* + Centrality	0.14	0.04	99%
FF5 + Mom + ICRF + IVVW	Model *A* + Centrality	0.15	0.04	99%
FF5 + Mom + ΔVIX + Δ(Default Spread) + ICRF + IVVW	Model *A* + Centrality	0.15	0.04	99%

Fig. 3 plots the time series of posterior model probabilities for the top five models with the highest probability over the entire sample period (ranked at the end of the sample). This figure shows that the top five models include the centrality factor. Jointly, the results presented in this section are consistent with the finding that centrality represents a new risk factor in the international market.

6. Economic grounds and alternative explanations

We argue that strategic risk reallocation by business group ultimate owners creates an intertemporal risk factor for investors. In Section 5 we confirmed the pricing power of centrality. We will now endeavor to understand the strategic reallocation effect.

6.1. The economic grounds of co-movement

First, we explore the intertemporal nature of the return-predicting power of centrality in periods of high and low uncertainty. All else equal, we expect business groups to do more strategic risk and asset reallocation in uncertain periods that could hurt their group control and, hence, we should observe a more prominent (negative) centrality risk premium. The results are reported in Table 7.

Given that the information business groups use to estimate the level of uncertainty for group control is difficult for econometricians to observe, we consider several commonly used measures to proxy for this information. VIX and default spread conditions are relevant. When these two variables are high, the bankruptcy risk for central firms is likely to be high. Hence, we define peri-

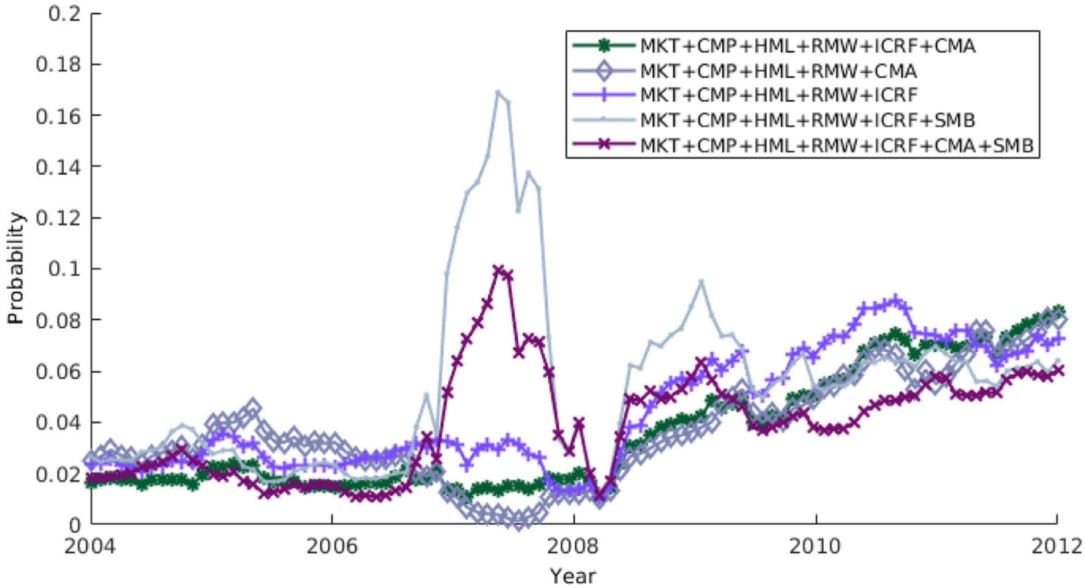

Fig. 3. Model probabilities. This figure presents the results of the time series of posterior model probabilities for the five models with highest probability (ranked at the end of the sample). The sample periods are recursive, beginning in January 2004 and ending each month up to December 2012. We require a minimum of three years of data. Models are based on a set of seven factors. The factors include the five factors of Fama and French (2012) (MKT = market, HML = high minus low book-to-market, SMB = small minus big size, CMA = conservative minus aggressive investment, RMW = robust minus weak profitability), the Carhart (1997) momentum factor (WML = winner minus loser), the He et al., 2017 intermediary capital risk factor (ICRF), and our centrality factor (CMP = central minus peripheral). The probabilities are calculated using the method of Barillas and Shanken (2018) with an alternative prior on the nuisance parameters, as suggested by Chib et al. (2020).

