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Massimo MASSA

Hong ZHANG

Hong ZHANG
Singapore Management University, hongzhang@smu.edu.sg

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Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

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Abstract

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.” The ensuing hedging demand induces co-movement among central firms, creating a new intertemporal risk factor. Based on a novel dataset 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.

JEL Classification: G20

Keywords: International Asset Pricing, Business Groups, Centrality, Co-movement

Massimo Massa - massimo.massa@insead.edu
INSEAD and CEPR

James O'Donovan - james.odonovan@cityu.edu.hk
City University of Hong Kong

Hong Zhang - zhangh@pbcsf.tsinghua.edu.cn
Tsinghua University Bejing

International Asset Pricing with Strategic Business Groups

Massimo Massa[1] James O'Donovan[2] Hong Zhang[3]

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Abstract

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." The ensuing hedging demand induces co-movement among central firms, creating a new intertemporal risk factor. Based on a novel dataset 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.

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[1] INSEAD, 1 Ayer Rajah Avenue, Singapore, massimo.massa@insead.edu.
[2] City University of Hong Kong, 83 Tat Chee Ave, Kowloon Tong, Hong Kong, james.odonovan@cityu.edu.hk.
[3] PBC School of Finance, Tsinghua University, 43 Chengfu Road, Haidian District, Beijing, PR China 100083, zhangh@pbcsf.tsinghua.edu.cn.

Introduction

Traditional asset pricing models start from the assumption 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, where multiple listed firms often belong to the same business group (e.g., Claessens, Djankov, and Lang, 2000; Faccio and Lang, 2002; Morck, 2005). The fraction of firms classified as group-affiliated ranges from about a fifth in Chile to two thirds in Indonesia (Khanna and Yishay, 2007), whereas in the US the formation of business groups has been discouraged by regulators since the 1930s (see Kandel, Kosenko, Morck, and Yafeh, 2015). Since 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 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 where business groups strategically respond to systematic risk. A business group will *not* treat all affiliated firms' systematic risk equally because the failure of some can be much

[1]In practice, this type of benefit can be easily achieved through internal capital markets and centralized treasury management, which may help explain the arise of business groups in the first place (see, among others, Stein, 1997, Johnson, La Porta, Shleifer, and Lopez-de-Silanes, 2000, Bertrand, Mehta, and Mullainathan, 2002, Bae, Kang, and Kim, 2002, Johnson et al. 2000, Jiang, Lee, and Yue, 2010). The value of the affiliated firms, in this case, will be affected by the value of assets reserved and reallocated by the group (in line with Merton, 1974, when firms use leverage).

[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.

more costly to the ultimate owner of the group than others. Indeed, since 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,b), 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 central firms' systematic risk—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 ones.

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. First, 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. Since retaining control is arguably the most important consideration of business groups, 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 can create a new intertemporal risk factor (i.e., Merton 1973) for affiliated assets. Indeed, group control could be in greater danger when the bankruptcy risk for central firms is high or when they become too cheap to deter corporate raiders—both of which can occur in the state of the economy when market uncertainty is high. Hence, we can interpret the strategic risk redistribution as an asset-based dynamic hedging demand. In line with Merton (1973), this dynamic hedging demand may create a new intertemporal risk factor in addition to the original (i.e., independent firm-based) asset-pricing factors. It can also induce central (peripheral) firms to co-move with other central (peripheral) firms. These intertemporal effects due to strategic business groups highlight a fundamental difference between international and traditional US-based asset pricing models.

We examine these predictions using a novel dataset of the worldwide ownership structure of firms for the 2001-2013 period, which is the most comprehensive in the literature for *both* public and private firms

(Aminadav and Papaioannou, 2020).[3] Since our goal is to understand the extent to which the strategic allocation of business group complements traditional US-based asset-pricing models, our analysis focuses on the non-US sample, which contains 9,179 unique affiliated firms from 77 countries. For each business group, we identify its ownership structure and construct a new measure—"centrality"—to describe the importance of each firm for retaining ownership of all group-controlled assets. It is worth emphasizing that these assets include not only public firms but *private* firms affiliated with the business group.

The first step in our analysis aims to provide evidence that central firms are indeed protected in bad times. To achieve this goal, we examine whether central firms are less affected by unexpected negative shocks to the industry than peripheral firms. Although unexpected negative shocks undermine firm value in general, using the framework of Bertrand, Mehta, and Mullainathan (2002), we find 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 on the firm's market-to-book value. Following the more recent work of Faccio, Morck, and Yavuz (2020), we also find consistent results that centrality buffers the adverse impact of commodity shocks.

A potential concern with the above evidence is that some omitted variables may simultaneously drive firm values and observed shocks in our analysis. Hence we exploit the exogenous shock introduced 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 now 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 (DGTW-adjusted returns) in the cross-section. After controlling

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

for firm-specific characteristics such as size, book-to-market, and momentum, we find a strong negative relationship between centrality and future stock returns. Indeed, in 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 portfolio analysis, constructing three 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 next two capture the asset-pricing influence of centrality within-group as well as across-groups, conditional on the firm being of the highest centrality to the respective business group. For all three specifications, we see that 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 three specifications is, respectively, 67 bps, 36 bps, and 78 bps (per month). These are highly economically and statistically significant. The presence of a within-group spread further confirms that, rather than conducting a risk-sharing, business groups strategically protect their central firms, an effect that traditional asset-pricing factors fail to capture.

Next, we explore the extent to which group strategic allocation can create a new intertemporal risk factor that will affect international asset pricing. For this purpose, we construct a centrality factor and conduct a list of tests to identify the incremental explanatory power it provides—in addition to that provided by traditional factor models such as the international CAPM model and the international Fama-French model (Fama and French 2012).

We perform the Bayesian asset-pricing test introduced in Barillas and Shanken (2018) as well as the Sharpe Ratio test introduced in Barillas, Kan, Robotti, and Shanken (2019), 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 using the Sharpe ratio comparison tests. Across these different types of asset-pricing tests, it is therefore clear that group strategic allocation creates a new intertemporal risk factor that influences stock returns in the international market.

For our final step, we conduct additional tests to understand the asset pricing grounds of central firms. Since the dynamic hedging demand for central firms is more likely to arise in bad times, we investigate whether the return spread between central and peripheral firms also gets enlarged at times of high market uncertainty. We consider a set of variables such as VIX, default spread, and the intermediary capital ratio and returns (He, Manela, and Kelly 2017) to proxy for the occurrence of market uncertainty that may trigger a strategic group risk reallocation. We find that central firms are indeed associated with lower expected returns than peripheral firms at times of greater uncertainty.[4]

Thus far, we have ignored the agency problems of business groups. Yet a widely observed agency issue—i.e., business groups often tunnel assets from peripheral to core firms—raises important questions about our analysis.[5] Do central firms also exploit other firms by asset tunneling? If so, our results on central firms may reflect time-varying agency costs instead of a dynamic hedging demand. To distinguish between the two effects, we follow the literature (e.g., Bertrand, Mehta, and Mullanaithan, 2002) to identify extractors, firms that are most likely to receive tunneled assets for exploitation purposes. We find that central firms for control purposes are distinct from extractors and that strategic protection largely applies to the former (but not the latter). Hence, although agency costs are an important feature of business groups, they 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. We are first related to studies exploring the economic grounds of international asset pricing.[6] Our novelty is to propose that international asset pricing

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[4] It is important to point out that these known variables do not absorb the asset-pricing impact of centrality in the cross-section. This observation is reasonable given that business groups utilize private information as well as public signals of uncertainty to make hedging decisions.

[5] 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 peripheral firms to them. Note that risk reallocation does not impose direct wealth transfer—if the systematic risk is property priced in the market, peripheral firms receiving risk will be compensated with a higher risk premium. Hence investors of the peripheral firms do not experience wealth loss.

[6] 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, Harvey, and Lumsdaine,

may 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 dynamic hedging demand 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).[7]

Moreover, we build on and extend the literature on business groups and pyramids (Johnson, La Porta, Shleifer, and Lopez-de-Silanes, 2000; Bertrand, Mehta, and Mullainathan, 2002; Bae, Kang, and Kim, 2002; Baek, Kang, and Lee, 2006; Johnson et al. 2000; Jiang, Lee, and Yue, 2010). 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 also 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 price, however, differs. Bartram, Griffin, and Ng (2012) 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 document that group ownership can affect asset prices by altering risk distribution among affiliated firms.