Table 7
Relation with different states of the economy.
This table presents results of multivariate Fama and MacBeth regressions of monthly firm-level excess returns on firm-level characteristics split by above and below median levels of uncertainty. Columns 1 and 2 contain results for the Volatility Index (VIX). Columns 3 and 4 contain results for the default spread. Columns 5 and 6 contain results for high and low intermediary capital ratio defined as the end-of-period ratio of total market capitalization to (total market cap + book assets - book equity) of Federal Reserve Bank of New York primary dealers' publicly traded holding companies. Columns 7 and 8 contain results for high and low intermediary investment return, which is the value-weighted investment return to a portfolio of NY Fed primary dealers' publicly traded holding companies. ***, **, and * represent the significance level at 1%, 5%, and 10%, respectively, with *t*-statistics given in parentheses.

	VIX		Default spread		Intermediary capital ratio		Intermediary investment return	
Variable	High (1)	Low (2)	High (3)	Low (4)	High (5)	Low (6)	High (7)	Low (8)
Centrality	−0.79***	0.06	−0.51***	−0.22	−0.20	−0.53***	0.02	−0.75***
	(−4.44)	(0.29)	(−2.71)	(−1.14)	(−1.04)	(−2.83)	(0.12)	(−3.82)
Log market value of equity	−0.11*	−0.02	−0.07	−0.05	−0.09	−0.04	0.09*	−0.22***
	(−1.94)	(−0.41)	(−1.33)	(−1.10)	(−1.64)	(−0.75)	(1.78)	(−4.29)
Log book-to-market	0.21	0.56***	0.25	0.52***	0.74***	0.03	0.67***	0.09
	(1.23)	(4.90)	(1.52)	(4.16)	(5.45)	(0.21)	(5.18)	(0.61)
Momentum	−0.89	0.91***	−0.92	0.94***	1.06**	−1.05	−1.34	1.36***
	(−0.97)	(3.13)	(−1.00)	(3.63)	(2.61)	(−1.21)	(−1.56)	(3.44)
Lag return	−4.30**	−1.30	−5.35***	−0.25	−2.09*	−3.51**	−5.18***	−0.41
	(−2.56)	(−1.27)	(−3.14)	(−0.27)	(−1.67)	(−2.29)	(−3.24)	(−0.38)
R-squared	0.06	0.04	0.06	0.04	0.05	0.05	0.05	0.04
Number of observations	147,359	144,877	145,674	146,562	128,270	163,966	143,013	149,223

ods of high (low) uncertainty if VIX and default spread are above (below) their median values. Models 1 and 2 show that the negative risk premium of centrality is more prominent in such high uncertainty periods. For instance, during periods of high VIX (default spread), a one standard deviation increase in centrality is related to 31 (21) bps lower returns, in contrast to the analogous effect of just 2 (−6) bps during low VIX (default spread) periods.

Furthermore, high external funding uncertainty can enhance the importance of internal resource reallocation in protecting group control. We follow He et al. (2017) in using two measures of intermediary capital to proxy for funding uncertainty: the end-of-period ratio of total market capitalization to total assets (measured as total market cap + book assets − book equity) of Federal Reserve Bank of New York primary dealers' publicly traded holding companies and the value-weighted investment return on a portfolio of NY Fed primary dealers' publicly traded holding companies. We find consistent empirical results when we split the sample at above and below median values of the intermediary capital measures. A one standard deviation increase in centrality is related to 17 (29) bps lower expected return in periods with low intermediary capital (low intermediary investment return), compared with the effect of −10 (2) bps when the opposite market funding conditions prevail.

Collectively, these results suggest that the negative risk premium of centrality reflects the strategic behavior of business groups, which lends support to the notion that centrality represents an intertemporal risk factor in the global market. These state variables of uncertainty do not absorb the asset pricing impact of centrality in the cross section. Hence, they provide coarse information about bad states to induce more intertemporal hedging but are not the main target of business groups in conducting strategic resource reallocation.

6.2. The influence of top and apex firms: group control versus expropriation

Thus far, we have focused on the asset pricing implications of the strategic incentives of business groups to protect their central firms. Two issues remain to pin down this economic interpretation. First, if the protection of group control is the main economic incentive for strategic reallocation, our results should be robust using alternative measures of group control. Second, a further consideration, given that the sophisticated organizational structure of business groups also could allow ultimate owners to tunnel assets from peripheral to core firms, is whether the effects could be related to, if not driven by, the expropriation incentives of affiliated firms and business groups.

To explore the potential difference between group control and expropriation, we can resort to the traditional definitions of "top" and "apex" firms in the literature (e.g., Bertrand et al., 2002; Almeida and Wolfenzon, 2006a). As discussed in Section 2 top or *E1* firms are those in which the ultimate owner has the highest stake. Although these firms may not be as closely related to the strategic incentives of business group owners as centrality, they provide a reasonable alternative measure to test group control–motivated strategic behavior. In contrast, *E2* firms are extractors used by group owners for expropriation, i.e., to receive tunneled assets and cash flows. The potential return impacts of these two variables can shed further light on the economic ground of our findings.

We revisit the cross-sectional return predictability test as reported in Table 4 by replacing centrality with *E1* and *E2*. Because both variables are dummies and may not be directly comparable with our (continuous) centrality measure, we also construct a centrality dummy to gauge our interpretation. The centrality dummy takes the value of one if a firm has the highest centrality in the business group. In other words, the centrality dummy identifies firms that business group owners have the highest incentives to protect in bad states. Consistent with the notion that central firms can differ from *E1* and *E2*, out of 17,120 business group-year observations around the world between 2002 and 2012, the most central firm in the group differs from *E1* in 3938 cases and from *E2* in 9073 cases.

The results of the Fama-MacBeth return predictability tests are presented in Table 8. When used alone (i.e., Models 1 and 3), both *E1* and the centrality dummy variable predict returns. The magnitude of the effects for the centrality dummy is larger, consistent with our earlier discussion of the differential incentives to protect *E1* firms relative to most central firms. Controlling for standard characteristics (i.e., Models 4 and 6) yields similar results. Therefore, our results are robust using an alternative measure that can capture the incentive of business group ultimate owners to strategically protect group control.[21]

In contrast, Apex (*E2*) firms do not have a significant influence on asset returns. Economically speaking, although apex firms allow business groups to expropriate, different business groups may have completely different patterns and timings for assets tunneling. In this case, expropriation and other cash flow–related considerations may can create a discount on asset prices but not the intertemporal risk factor as examined before. This difference helps explain the insignificant influence of apex firms. Econometrically speaking, the test on apex firms could be treated as a placebo test, confirming that the empirical approach adopted in our analysis is powerful enough to reject the nonexistent pricing power of affiliated firms.

6.3. Idiosyncratic risk

We have argued that the desire of business group owners to retain control over the entire group motivates them to redistribute risk from central firms to peripheral firms. Though our previous tests focus on this effect with systematic uncertainty such as negative industry shock and sovereign downgrades, the same logic applies to idiosyncratic risk. Instead of pooling assets to diversify idiosyncratic risk for all affiliated firms, business groups could strategically reduce more of the idiosyncratic risk for central firms. Hence, we conduct a test of how centrality affects idiosyncratic volatility to complete our analysis.

Results are presented in Table 9. Across all specifications, centrality is related to lower idiosyncratic volatility.[22] The coefficient estimate of centrality is −0.03, which implies that increasing centrality by 0.3 (one standard deviation), and idiosyncratic volatility drops by 0.01 on average (Column 3) or by roughly 0.1 standard deviations. Although the interpretation of idiosyncratic volatility is sub-

[21] Additional analysis on the relation between the mimicking portfolios of *E1* and centrality further confirms the similarity between the two measures. Table OA5 in the Online Appendix shows that the return spreads of the two portfolios are highly correlated. Moreover, consistent with the notion that centrality can better capture the strategic behavior of business group owners, we find that the centrality portfolio can largely explain the return spread of the *E1* portfolio, but the *E1* portfolio does not absorb the centrality spread.