The remainder of the paper is organized as follows. Section II presents the data that we employ and the main variables constructed for the analysis. Section III examines whether central firms are strategically protected by business groups. The asset pricing implications of such strategic behavior are discussed in section IV. Section V provides additional tests and robustness checks, and a brief conclusion follows.

2002, Bekaert, Harvey, and Lundblad, 2007, Bekaert, Harvey, Lundblad, and Siegel, 2010, Bekaert, Hodrick, and Zhang, 2009, Carrieri, Errunza, and Hogan, 2007, Chan, Hameed, and Tong, 2000, Chan, Karolyi, and Stulz, 1992, Doidge, Karolyi, and Stulz, 2007, Ferson, and Harvey, 1993, Ferson and Harvey, 1994, Griffin, 2002, Griffin, Ji, and Martin, 2003, Griffin and Stulz, 2001, Hou, Karolyi and Kho, 2011, Kang and Stulz, 1997, Karolyi, and Stulz, 2003).

[7] Note that this effect does not apply to independent firms because these 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 hedge. 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 Kim's model.

2. Data and Main Variables

We first describe the data sources and the main variables, 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, which contains data on worldwide private and publicly listed firms over the period of 2001-2013. The centrality data is available for some firms in 2001 but we only have comprehensive centrality data from 2002-2012. 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 as follows: 4,612 insurance companies; 9,223 banks; 180,648 industrial firms (all companies that are neither banks nor financial companies nor insurance companies); 58,566 mutual or pension funds, nominees, trusts or trustees; 40,117 financial companies; 212,337 single private individuals or families; 3,275 foundations or research institutes; 2,465 employees, managers or directors; 1,058 private equity firms; 4,181 public authorities, states and governments; 884 venture capital firms; 30 hedge funds; and 17,692 where type is unidentified.

We use this ownership data to identify the controlled firms (as opposed to non-controlled or widely held firms) and their ultimate owners. From these we identify the public and private firms that are affiliated to 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 included 8,760 unique publicly listed group affiliated firms from 77 countries (46,483 firm-year observations).

Data on accounting variables come from Bureau van Dijk (especially for the private firms), from Datastream/Worldscope and from 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,[8] 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).

2.2 Group Ownership Structure and Centrality of Control

We rely on the measure of contribution to group control in Kim et al. (2004), as well as the measure of centrality in Almeida et al. (2011) 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 book value of the equity of affiliated firms.

We define the *centrality* of an affiliate firm as the fraction of the entire group's (book) value that the owner will lose control over if control of that particular firm is lost. We use the book value of equity instead of the market value of equity to avoid the possibility that the stock price already reflects centrality. 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 -

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

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

By construction, the $Centrality$ measure of a firm is a number between 0 and 1. 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, a firm with a centrality of 0.5 means that its loss would lead to the owner ceding over 50% of the entire group. To make the interpretation of the results simpler, we use this information to

[8] 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 non-operating income for firm A.

construct a dummy variable, *Central*, which equals one if an affiliated firm has the highest centrality measure (i.e., the most central firm) compared to all the other firms affiliated to the group, and zero otherwise.

A hypothetical example of a business group is shown in Figure 1. Appendix B further describes how we compute the measure of centrality for this case. Note that, given the separation between the voting rights and cash flow rights, we can also define the most important firm(s) for the owner to reap income. These are potential extractors from other firms in the business group but are not necessarily central firms. We later discuss how we identify the major extractors (denoted as E1 and E2) to explore the potential influence of agency costs on our results. Our results are robust when we control for extractors.

2.3 Control variables 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 12-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, Karolyi, and Kho (2011), Ince and Porter (2006), and others. [9]

In the panel regressions, we further control for trading volume using the daily trading volume averaged across all trading days in the year. We capture stock price volatility using the standard deviation of daily stock returns in the previous year. 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 total number of group firms (we exclude the focal firm from both measures).

[9] 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, andextreme return reversalsExtreme 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. $(1+Rt) \times (1+Rt-1) - 1 < 50\%$), then both Rt and Rt-1 are set to “missing. We also winsorize returns at the bottom 0.1% and top 99.9% of the distribution in each market.

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 4-digit SIC code of the primary industry of each firm) to account for industry effects, dummy variables to capture time effects, and 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 11,298 firms and 5,443 business groups from 2002 to 2012. There are 46,843 firm-year observations.

Panel A indicates 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 valud of centrality to assess differences in characteristics between central and non-central firms. The last three columns indicate that the average centrality is 0.7 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.

We also observe that central firms are typically larger and older - five to six times larger than non-central firms. They have five more years of operation and a lower valuation. These patterns further illustrate the importance of central firms, consistent with Almeida, Park, Subrahmanyam, and Wolfenzon (2011). The distribution of these variables is in general consistent with the literature.[10]

[10] For example, mean Total assets ($ billions) is 11.5 in our sample, compared to 7.33 in Anderson, Duru and Reeb (2012). The international averages of leverage, is 0.25 in Ferreira and Matos (2008), compared to 0.22 in our sample. In Lau, Ng, and Zhang (2010) the market-to-book ratio averages around 1.7 across stocks in different countries, compared to the mean of 2.1 in our sample. Mean Idiosyncratic volatility (scaled by total volatility) in Durnev, Morck, and Yeung (2004) is between 0.923 (for high) and 0.610 (for low) compared to a mean of 0.82 in our sample.

Conversely, Panel B reports that a typical business group has about 19 affiliated firms (public and private), albeit there are substantial cross-group variations in the number of affiliated firms as well as group assets and book equity. The next few lines demonstrate 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 the line "Difference within Group Max Centrality - Min 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 non-central firms (note that the Panel A difference is not conditioning on the same business group). The line "Difference within Group Value Max Centrality - Min Centrality (US$ billions)" calculates 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. 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 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

3.1 Sensitivity to Industry Shocks

Since business groups rely on central firms to control for assets, we need to investigate the extent to which central firms are strategically protected by business groups in bad times. We address this question by investigating the influence of unexpected negative industry shocks. We consider two ways. First, we follow Betrand, Mehta, and Mullainathan (2002) to assess the "help" from the low-centrality firms – to the high-centrality ones. We consider the following panel specifications:

$$MB_{i,t} = \alpha + \beta_1 \neg Shock_{i,t} + \beta_2 Centrality_{i,t} + \beta_3 Centrality_{i,t} \times \neg Shock_{i,t} + c \times \Delta x_{i,t} + \epsilon_{i,t}, (1)$$

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. Note that we control for changes in these characteristics. We also control for serial correlation and heteroscedasticity using the Huber-White sandwich estimator (clustered on group-level identifier) for the standard errors. We control for time fixed effects. In alternative specifications, we include either the firm-fixed effects or the country, industry, and group fixed effects. The unexpected yearly shocks for each industry are measured as the residual term, $\eta_{i,t}$, from the following AR regression (Anderson, Duru, and Reeb, 2012):

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

where $ROA_{i,t}$ is the realized size-weighted mean return on assets of industry i of the 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 use the size weighted mean industry earnings per share (Anderson, Duru, and Reeb, 2012) instead of ROA to compute the residual in the regression above. Alternatively, following Jian and Wong (2010), we also 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 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., $\sigma \times \frac{\beta_3}{\beta_1} = 12\%$, [0.40*(0.11/-0.37)] where $\sigma = 0.40$ is the magnitude of the one-standard-deviation change in centrality), while in the case of both firm and time fixed effects the effect is around 11% [0.40*(0.10/-0.35)]. 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 protested by business groups in bad times. These results should be considered as suggestive given the non-normality in the distribution of the centrality variable. While this will not affect 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, Morck, and Yavuz (2020), 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 its interaction with Business group affiliation. While their goal is to assess the degree by which firms affiliated to business groups are sensitive to shocks, ours is to investigate whether within business groups certain firms – the central ones – are less sensitive to shocks. Thus we interact the unexpected commodity shocks on Centrality rather than 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, Morck, and Yavuz (2020).[11] We use a Fama-MacBeth specification and regress idiosyncratic returns – defined as the residual of the firm's weekly returns on the local market return – on the shock, centrality and its interaction.