[22] This table includes all stocks. Our results are robust using the main sample of non-US stocks.

Table 8
Alternative measures.
This table presents results of multivariate Fama and MacBeth regressions of monthly firm-level excess returns on firm-level characteristics and alternative measures for centrality. *E1* is a dummy variable for highest stake of ultimate owner that equals one for such a firm and zero otherwise. *E2* is a dummy variable for highest cash flow rights that equals one if a firm is responsible for the highest amount of cash flows or value of the group and zero otherwise. *Centrality Dummy* is a dummy that is equal to one if a firm has the highest centrality in the group. The dependent variable is the raw return. ***, **, and * represent the significance level at 1%, 5% and 10%, respectively, with *t*-statistics given in parentheses.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
E1	−0.40***			−0.29**		
	(−2.99)			(−2.56)		
E2		−0.06			−0.06	
		(−1.09)			(−1.12)	
Centrality Dummy			−0.69***			−0.59***
			(−6.07)			(−6.14)
Controls	No	No	No	Yes	Yes	Yes
R-squared	0.01	0.01	0.00	0.05	0.05	0.05
Number of observations	292,236	292,236	292,236	292,236	292,236	292,236

Table 9
Idiosyncratic volatility and centrality.
This table reports the results of regressing yearly estimated *Idiosyncratic volatility* on lagged centrality and control variables. In Columns 1–4, we control for serial correlation and heteroskedasticity using the Huber-White sandwich estimator (clustered by group-level identifier) for the standard errors on the coefficient estimates. In Column 5, we report the results using the Fama-MacBeth methodology with heteroskedasticity and autocorrelation consistent Newey and West (1987) standard error estimates with four periods lags. ***, **, and * represent the significance level at 1%, 5%, and 10%, respectively, with *t*-statistics given in parentheses.

	(1)	(2)	(3)	(4)	(5)
Variable					
Centrality	−0.06***	−0.11***	−0.03***	−0.03***	−0.04***
	(−16.92)	(−28.64)	(−6.12)	(−4.87)	(−6.33)
E2			0.00	0.00	−0.00
			(0.65)	(0.44)	(−0.76)
Ownership stake of the ultimate owner			−0.01	−0.01*	0.00
			(−1.24)	(−1.87)	(0.53)
Log assets			−0.03***	−0.01***	−0.03***
			(−23.30)	(−3.48)	(−24.51)
Leverage			0.06***	0.06***	0.05***
			(7.43)	(5.63)	(7.51)
Mean monthly return last year			0.05***	0.07***	0.07***
			(2.86)	(4.81)	(3.08)
Log age			−0.01***	−0.01***	−0.01***
			(−7.72)	(−4.12)	(−4.01)
Market-to-book			−0.01***	−0.00***	−0.00***
			(−7.93)	(−6.04)	(−3.53)
Listed on NYSE			−0.00	0.00	−0.01
			(−0.29)	(0.00)	(−1.06)
Log group total book value			−0.01	−0.01***	−0.00
			(−1.59)	(−2.72)	(−0.30)
Log number of group firms			0.00	0.00*	−0.01
			(0.12)	(1.78)	(−1.05)
Time fixed effects	Yes	Yes	Yes	Yes	No
Industry fixed effects	No	No	Yes	No	Yes
Country fixed effects	No	No	Yes	No	Yes
Group fixed effects	No	Yes	Yes	No	Yes
Firm fixed effects	No	No	No	Yes	No
R-squared	0.08	0.41	0.55	0.16	0.77
Number of observations	51,837	51,837	30,437	30,437	30,437

ject to debate, this result complements our main analysis in suggesting that business groups strategically protect central firms against major risk.

7. Conclusion

Our paper has explored the idea that the strategic behavior of business group ultimate owners in global markets could create a new intertemporal risk factor in the cross section of asset prices. We show that the position of a firm within a business group is important. Central firms play a crucial role in allowing the ultimate owner to control a large share of the entire group. When their control is under threat, business group owners can strategically reallocate group assets to protect central firms in retaining control, thus changing the risk profile of these firms. The ensuing investor hedging demand induces co-movement among central firms and creates a new intertemporal risk factor.

Using a novel data set of worldwide ownership for 2002–2012, we show that central firms are better protected in bad times. We also find lower expected returns for these firms. Overall, centrality helps to explain the cross section of stock returns in the international market, thereby augmenting the explanatory power of traditional models.

Our results suggest that international asset pricing fundamentally differs from that in the US in the presence of strategic business groups. The more complex organizational structure of business groups in the global market allows them to strategically redistribute risk across affiliated firms, which gives rise to a new intertemporal risk factor. They serve to underline the need to pay more attention to the potential influence of strategic behavior by firm owners on asset pricing in the global market.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jfineco.2021.09.002.

Appendix A. Identifying control relations

Our proxy relies on the weighted voting games theoretical framework and the Shapley and Shubik (1954) and Banzhaf power indices measures to determine control rights, as well as on the idea that the level of holdings required to achieve direct control is firm-specific and structure-dependent and cannot be based on a simple 10–20% cutoff rule. The method was first suggested by Aminadav et al. (2011). By simultaneously analyzing both the firm-specific ownership map and the corporate network in which the firm is embedded, this method provides a refined alternative to traditionally used tests, i.e., with more precise and distinctive identification of corporate controllers in complex ownership structures. One of these tests is a widely used weakest-link principle (WLP) (Berle and Means, 1932; La Porta et al., 1999; Claessens et al., 2002; Faccio and Lang, 2002).

The Shapley-Shubik power index is interpreted as a prior estimate of a voter's expected relative share in a fixed prize available to the winning coalition as a measure of voting power. Intuitively, for the calculation of this index, we assume that, whenever a vote takes place, shareholders join a coalition in a particular order according to their preferences from the strongest supporter to the fiercest objector. A pivotal shareholder for a given ordering is the member whose joining turns a developing coalition from a losing coalition into a winning coalition.

Denote $[q; w_1, \dots, w_n]$, where q and $w_1, \dots, w_n$ are non-negative real numbers satisfying

$0 < q \le \sum_{i \in N} w_i$. w_i can be thought of as the fraction of voting rights, or weight, of shareholder i in the set $N\{1, \dots, n\}$ of the direct shareholders in a specific firm and q as the threshold, or quota, needed for a coalition to win the game by passing the decision they support in that firm. Thus, $[q; w_1, \dots, w_n]$ represents the simple game v defined by

$$v(S) = \begin{cases} 1(win), \wedge w(S) \ge q \\ 0(lose), w(S) < q \end{cases}, \tag{5}$$

where, for $S \subseteq N$, $w(S)$ means $\sum_{i \in S} w_i$. For a game v, the Shapley-Shubik power index of shareholder i is given by

$$SS_i(v) = \frac{Number\ of\ orderings\ in\ which\ player\ i\ is\ pivotal}{n!}. \tag{6}$$

We use the ownership data from the Bureau van Dijk databases and proceed as follows. We first set the required parameters for the control identification process: the majority quota needed to pass a vote to 50% (a number between 0% and 100%) and the Shapley-Shubik power index control threshold to 75% (a number between 50% and 100%). According to the control identification method we use, a shareholder (or a specific concert of shareholders) in a firm is said to directly control that firm if, given the majority quota of 50%, the Shapley–Shubik power index of this shareholder is at least as large as the control threshold of 75%. The power index is calculated for the shareholders of the firm as a player-set in a weighted majority game with weights equal to their fraction of voting rights in the firm. If, for a given firm, no shareholder has direct holdings that fulfill the conditions above, then we say that this firm is not directly controlled, i.e., the firm is widely held.

After determining the direct controllers, for each controlled firm we identify the ultimate owner by searching up along the direct control links that lead to that controlled firm. The ultimate owner is defined as a single non-controlled shareholder that directly or indirectly, via other shareholders, controls the firm.