The results reported in columns (4)-(6) show that, again, central firms are much less sensitive to unexpected negative industry shocks. Indeed, 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 with firm-fixed effects, 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), while in the case of both firm and time fixed effects the effect is around 31%.

[11] We thank Faccio, Morck, and Yavuz for kindly making this data available to us. We use commodity shocks matched using the statistical method.

In brief, our results show that central firms are protected by business groups in bad times. The message about valuation and default risk is broad. However, 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 to their industry competitors, then a negative shock to their competitors could directly benefit them. In the next section, we use an exogenous shock induced by country sovereign downgrades to address potential concerns about a spurious correlation.

3.2 Sensitivity to the Exogenous Shock of Sovereign Downgrade

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

We provide a brief description of the experiment below. Interested readers can find more details 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') will also be downgraded—even when everything about the firm remains the same. In practice, the ratings of bound firms indeed 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 vs. non-bound firms in a downgraded sovereign setting, we focus on 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 includes 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.[12] The control firms consist of firms in countries with a sovereign downgrade but 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. In contrast, 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. If we focus on 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., $\sigma \times \beta_{tripple}/\beta_{interaction} = 0.38 \times 1.279/0.544 = 89.3\%$). Consistent with our findings in the previous section, 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 should expect centrality to affect the cross-section of asset prices. This section examines this prediction.

4.1 A Multivariate Analysis

We start by performing a multivariate analysis at the stock level. Following Hou, Karolyi, and Kho (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, and the lagged return. More

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

specifically, we regress the returns in month t on centrality in month t-3 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 we use the DGTW-adjusted returns. The first columns only consider centrality, while columns 2-5 consider specifications in which the control variables are incrementally added, and in column 5 all the control variables are jointly considered. The results suggest that centrality is always negatively related to returns across all the specifications. If we focus on the specification in column 5 with all the control variables, we see that one standard deviation higher centrality is related to 14 (12) bps lower monthly return (DGTW-adjusted return).

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 relationship 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 within- or across-business group effects. First, we sort stocks into high and low centrality portfolios without conditioning on business group membership. Second, we sort stocks into high and low centrality within each group. Third, we sort stocks into high and low centrality portfolios using only the most central firm from each business group. The first sorting captures overall differences in centrality, the second sorting captures within-group variations, while the third captures between-group variations conditional on being a most central firm.

More specifically, in the first sorting, each quarter, we rank stocks 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. In the second sorting, in each quarter we rank stocks as a function of their degree of centrality within each business group in the prior quarter. Specifically, we take the most and least central firm from each business group, then group them in high- and low-centrality portfolios. In the third sorting, we select the most central firm from all business groups with more than two publicly traded companies for which we have a centrality measure, then group these into high- and low-centrality portfolios.

In either case, we define the portfolio returns as the equal-weighted average of the stock returns with the highest (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 Table 5, Panel A for the first sorting, Panel B for the second sorting, and Panel C for the third sorting. Across all the specifications and portfolio sorts, we observe a strong negative alpha. If we focus on the four-factor model, we see that the high-centrality portfolios deliver 73 bp 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 37 bp per month in the case of the within-group sorting and 41bp for most central firms across different business groups. These results confirm that centrality significantly influences asset returns for affiliated firms within and across business groups.

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? In the next section, we take on the task of assessing the marginal power of a centrality factor—in addition to that of traditional factors—in international asset pricing.

5. Asset Pricing Tests on Centrality as an Additional Risk Factor

The results in the preceding sections suggest that a centrality factor may 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).

Table 6 contains pairwise tests of equality of the squared Sharpe ratios of 8 asset pricing models. This test was introduced in Barillas, Kan, Robotti, and Shanken (2019). The models include the CAPM (MKT), the Fama and French (1993) 3-factor model (3F), and the Carhart Model, which adds the momentum factor (3F+Mom). The model (3F+CmP) adds the Central minus Peripheral portfolio to the 3 Factor model, the Fama and French (2018) 5-factor model (5F) and its extension with the momentum factor (FF5+Mom). The model (FF5+CmP) adds the central minus peripheral portfolio to the 5F model. Lastly, we include the highest probability model (BS-Optimal Model refers to the optimal model chosen using methodology of Barillas and Shanken (2018)) which combines the Market Factor, the HML and RMW factors from the 5F model, and the CmP portfolio.

Looking at the column for the model FF5+CmP, we can see that the null hypothesis of equal Sharpe ratios can be rejected when comparing to all other models except the BS-Optimal Model, which is described below.

Although the tests in Table 6 panels A and B do not depend on test assets, they still depend on a somewhat arbitrary decision about which factor models to compare. In light of this, we use the method of Barillas and Shanken (2018)[13] to calculate the posterior probability of every single factor model that can be constructed given our set of factors. Barillas and Shanken (2018) derive a closed-form solution for the posterior probability of a given factor model of the form:

$$P(Mi|D) = \frac{[ML(Mi|D)\times P(Mi)]}{jML(Mj|D)\times P(Mj)},$$

[13] We use an alternative prior on the nuisance parameters, as suggested by Chib, Zeng, and Zhao (2020)

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

We perform two Bayesian asset pricing tests using the results of Barillas and Shanken (2018). We first compare some common factors models with and without the centrality factor to find the posterior probability of the model including centrality. The results can be seen in Table 6 Panel C. For each factor model consider, the posterior probability of the factor model augmented with the centrality factor is overwhelmingly in favor of including the centrality factor. This arises from the fact that the other factors are unable to span the centrality factor.

We also perform another test in which we consider all possible models that contain combinations of the factors Mkt, Size, Value, Profitability, Investment, Momentum, and Centrality. We then calculate the posterior probability of each model. The highest probability model includes the factors Mkt, Value, Momentum, and Centrality verifying that the centrality factor should be included in international factor models, this is the BS-Optimal Model in panels A and B and it compares favourably to all other models. The top 5 highest probability models over the entire sample likewise include the Centrality factor. We show results in Figure 2 which contains the time series of posterior model probabilities for the 5 models with highest probability (ranked at the end of the sample), we can see that the model with highest posterior probability over almost the entire sample contains 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

6.1 The Economic Grounds of Co-movement

We argue that centrality represents a new risk factor because the strategic risk reallocation by business groups among affiliated firms create an intertemporal hedge demand against market uncertainty for control. The previous section confirms the pricing power of centrality. To further understand the strategic reallocation effect, we now explore the intertemporal nature of the return-predicting power of centrality in periods of high and low uncertainty. Given that the information business groups use to estimate market uncertainty for group control is difficult for econometricians to observe, we consider several commonly used measures of uncertainty to proxy for this information. The results are reported in Table 7.

We first consider VIX and default spread. When these two variables are high, the bankruptcy risk for central firms is likely to be high. Hence we would expect business groups to do more strategic risk and asset reallocation in economic settings of this kind. The negative risk premium of centrality should therefore be more prominent in such high-uncertainty periods. Models (1) and (2) indeed confirm this prediction, in which we define periods of high (low) uncertainty if VIX and default spread are above (below) the median value of VIX. 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.

Next, we consider the funding uncertainty faced by central firms. When the uncertainty of external funding is high, within-group internal asset reallocation is more critical in helping business groups to achieve dynamic hedging. Empirically, we follow He, Manela, and Kelly, (2017), using two measures of intermediary capital to proxy for funding uncertainty: the end-of-period ratio of total market cap to the total asset (measured as total market cap + book assets - book equity) of NY Fed primary dealers' publicly-traded holding companies, as well as the value-weighted investment return on a portfolio of NY Fed primary dealers' publicly-traded holding companies. We expect a low level of intermediary capital to be associated with a higher return impact of centrality given the enhanced importance in internal asset reallocation. 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 to the effect of -10 (2) bps when the opposite market funding conditions prevail.

Finally, business groups may particularly want to protect central firms when several negative shocks occur to magnify the downside risk for all affiliated firms—i.e., periods of contagion. Although it is difficult to exhaustively identify all such shocks (our previous negative industry shocks and country downgrades offer examples in the same spirit), the co-skewness factor of Harvey Siddique (2000) allows us to capture the occurrence of contagion periods. Hence, we construct both a global and a local co-skewness factor by taking a long-short portfolio in firms sorted by level of co-skewness calculated using the global (local) market portfolio. We find that centrality is mainly significant in periods of high global (local) co-skewness risk. A one-standard-deviation increase in centrality is related to 46 (42) bps lower return in such contagion periods.