Once the ultimate owners of all the controlled firms were identified for the first time (first iteration of the method), we extract cases in which several shareholders of each firm are directly or indirectly controlled by the same identified ultimate owner. We refer to each such subset of shareholders in each firm as a "concert of shareholders." The set of shareholders of a certain firm can contain several concerts of shareholders. Given the uniqueness of control relations and of the ultimate owner, these concerts must be disjoint sets.

In the next stage, we consider concerts of shareholders as one voter, i.e., a bloc whose weight is equal to the sum of the weights of its members. Thus, for each such bloc (concert), we calculate the power index of the entire bloc, not the individual index of each member. We perform the Shapley-Shubik power index control test again, finding direct controllers, ultimate owners, concerts of shareholders, and so on. After repeating the same procedure for a finite number of iterations, the outcomes remain fixed for all subsequent iterations, and the method converges to a final solution. This solution is the set of all control relations, in which each controlled firm is linked to its direct controlling concert (or one controlling shareholder) and to its ultimate owner. Furthermore, for each controlled firm, we obtain the ultimate owner's direct and indirect ownership stake, the number of control links between the firm and the ultimate owner (the level in a pyramid), and the minimal stake required for control given the ownership stakes of all the other noncontrolling shareholders (concerts) and the predetermined majority quota of 50% and control threshold of 75% (by solving the inverse Shapley-Shubik power index problem).

Appendix B. Example of a hypothetical business group

Fig. 1 illustrates a business group and how we calculate the centrality measure for each affiliated firm. The top box is the ultimate owner (e.g., a family), and the arrows represent control relations, such that an arrow points from the direct controlling shareholders to the controlled firm. The other boxes represent individual group firms. The percentages over the arrows show the voting rights that each controlling entity (ultimate owner or a firm) holds in other firms. The ultimate owner owns a direct stake of 75% in Firm A and 25% in Firm B. In addition, Firm A owns 20% in Firm C, Firm B also owns 20% in Firm C, and Firm C owns 50% in Firm D. We assume that, in each firm, the ownership distribution of the other (not controlling and not illustrated) minority shareholders is so dispersed that 20% stake is enough to control a corporation. While this simple structure is not representative of real-world business group structures, it can still help explain the concept of centrality. To further simplify, we assume that the value of each firm is $100 million and that voting rights are equal to cash flow rights.

The cash flow rights of the ultimate owner are 75% for Firm A, also 25% for Firm B, 25% [(20%)(75%) + (20%)(50%)] for Firm C, and 12.5% (50% x [(20%)(75%) + (20%)(50%)]) for Firm D (see Almeida et al., 2011). Firm A is the firm with the highest cash flow rights of the ultimate owner. The literature traditionally refers to it as the apex firm or the top firm in the group (e.g., Bertrand et al., 2002).

Regarding the importance of controlling other group firms (centrality), suppose the ultimate owner loses control over Firm A because another coalition of owners increases its cumulative votes in the board or another owner buys 20% in Firm A. The amount of cash flows the ultimate owner is entitled to receive from Firm A based on its ownership stake remains 75%. However, the ultimate owner loses the private benefits of controlling Firm A. In terms of total value, the ultimate owner loses control over $100 million or over 25% [100/(100 + 100 + 100 + 100) = 100/400] of the value of the group. The ultimate owner does not lose control over Firm C as a result of losing control over Firm A, because Firm B also holds 20% in Firm C, which allows the ultimate owner to retain control over Firm C indirectly through Firm B, even when losing control over Firm A. Thus, Firm A is not critical in bringing control over Firm C. The same argument can be applied to the case in which the ultimate owner loses control over Firm B. The loss would similarly trigger losing control over 25% of the value of the group. Now, suppose the ultimate owner loses control over Firm C. In terms of total value, the ultimate owner loses control over $200 million or over 50% [(100 + 100)/(100 + 100 + 100 + 100) = 200/400] of the value of the group. This is because losing control over Firm C triggers the loss of control also over Firm D, as Firm C is critical to retain direct control over Firm D. As the loss of Firm C would trigger the highest loss of control over value compared with all other group firms, we call Firm C the central firm in the group.

Appendix C. Variable definitions

Ownership and affiliation variables

Centrality—Fraction that the ultimate owner loses out of the group's value as a result of losing control over that particular firm. If by losing control over firm F the ultimate owner of group G loses control over the set of firms $G_{-\mathrm{F}}$ (which includes F), then $Centrality_F = \frac{1}{Value_{UO}} \sum_{i \in G_{-F}} Value_i$, where $Value_i$ is the market value of equity of firm i and $Value_{UO} = \sum_{i \in GroupG} Value_i$ is the sum over the market value of equity of all the firms in group G.

Central— Dummy variable that equals one if an affiliated firm has centrality above the median centrality.

E1 — Dummy that equals one for a firm in which the ultimate owner has the highest ownership stake and zero otherwise.

E2 — Dummy that equals one if the firm is entitled to the highest amount of cash flows or value of the group based on its direct or indirect stake in other group firms and zero otherwise. For a specific group G, for each firm A, we compute $\sum_{F affiliated} G \alpha_{A \to F} Value_F$, where $\alpha_{A \to F}$ is the direct or indirect ownership stake of firm A in any other firm F affiliated with the same group G and $\alpha_{A \to F} = 0$ if there is no direct or indirect ownership link between firm A and firm F. The group firm with the maximum $\sum_{F affiliated} G \alpha_{A \to F} Value_F$ value has dummy $E2 = 1$.

Sensitivity to industry shock

Industry shock— Residual term from the regression

$$ROA_{i,t} = \alpha + \beta_1 ROA_{i,t-1} + \beta_2 ROA_{i,t-2} + \beta_3 ROA_{i,t-3} + \epsilon_{i,t},$$

where ROA is actual size-weighted mean return on assets of industry i in year t, one year ago$(t-1)$, two years ago $(t-2)$, and three years ago $(t-3)$. In our estimation, we use the one-year lag of this residual.

Firm characteristics

Age in years since incorporation—Current year minus year of incorporation.

Idiosyncratic volatility—Sum of squared errors (scaled by total return volatility) from the regression model:

$$R_{i,t} = \alpha + \beta_1 R_{LocalM,t} + \beta_2 R_{GlobalM,t} + \beta_3 R_{I,t} + \beta_4 R_{G,t} + \epsilon_{i,t},$$

where $R_{i,t}$ is the return of firm i on day t, $R_{LocalM,t}$ is the return on the local market portfolio for day t, $R_{GlobalM,t}$ is the return on the global market portfolio for day t, $R_{I,t}$is the firm's industry return for day t, and $R_{G,t}$ is a group market value–weighted stock return that excludes that firm.

Lag return — one month lagged stock return.

Leverage—Total debt (WS item 03,255) divided by total assets (WS item 02,999).

Listed on NYSE—Dummy equal to one if the firm is listed on the NYSE.

Log assets—Natural log of total assets [WorldScope (WS) item 02,999].

Log book-to-market —(Natural log of) the lagged book value of equity (WS item 03,501) divided by the market value of equity (WS item 08,001).

Log group total book value—(Natural log of) the sum of the book value of equity of all the firms in the same group (excluding the firm itself).

Log market value of equity —(Natural log of) the lagged market value of equity of the firm (WS item 08,001).

Log number of group firms—(Natural log of) the number of firms in the same group (excluding the firm itself).

Market-to-book—Market value of equity (WS item 08,001) divided by book value of equity (WS item 03,501).

Momentum —Past twelve-month stock returns, leaving out the most recent month.

Return on assets (ROA) —Net income before extraordinary items (WS item 01,551) plus interest expenses (WS item 01,151) divided by total assets (WS item 02,999).

Appendix D. Two real-world examples of business groups and central firms

Two examples of groups in which top and apex firms differ from the central firms are reported in Fig. 2. Panel A depicts the Italian group De Benedetti controlled by the Italian tycoon Carlo De Benedetti and his family. The *E1*/*E2* firm (*E1* coincided with *E2*) is Cofide—Gruppo De Benedetti SpA with ultimate owner direct and indirect cash flow rights of 38% and centrality measure of 20% (that is, losing control over Cofide would cause the ultimate owner Carlo De Benedetti and his family to lose control over firms that comprise 20% of the total value of the group controlled by De Benedetti).[23] The central firm is CIR SpA with cash flow rights of 35% and centrality measure of 56% (that is, losing control over CIR SpA would cause the ultimate owner Carlo De Benedetti and his family to lose control over firms that comprise 56% of the total value of the group controlled by De Benedetti). Even though the firm Cofide is part of the controlling concert of shareholders that controls CIR SpA, it is not a critical shareholder for control.