Collectively, these results suggest that the low-risk premium of centrality reflects a dynamic hedging demand of business groups, which lends support to the notion that centrality represents an intertemporal risk factor in the global market. It is important to note that these state variables of uncertainty do not explain the asset pricing impact of centrality in the cross-section. To save space, we tabulate the result in the Internet Appendix, Table IN1. We also show that the asset-pricing influence of centrality is not explained by several other market liquidity or co-movement-related variables, including the liquidity measures of Amihud (2002) and Sadka (2006), and the global and local co-skewness measures based on Harvey Siddique (2000).

6.2 Agency costs

Thus far, we have focused on the strategic hedging demand of business groups to protect their central firms and the asset-pricing implications. A further consideration – given that the sophisticated organizational structure of business groups may also allow ultimate owners to tunnel assets from peripheral to core firms – is whether the aforementioned effects may be related to, if not driven by, agency problems of affiliated firms and business groups.

To explore the influence of agency problems, we identify affiliated firms in each group that correspond to the traditional definitions of "top" or "apex" in the literature (e.g., Bertrand, et al., 2002). These are the "extractors" – i.e., firms used by the owner to "extract" the cash flows/benefits of the group. We identify two potential extractors in terms of direct and pyramid ownership. The first, denoted by the dummy variable E1, is a firm in which the owner has the highest ownership stake, which allows the owner to receive cashflows, at the expense of the minority shareholders. The second firm, E2, is entitled to the highest amount of cash flows/value of the group thanks to its stakes in other group firms.[14] E2 basically allows the owner to reap cash flows based on the pyramid structure of the business group. E1 and E2 may be the same firm for some groups.

Figure 3 reports two examples of groups in which the apex (or top) firms differ from the central firm. The first is the De Benedetti Group. The extractor firm (E1 coincided with E2)[15] is Cofide – Gruppo De Benedetti SpA, with the owner holding direct and indirect cash-flow rights of 38% and a centrality measure of 20%. That is, losing control over Cofide would cause the owner Carlo De Benedetti to lose control over firms that comprise 20% of the group's total value. However, the central firm is CIR SpA with cash-flow rights of 35% and a centrality measure of 56%. That is, losing control over CIR would cause the ultimate owner Carlo De Benedetti to lose control over firms that comprise 56% of the total value of the group controlled by De Benedetti. Another example is the Møgster Family group from Norway (Panel B). Appendix D provides more details.

In the above examples, central firms differ from apex firms, a property that generally pertains in our data. To potentially differentiate the influence of control and that of exploitation, we have already included apex firms in Table 2. We can see that, unlike high centrality firms, apex firms are not strategically protected during bad times. This observation could arise because extractors are substitutable. Indeed, as long as the

[14] For a specific group G, for each firm A we compute $\sum_{Faffiliated\ G} \alpha_{A\rightarrow F} Book_F$ where $\alpha_{A\rightarrow F}$ is the direct/indirect ownership stake of firm A in any other firm F affiliated to the same group G, and $\alpha_{A\rightarrow F} = 0$ if there is no direct/indirect ownership link between A and F. The group firm with the maximum $\sum_{Faffiliated\ G} \alpha_{A\rightarrow F} Book_F$ value has dummy$E2 = 1$.

[15] Extractor Firm 1 (E1) – the firm in which the ultimate owner has the highest ownership stake; Extractor Firm 2 (E2) – the firm that is entitled to the highest amount of cash flows/value of the group due to its direct/indirect stake in other group firms; and the most central firm is the firm that exclusively controls directly/indirectly (i.e. the firm is critical for control) the highest value in the group.

ultimate owner has full control of business group assets (with the help of central firms), an existing extractor can be easily replaced with another to reap cash flows from affiliated firms.

Perhaps more importantly, we expand the cross-sectional test of Table 4 to include apex firms. The results shown in Table 8 give rise to two interesting observations. First, the inclusion of apex firms does not affect the negative risk premium of central firms. Second, apex firms do not exhibit similar pricing power. To reconcile these two observations, we notice that although apex firms impose agency costs, different business groups may have completely different patterns and timings for exploiting minority investors. In this case, economically speaking, agency costs create a discount on asset prices but not an intertemporal hedge demand or an ensuing risk factor. 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 non-existent pricing power of affiliated firms.

6.3 Idiosyncratic risk

We have argued that the goal of business groups in retaining control allows 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 may 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 8. Across all specifications, centrality is related to lower idiosyncratic volatility. The coefficient estimate of centrality is -0.032, which implies that increasing centrality by 0.3 (one standard deviation), idiosyncratic volatility drops by 0.01 on average (column 3), or by roughly 0.1 standard deviations. Although the interpretation of idiosyncratic volatility is subject to debate, this result complements our main analysis in suggesting that business groups strategically protect central firms against major risk.

Conclusion

Our paper has explored the idea that the dynamic hedging demand of strategic business groups in global markets may create a new intertemporal risk factor to influence the cross-section of asset prices. We show that the position of a firm within a business group is important. In particular, central firms that play a crucial role in allowing the ultimate owner to control a large share of the entire group differ from peripheral firms. In states of the economy with high uncertainty, business groups may strategically reallocate group assets to protect central firms in retaining control. The ensuing hedging demand induces co-movement among central firms and creates a new intertemporal risk factor.

Using a novel dataset of worldwide ownership for 2001-2013, we have shown that central firms are better protected in bad times. We have also documented 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. Indeed, 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 dynamic hedging demand and can ultimately create intertemporal risk factors. 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.

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Appendix A: Identifying Control Relations

Our empirical analysis relies on the identification of the firm's ultimate owner, on the position of the firm within the entire control structure dominated by its ultimate owner and on the power of control over the firm. We use a method for identifying control relations in complex ownership structures, suggested by Aminadav et al. (2011). By making the simultaneous analysis of 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 results for the identification of corporate controller 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, 2000; Faccio and Lang, 2002; Almeida et al., 2009). The novel method we use relies on the weighted voting games theoretical framework and the Shapley-Shubik (Shapley and Shubik, 1954) and Banzhaf power indices measures to determine control rights, and 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 percent cutoff rule.

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 occurs 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 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 nonnegative real numbers satisfying $0 < q \le \sum_{i \in N} w_i$. We may think of w_i as the fraction of voting rights, or weight, of shareholder$i$ in the set $N \coloneqq \{1, \dots, n\}$ 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:

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

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:

$$SS_i(v) \coloneqq \frac{Number of orderings \in which player i is pivotal}{n!} = \sum_{\substack{S \subseteq N \\ (i \in S)}} (S \vee -1)!$$

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, as will be explained below) 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 there is no shareholder with direct holdings that fulfills 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 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 where several shareholders of each firm are directly or indirectly controlled by the same identified ultimate owner. We will refer to each such subset of shareholders in each firm a “concert of shareholders”. The set of shareholders of a certain firm may contain several concerts of shareholders. However, 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 rather than the individual index of each member. We perform the Shapley-Shubik power index control test again; find direct controllers, ultimate owners and concerts of shareholders and so on. After repeating the same procedure for a finite number of iterations the outcomes will remain fixed for all subsequent iterations, and the method converge into a final solution. This solution is the set of all control relations, where 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 non-controlling 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

Figure 1 illustrates a business group and how we calculate the centrality measure for each affiliated firms. 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 figures over the arrows show the voting rights that each controlling entity (ultimate owner or a firm) holds in other firms. The ultimate owner owns direct stake of 75% in firm A and of 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. For further simplicity, we further assume that the value of each firm is $100 million, and that voting rights are equal cash flow rights.

Cash flow rights of the ultimate owner: For Firm A it is 75%, for Firm B is also 25%, for Firm C it is (20%)(75%)+(20%)(50%)=25%, and for Firm D it is 50%[(20%)(75%)+(20%)(50%)]=12.5%. (see Alemida et al., 2011). Firm A is the firm with the highest cash flow rights of the ultimate owner. The literature traditionally referred to it as the "apex" firm or the "top" firm in the group (e.g., Bertrand, Mehta, and Mullainathan, 2002).

Importance to control 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 even 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 will lose the private benefits of controlling Firm A. In terms of total value, the ultimate owner will lose control over $100 million, or over $100/(100+100+100+100) = 100/400 = 25\%$ of the value of the group. Note that the ultimate owner will 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 where the ultimate owner loses control over Firm B, which 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 will lose control over $200 million, or over 50% of the value of the group (i.e., $(100+100)/(100+100+100+100) = 200/400 = 50\%$). This is because losing control over Firm C will trigger 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 to all other group firms, we call Firm C the "central" firm in the group.

Appendix C: Variable Definitions

Variable	Definition
Panel A: Ownership and Affiliation Variables	
Centrality	The 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 will lose control over the set of firms G_{-F} (which includes F) then $Centrality_F = \frac{1}{Book_{UO}} \sum_{i \in G_{-F}} Value_i$ Where $Value_i$ is the book value of equity of firm i, and $Value_{UO} = \sum_{i \in GroupG} Value_i$ is the sum over the book value of equity of all the firms in group G.
Central	A dummy variable which equals one if an affiliated firm has the Centrality above the median centrality
Extractor 1 Firm - E1	Dummy that equals one for a firm in which the ultimate owner has the highest ownership stake and zero otherwise.
Extractor 2 Firm - E2	Dummy that equals one is the firm entitled to the highest amount of cash flows/value of the group based on its direct/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/indirect ownership stake of firm A in any other firm F affiliated to the same group G, and $\alpha_{A \to F} = 0$ if there is no direct/indirect ownership link between A and F. The group firm with the maximum $\sum_{F affiliated} G\, \alpha_{A \to F} Value_F$ value has dummy $E2 = 1$.
Panel C: Sensitivity to Industry Shocks Variables	
$IndustryShock$	The residual term from the following 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 of the year t, one year ago$(t-1)$, two ($t-2$ years ago and three ($t-3$ years ago. In our estimation we use the one-year lag of this residual.
Panel D: Firm Characteristics	
Size	Natural log of total assets (WS item 02999)
Market-to-book	Market value of equity (WS item 08001) divided by book value of equity (WS item 03501)
Return on assets (ROA)	Net income before extraordinary items (WS item 01551) plus interest expenses (WS item 01151) divided by total assets (WS item 02999)
Leverage	Total debt (WS item 03255) divided by total assets (WS item 02999)
Share turnover	Share volume (Datastream item VO) divided by adjusted shares outstanding (DS items NOSH/AF)
Idiosyncratic volatility	The sum of squared errors (scaled by total return volatility) from the following regression model: $r_t = \alpha + \beta_1 R_{LocalM,t} + \beta_2 R_{I,t} + \beta_3 R_{GlobalM,t} + \beta_4 R_{G,t} + \epsilon$, where r_t is the return on day t and $R_{LocalM,t}$ 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.
Log Group Total Book Value	(The natural log of) the sum of the book value of equity of all the firms in the same group (excluding the firm itself)
Log Number of group firms	(The natural log of) the number of firms in the same group (excluding the firm itself)
Standard Deviation of Stock Returns	The standard deviation of daily stock returns for the previous year
Age in Years since Incorporation	Current year minus year of incorporation

Appendix D: Two Real World Examples of Business Groups and Central Firms

Two examples of groups in which extractors firms ("top" and "apex") differ from the central firms are reported in Appendix C. In Appendix Figure 2, Panel A, we report the Italian group De Benedetti controlled by the Italian tycoon Carlo De Benedetti and his family. We can see that the extractor firm (E1 coincided with E2)[16] 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). However, the central firm is CIR SpA with cash-flow rights of 35% and centrality measure of 56% (that is, losing control over CIR 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, still it is not a critical shareholder for the control.

The reason is that CIR SpA is jointly controlled by two shareholders: (1) the firm Cofide; and (2) the firm Carlo De Benedetti & Figli S.a.p.a. Siglabile Cdb & F. Both controlling shareholders are ultimately controlled by De Benedetti Family. Even if the family losses control over Cofide, it will 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 will allow 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 defined below in section 2.1 and in more technical detail in appendix D). Consequently Carlo De Benedetti and his family will not lose control over the part of the group that is below CIR SpA. However, this is not the case if Carlo De Benedetti and his family lose control over CIR SpA, in which case they will 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.

Even though the firm Cofide is part of the controlling concert of shareholders that controls CIR SpA, still it is not a critical shareholder for the control. The reason is that CIR SpA is jointly controlled by two shareholders: (1) the firm Cofide; and (2) the firm Carlo De Benedetti & Figli S.a.p.a. Siglabile Cdb & F. Both controlling shareholders are ultimately controlled by Carlo De Benedetti. Even if he loses control over Cofide, it will not lose control over CIR

[16] Extractor Firm 1 (E1) – the firm in which the ultimate owner has the highest ownership stake; Extractor Firm 2 (E2) – the firm that is entitled to the highest amount of cash flows/value of the group due to its direct/indirect stake in other group firms; and the most central firm is the firm that exclusively controls directly/indirectly (i.e. the firm is critical for control) the highest value in the group.

SpA because it still holds a stake of 24% via Carlo De Benedetti & Figli S.a.p.a. Siglabile Cdb & F which will allow it to maintain control over 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 will not lose control over the part of the group that is below CIR SpA. However, this is not the case if Carlo De Benedetti loses control over CIR SpA, in which case they will 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 given in Appendix Figure 2 Panel B which is the Møgster Family group from Norway where the extractor firm (again E1 and E2 coincide) is AUSTEVOLL SEAFOOD ASA with Ultimate Owner Direct/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 do not usually coincide with the extractor firms (E1 and E2) within the same group. Out of 11,178 business groups - years around the world between 2000-2013, in 6,675 of them the central firm differs from the Extractor firm 1 (E1) and in 5,793 the central firm differs from the Extractor firm 2 (E2).

These considerations make it clear that the traditional idea of subsidization within a business group has to be reconsidered. Indeed, 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 S.P.A for Carlo De Benedetti and AUSTEVOLL SEAFOOD ASA for the Møgster Family. However, the firms that guarantee the two families the control of most of their groups are actually CIR S.P.A. - COMPAGNIE INDUSTRIALI RIUNITE for Carlo De Benedetti and DOF ASA. for the Møgster Family. The separate identification of the central firms helps to distinguish the value of control from the pure value of cash flows that it carries with it.

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. Our paper addresses this by exploiting a unique dataset on 3,180 unique business groups around the world over the 2000-2013 period with ownership data detailed at the level of both private and public companies. This allows us to distinguish central, E1 and E2 firms. We focus on centrality and use it to study how the market reacts to the fact that some firms are useful as controlling entities, independently of the cash flows benefits they themselves receive.

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, percentiles 5, 95, 50 (median), and number of observations for the centrality measure, ownership measures, top cash flow rights firms (E1 and E2), financial variables, as well as the difference of mean tests between central and non-central firms (where central is a dummy variable equal to one if centrality is above the median and zero otherwise. Panel B reports group-level statistics (we also add the 25th and 75th percentiles. The sample consists of worldwide public firms that are affiliated to business groups in the 2002-2012 period.

Panel A: Summary Statistics for Firm-level Variables

							Central vs. Non-Central firms		
	Mean	Std. dev.	5%	50%	95%	N. Obs	Non-Central (Mean)	Central (Mean)	t-test (p-value)
Centrality	0.37	0.40	0.00	0.16	1.00	46483	0.04	0.71	(0.00)
Ownership Stake of the Ultimate Owner	0.47	0.23	0.11	0.49	0.90	46483	0.43	0.50	(0.00)
E1 - Dummy Highest Stake of Ultimate Owner	0.36	0.48	0.00	0.00	1.00	46483	0.12	0.60	(0.00)
E2 - Dummy Highest Value Owned	0.42	0.49	0.00	0.00	1.00	46483	0.39	0.45	(0.00)
Total Assets ($ billions)	11.54	50.55	0.03	0.69	38.90	46483	2.94	20.13	(0.00)
Market Capitalization ($ billions)	3.93	15.45	0.01	0.39	16.33	46483	1.26	6.61	(0.00)
Market-To-Book Ratio	2.12	2.62	0.27	1.36	6.51	46483	2.35	1.88	(0.00)
Leverage	0.22	0.20	0.00	0.19	0.60	46483	0.20	0.25	(0.00)
Age in Years since Incorporation	41.94	40.97	4.00	29.00	118.00	43904	41.10	42.77	(0.00)
Idiosyncratic Volatility (Scaled By Total Volatility)	0.82	1.74	0.51	0.83	0.97	39676	0.85	0.77	(0.00)