The reason is that CIR SpA is jointly controlled by two shareholders: the firm Cofide and the firm Carlo De Benedetti & Figli S.a.p.a. Siglabile Cdb & F. Both controlling shareholders are ultimately controlled by the De Benedetti family. Even if the family losses control over Cofide, it would not lose control over CIR SpA because it still holds a stake of 24% via Carlo De Benedetti & Figli S.a.p.a. Siglabile Cdb & F, which allows it to maintain control over CIR SpA (given the distribution of the other shareholders in CIR SpA who are not related to the group. These other shareholders are not presented in the figure, but their distribution of voting rights is such that they cannot create an effective opposition in terms of voting power to Carlo De Benedetti & Figli S.a.p.a. Siglabile Cdb & F. The determination of control is detailed in Section 2.1 and in more technical detail in Appendix A.). Consequently, Carlo De Benedetti and his family would not lose control over the part of the group that is below CIR SpA. This is not the case if Carlo De Benedetti and his family lose control over CIR SpA, in which case they would lose control over everything below that firm. This explains why CIR SpA has a higher centrality measure than Cofide—Gruppo De Benedetti SpA, even though Cofide—Gruppo De Benedetti SpA has higher cash flow rights and is even one of the controlling shareholders of CIR SpA.

The other shareholders are not presented in the figure, but their distribution of voting rights is such that they cannot create an effective opposition in terms of voting power to Carlo De Benedetti & Figli S.a.p.a. Siglabile Cdb & F. Consequently, Carlo De Benedetti would not lose control over the part of the group that is below CIR SpA. If Carlo De Benedetti loses control over CIR SpA, it would lose control over everything below that firm. This explains why CIR SpA has a higher centrality measure than Cofide—Gruppo De Benedetti SpA, even though Cofide—Gruppo De Benedetti SpA has higher cash flow rights and is even one of the controlling shareholders of CIR SpA.

Another example is given in Fig. 2, Panel B. For the Møgster family group from Norway, the extractor firm (again *E1* and *E2* coincide) is Austevoll Seafood ASA with ultimate owner direct and indirect cash flow rights (voting rights) of 56% and centrality measure of 10%. The central firm is DOF ASA with cash flow rights (voting rights) of 48% and centrality measure of 39%.

Central firms often differ from *E1* and *E2* firms within the same group. Out of 17,120 business group-years around the world between 2001 and 2013, the most central firm differs from the *E1* firm in 3938 cases and from the *E2* firm in 9073 cases.

These considerations clearly show that the traditional idea of subsidization within a business group has to be reconsidered. The traditional view suggests that the ultimate owner subsidizes the firm in which it has the highest amount of cash flow rights (*E1*) or protects the one from which it derives the highest amount of cash flows (*E2*). In the examples above, they would be, respectively, Cofide—Gruppo De Benedetti SpA for Carlo De Benedetti

[23] *E1* is the firm in which the ultimate owner has the highest ownership stake. Extractor firm *E2* is the firm that is entitled to the highest amount of cash flows of the group due to its direct and indirect stakes in other group firms. The most central firm is the firm that exclusively controls (i.e., the firm is critical for control) the highest value in the group.

and Austevoll Seafood ASA for the Møgster family. The firms that guarantee the two families the control of most of their groups are CIR SpA—Compagnie Industriali Riunite for the Carlo De Benedetti family and DOF ASA for the Møgster family. The separate identification of the central firms helps to distinguish the value of control from the value of cash flows that a firm is entitled to.

This issue has been rarely addressed, as the sheer complexity of identifying the controlling entities in the corporate ownership network, wading through the complicated maze of links among private and public companies, and constructing the complete structure of the business groups has made this task very difficult.

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