Panel B: Summary Statistics for Business Groups

	Mean	Std. dev.	5%	25%	50%	75%	95%	N. Obs
Total Number of Group Firms	13.97	26.34	2.00	2.00	4.55	13.00	58.05	17120
Group Total Assets (US$ Billions)	31.32	102.34	0.05	0.38	2.13	12.98	153.31	17120
Group Total Book Value (US$ Billions)	14.29	43.29	0.03	0.25	1.50	8.37	70.43	17120
Within Group Max Centrality	0.81	0.29	0.12	0.67	1.00	1.00	1.00	17120
Within Group Median Centrality	0.49	0.35	0.01	0.14	0.50	0.80	1.00	17120
Difference within Group Max Centrality - Min Centrality	0.46	0.41	0.00	0.00	0.46	0.90	1.00	17120
Difference within Group Value Max Centrality - Min Centrality (US$ Billions)	6.05	22.05	-0.12	0.00	0.07	2.20	32.73	17120

Table 2: Sensitivity to Shocks

This table reports the results of how unexpected shocks influence the valuation and returns of central and non-central firms. In columns (1)-(3) we report how yearly industry 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. In columns (4)-(6), we report how weekly firm-level commodity shocks influence the idiosyncratic returns of central firms. Following Faccio, Morck, and Yavuz (2020), 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. ***, ** and * represent significance levels at 1%, 5% and 10% respectively using robust standard errors with t-statistics given in parentheses.

	[1]	[2]	[3]	[4]	[5]	[6]
(t+1)	Market-to-Book	Market-to-Book	Market-to-Book	Idiosyncratic Return	Idiosyncratic Return	Idiosyncratic Return
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	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	-	-	-
Time FE	No	No	Yes	-	-	-
R Squared	0.011	0.012	0.037	0.012	0.014	0.058
No. of obs	9,405	9,405	9,405	200,127	200,127	200,127

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 equal 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, leverage. Regressions also include year, country, and business group fixed effects. The sample consists of WRDS-Factset Fundamentals Annual Fiscal (International) non-financial firms in the 2002-2012 period. Robust standard errors clustered by country event are reported in parentheses. ***,**,* indicates significance at the 1%, 5% and 10% level respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Centrality× Downgrade× Bound	1.237***	1.199***	1.307***	1.149***	1.666***	1.279***
	(5.84)	(5.70)	(5.57)	(6.18)	(5.63)	(5.01)
Centrality	-0.0591	-0.0432	-0.0384	-0.0310	0.0115	0.0671
	(-1.67)	(-1.29)	(-1.12)	(-1.07)	(0.13)	(0.93)
Downgrade	-0.134	-0.116	0.169	-0.0800	0.118	-0.112
	(-1.66)	(-1.67)	(1.04)	(-0.66)	(0.73)	(-0.92)
Bound	0.0507	0.0445	-0.0862*	-0.0573	0.0241	0.128*
	(0.89)	(0.80)	(-1.93)	(-1.02)	(0.31)	(1.90)
Bound × Centrality	0.0621	0.0629	0.0922	0.120*	-0.0665	-0.199
	(0.69)	(0.76)	(1.23)	(1.85)	(-0.68)	(-1.52)
Downgrade × Centrality	0.0418	0.0163	-0.0392	0.0346	-0.00851	0.00457
	(0.22)	(0.08)	(-0.18)	(0.20)	(-0.03)	(0.02)
Bound × Downgrade	-0.616***	-0.588***	-0.712***	-0.631***	-0.883***	-0.544***
	(-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	0.521	0.525	0.0766	0.567	0.180	0.660
N. Obs	964	964	963	963	842	842

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 DGTW adjusted return, which is the raw return minus the return on the corresponding size, book-to-market and momentum portfolio. respectively. ***, ** and * represent significance levels at 1%, 5% and 10% with t-statistics given in parentheses.

Panel A: Predicting out-of-sample stock returns

Monthly Return	(1)	(2)	(3)	(4)	(5)	(6)
Centrality	-0.472***	-0.508***	-0.320**	-0.378**	-0.511***	-0.366***
	(-2.86)	(-3.22)	(-2.02)	(-2.37)	(-3.34)	(-2.71)
Log Market Value of Equity			-0.109***			-0.0632*
			(-3.02)			(-1.68)
Log Book-to-Market				0.452***		0.384***
				(4.40)		(3.72)
Momentum					0.131	0.0128
					(0.27)	(0.03)
Lag Return		-2.030*				-2.801***
		(-1.93)				(-2.84)
R-squared	0.00	0.02	0.01	0.01	0.02	0.05
N. Obs.	292236	292236	292236	292236	292236	292236

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

Centrality	-0.274**	-0.307***	-0.254*	-0.262**	-0.318***	-0.311**
	(-2.29)	(-2.67)	(-1.85)	(-2.12)	(-2.82)	(-2.49)
Log Market Value of Equity			-0.0189			-0.0204
			(-0.90)			(-0.96)
Log Book-to-Market				0.0616		0.0445
				(1.16)		(0.80)
Momentum					-0.0753	-0.121
					(-0.18)	(-0.28)
Lag Return		-2.445**				-3.013***
		(-2.56)				(-3.26)
R-squared	0.00	0.01	0.00	0.00	0.01	0.03
N. Obs.	292236	292236	292236	292236	292236	292236

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. Panel B contains portfolios constructed using variation within groups. Panel C contains portfolios constructed using variation between groups (keeping only the most central firm from each group). All central minus peripheral portfolios are constructed using a 1 quarter lag of centrality where returns are equal-weighted. Panels D, E, and F columns 1-2 (3-4) contain sample splits into high and low VIX (Default Spread), respectively, using portfolio construction as in Panels A and B. ***, ** and * represent significance levels at 1%, 5% and 10% with t-statistics given in parentheses.

Panel A: The Performance High-minus-low Centrality Portfolios, Sorted by Centrality

	(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
N. Obs.	132	132	132	132

Panel B: The Performance High-minus-low Centrality Portfolios, created by within-group centrality dispersion

	(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
N. Obs.	129	129	129	129

Panel C: The Performance High-minus-low Centrality Portfolios, within most central firms

	(1)	(2)	(3)	(4)
Intercept	-0.63***	-0.76***	-0.66***	-0.68***
	(-3.46)	(-5.15)	(-5.35)	(-5.42)
Market Factor		26.09***	26.48***	27.59***
		(8.59)	(10.43)	(9.80)
Size Factor			-59.09***	-60.24***
			(-8.02)	(-8.05)
Value Factor			13.39*	13.71*
			(1.80)	(1.84)
Momentum Factor				3.13
				(0.91)
R-squared	0.00	0.36	0.58	0.58
N. Obs.	132	132	132	132

Table 6: Model Comparisons

Table 6 contains pairwise tests of equality of the squared Sharpe ratios of 8 asset pricing models. The models include the CAPM (MKT), the Fama and French (1993) 3-factor model (3F), and the Carhart Model with the additional momentum factor (3F+Mom). The model (3F+CmP) adds the Central minus Peripheral portfolio to the 3 Factor model, the Fama and French (2018) 5-factor model (5F) and its extension with the momentum factor (FF5+Mom). The model (FF5+CmP) adds the central minus peripheral portfolio to the 5F model. Finally, we include the highest probability model from Figure 2 (BS Opt. Model is the optimal model using the method of Barillas and Shanken (2018)), which combines the Market Factor, the HML and RMW factors from the 5F model, and the CmP portfolio. The sample period is Jan. 2002–Dec. 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.

Model	3F	3F +Mom	3F +CmP	5F	FF5 +Mom	FF5 +CmP	BS Opt. Model	3F	3F +Mom	3F +CmP	5F	FF5 +Mom	FF5 +CmP	BS Opt. Model
Panel A. Differences in Sample Squared Sharpe Ratios								**Panel B: P-values**						
Mkt	0.063	0.105	0.268	0.207	0.203	0.401	0.406	0.005	0.001	0.000	0.000	0.000	0.000	0.000
3F		0.041	0.205	0.144	0.139	0.338	0.342		0.007	0.000	0.000	0.000	0.000	0.001
3F+Mom			0.163	0.103	0.098	0.296	0.301			0.065	0.138	0.003	0.003	0.002
3F+CmP				-0.061	-0.065	0.133	0.138				0.599	0.572	0.000	0.054
5F					-0.005	0.194	0.198					0.445	0.000	0.022
FF5+Mom						0.198	0.203						0.017	0.019
FF5+CmP							0.005							0.485

Panel C: Bayesian Model Comparisons

Model A	Model B	Posterior probability: Model B vs Model A
Market Model	Model A + centrality	100%
Fama-French 3 factor	Model A + centrality	100%
Carhart	Model A + centrality	100%
Fama-French 5 Factor	Model A + centrality	100%

Table 7: Relationship 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. The dependent variable is the raw return. Panel A Columns 1-2 contain results for high and lowIntermediary Capital Ratio defined as The end of period ratio of total market cap to (total market cap + book assets - book equity) of NY Fed primary dealers' publicly-traded holding companies. Columns 3-4 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.. Columns 5-6 contain results for the VIX index. Columns 7-8 contain results for the Default Spread. Panel B Columns 1-2 contain results for high and low Sadka liquidity. Columns 3-4 contain results for high and low Amihud illiquidity. Columns 5-6 contain results for high and low global coskewness. Columns 7-8 contain results for high and low local coskewness.
***, ** and * represent significance levels at 1%, 5% and 10% with t-statistics given in parentheses.

	VIX		Default Spread		Intermediary Capital Ratio		Intermediary Investment Return	
	H	L	H	L	H	L	H	L
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Centrality	-0.79***	0.056	-0.51***	-0.22	-0.20	-0.53***	0.021	-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	0.087*	-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***	0.031	0.67***	0.093
	(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
N. Obs.	147359	144877	145674	146562	128270	163966	143013	149223

Table 8: Controlling for Apex firms

This table presents results of multivariate Fama and MacBeth regressions of monthly firm level excess returns on firm level characteristics controlling for Apex firms. Dummy Highest Stake of Ultimate Owner is a dummy that equals one for such a firm and zero otherwise. Dummy Highest Value Owned is equal to one if a firm is responsible for the highest amount of cash flows/value of the group. The dependent variable is the raw return. Missing Values of the apex firm dummy are replaced by zeros. ***, ** and * represent significance levels at 1%, 5% and 10% with t-statistics given in parentheses.

	(1)	(2)	(3)	(4)
Monthly Return				
Centrality	-0.40**	-0.43***	-0.30**	-0.34**
	(-2.52)	(-2.70)	(-2.28)	(-2.56)
Dummy Highest Stake of Ultimate Owner	0.00		0.01	
	(0.02)		(0.06)	
Dummy Highest Value Owned		-0.00		-0.00
		(-0.00)		(-0.02)
Controls	No	No	Yes	Yes
R-squared	0	0	0	0
N. Obs.	296225	296225	296225	296225

Table 9: Idiosyncratic Volatility and Centrality

This table reports the results of regressing Idiosyncratic Volatility on centrality and control variables. In Columns (1)-(4) we control for serial correlation and heteroscedasticity using the Huber–White sandwich estimator, (clustered by group-level identifier) for the standard errors on the coefficient estimates, and in column (5) we are reporting the results using the Fama-Macbeth methodology with heteroscedasticity and autocorrelation consistent Newey-West (1987) standard error estimates with 4 periods lags. ***, ** and * represent significance levels at 1%, 5% and 10% with t-statistics given in parentheses.

	(1)	(2)	(3)	(4)	(5)
Idiosyncratic Volatility					
Centrality	**-0.062*** **	**-0.114*** **	**-0.032*** **	**-0.029*** **	**-0.040*** **
	(-16.92)	(-28.64)	(-6.12)	(-4.87)	(-6.33)
E2 - Dummy Highest Value Owned			0.002	0.001	-0.001
			(0.65)	(0.44)	(-0.76)
Ownership Stake of the Ultimate Owner			-0.007	-0.009*	0.004
			(-1.24)	(-1.87)	(0.53)
Log Assets			-0.030***	-0.009***	-0.029***
			(-23.30)	(-3.48)	(-24.51)
Leverage			0.057***	0.058***	0.054***
			(7.43)	(5.63)	(7.51)
Mean Monthly Return Last Year			0.046***	0.068***	0.071***
			(2.86)	(4.81)	(3.08)
Log Age			-0.012***	-0.014***	-0.010***
			(-7.72)	(-4.12)	(-4.01)
Market-To-Book Ratio			-0.005***	-0.004***	-0.003***
			(-7.93)	(-6.04)	(-3.53)
Listed on NYSE			-0.002	0.000	-0.009
			(-0.29)	(.)	(-1.06)
Log Group Total Book Value			-0.005	-0.005***	-0.003
			(-1.59)	(-2.72)	(-0.30)
Log Number of group firms			0.000	0.004*	-0.012
			(0.12)	(1.78)	(-1.05)
Time effects	Yes	Yes	Yes	Yes	No
Industry effects	No	No	Yes	No	Yes
Country effects	No	No	Yes	No	Yes
Group 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
N. Obs.	51837	51837	30437	30437	30437

Figure 1: An illustration of a hypothetical Business Group

This figure illustrates a 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 figures over the arrows show the voting rights that each controlling entity (ultimate owner or a firm) holds in other firms. The ultimate owner owns direct stake of 75% in firm A and of 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.

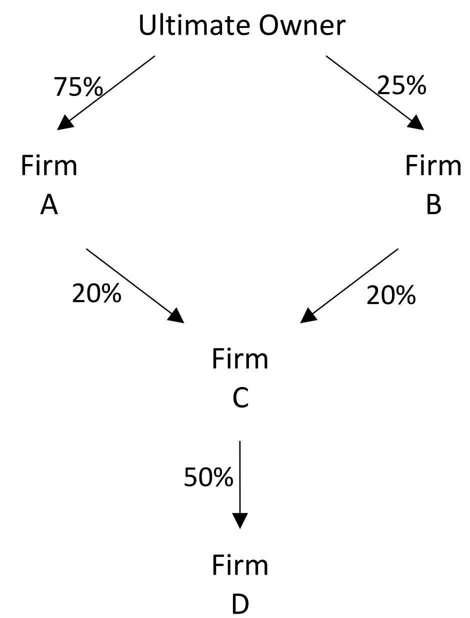


Figure 2: Model Probabilities

This figure presents the results of the time series of posterior model probabilities for the 6 models with highest probability (ranked at the end of the sample). The sample periods are recursive, beginning in January 2001 and ending each month up to December 2012. We require a minimum of 3 years data. Models are based on a set of 7 factors. The factors include the 5 factors of Fama and French (2015) factors (mkt=Market,hml=high minus low book to market, cmb = small minus big size, cma=conservative minus aggressive investment, rmw=robust minus weak profitability), the Carhart (1997) momentum factor (=wml) and our centrality factor (=cmp). The probabilities are calculated using the method of Barillas and Shanken (2018) with an alternative prior on the nuisance parameters, as suggested by Chib, Zeng, and Zhao (2020).

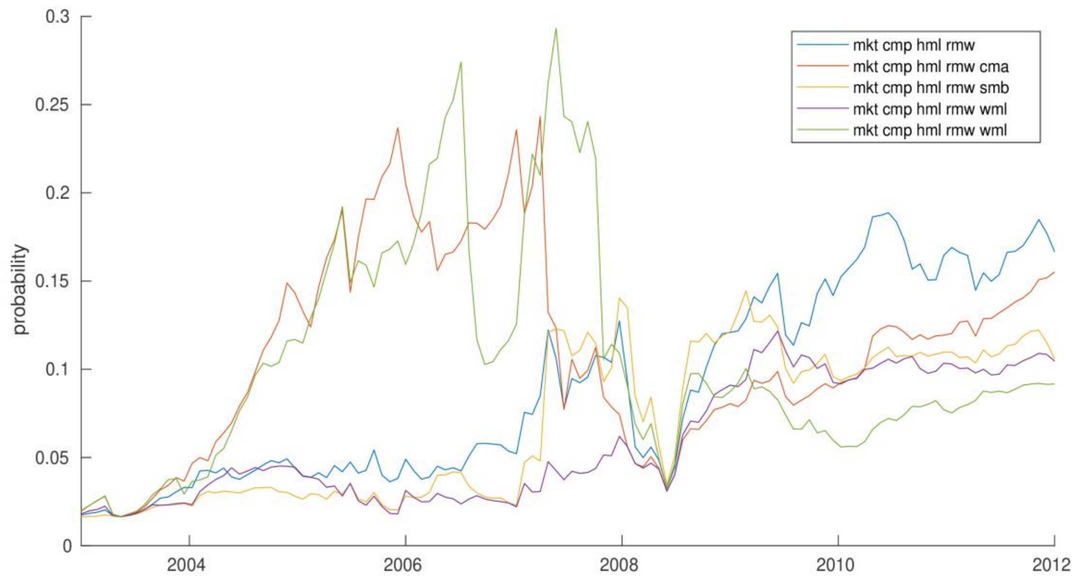
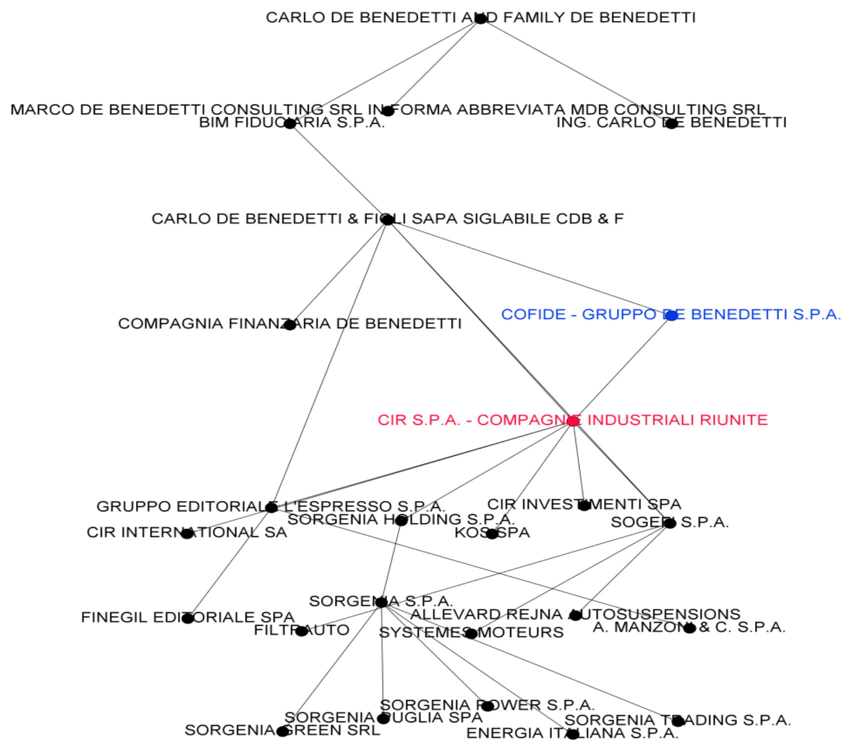


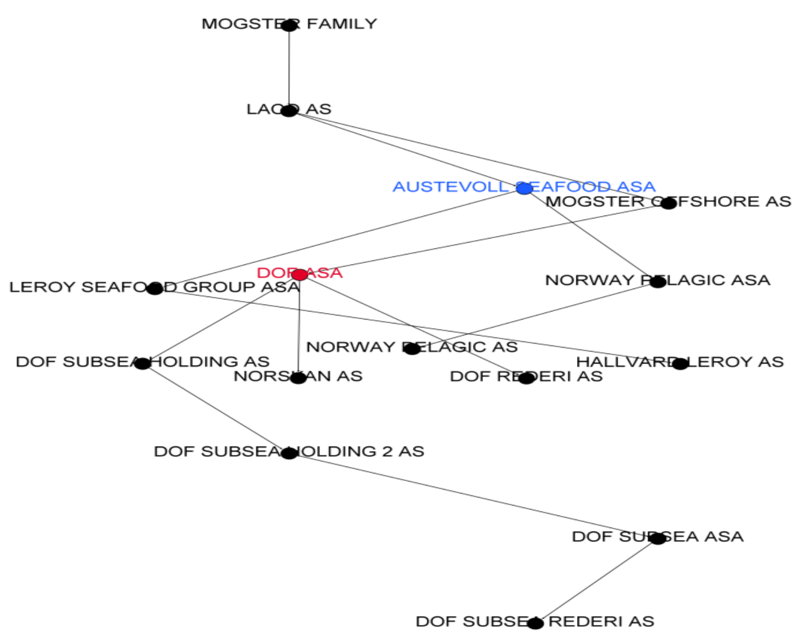
Figure 3: Two Real Examples of Apex Firms vs. Central Firms

This figure illustrates two real examples of business groups where the listed central firm (Colored Red) differs from the list Extractor Firms (called as E1 and E2, in Colored Blue). In Panel A, the E1 and E2 Firm is COFIDE – GRUPPO DE BENEDETTI SPA with Ultimate Owner Direct/Indirect Cash-Flow Rights (Voting Rights) of 38%, and Centrality Measure of 20%. The Central Firm is CIR S.P.A. - COMPAGNIE INDUSTRIALI RIUNITE with Cash-Flow Rights (Voting Rights) of 35% and Centrality Measure of 56%. Notice that even though the firm COFIDE is part of the controlling concert of shareholders that controls CIR S.P.A. - COMPAGNIE INDUSTRIALI RIUNITE it is not a critical shareholder for the control. The reason is that CIR S.P.A. - COMPAGNIE INDUSTRIALI RIUNITE is jointly controlled by two shareholders the firm COFIDE and the firm CARLO DE BENEDETTI & FIGLI SAPA SIGLABILE CDB & F. Both controlling shareholders are ultimately controlled by De Benedetti Family. If the family losses control over COFIDE, it will not lose control over CIR S.P.A. - COMPAGNIE INDUSTRIALI RIUNITE as it still holds a stake of 24% via CARLO DE BENEDETTI & FIGLI SAPA SIGLABILE CDB & F which allows it to maintain control over CIR S.P.A. - COMPAGNIE INDUSTRIALI RIUNITE. Consequently, it will not lose the part of the group that is below CIR S.P.A. - COMPAGNIE INDUSTRIALI RIUNITE. However, this is not the case if the family loses control over CIR S.P.A. - COMPAGNIE INDUSTRIALI RIUNITE, in which case they lose control over everything below that firm. This explains why CIR S.P.A.-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 S.P.A.-COMPAGNIE INDUSTRIALI RIUNITE. In Panel B, the E1 and E2 firms are AUSTEVOLL SEAFOOD ASA with Ultimate Owner Direct/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%.

Panel A: De Benedetti Family from Italy



Panel B: Møgster Family from Norway



Internet Appendix

Table IN1: Controling for state variable Sensitivity.

Monthly Return	(1)	(2)	(3)	(4)
Centrality	-0.35**	-0.35**	-0.34**	-0.35**
	(-2.39)	(-2.48)	(-2.42)	(-2.42)
VIX beta	-0.03			
	(-0.44)			
Default Spread beta		0.07		
		(0.18)		
Intermediary Capital beta			2.04	
			(0.05)	
Intermediary VW Return beta				0.56
				(0.17)
Controls	Yes	Yes	Yes	Yes
R-squared	0.05	0.07	0.06	0.06
N. Obs.	293338	293338	293338	293338

Table IN2: Controlling for Institutional Ownership

Monthly Return	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Centrality	-0.43***	-0.40***	-0.45***	-0.45***	-0.44***	-0.42***	-0.41***
	(-3.24)	(-2.94)	(-3.42)	(-3.28)	(-3.33)	(-3.08)	(-3.02)
Total IO	0.44						
	(0.67)						
Domestic IO		-0.93					
		(-1.05)					
Foreign IO			1.73**				
			(2.02)				
US Foreign IO				2.92***			
				(2.66)			
Non-US Foreign IO					1.95		
					(1.21)		
Investment Company IO						3.20	
						(1.60)	
Hedge & Venture IO							1.77
							(0.56)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.06	0.05	0.05	0.05	0.05	0.05	0.05
N. Obs.	262071	262071	262071	262071	262071	262071	262071