Naïve diversification and partition dependence in capital allocation decisions: Field and experimental evidence

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Abstract

We explore the role of a cognitive bias in organizational capital allocation decisions by managers. Previous research on capital investment has identified a tendency in multi-business firms toward cross-subsidization from well performing to poorly performing divisions, a phenomenon that has previously been attributed to social/political factors and/or incentives (Stein 2003). However, evidence for this phenomenon relies on strong assumptions concerning rational allocations and the extant evidence for the purported mechanisms is indirect. The present paper advances a methodology for cleanly demonstrating a counter-normative bias toward even allocation. Our first study uses archival data to show that firms' internal capital allocations are biased toward equality over the number of business units into which the firm is partitioned, an effect that is consistent with the cognitive bias known as naïve diversification (Bernatzi and Thaler 2001). In three further experimental studies, we show that this bias persists in a simplified experimental setting in which social/political and incentive-based mechanisms can be ruled out. In those experiments, experienced managers were provided information concerning forecast returns of capital allocations to various divisions of a hypothetical firm. We find that allocations exhibited *partition dependence*, varying systematically with the salient grouping of divisions.

1. Introduction

Perhaps the most important decisions made by top managers concern how to allocate investment resources among various business opportunities. In companies with multiple divisions, managers have the ability to shift capital between business units in order to fund the best opportunities, thus creating "internal capital markets" (Stein, Scharfstein and Gertner 1994; Lang and Stulz 1994). In this respect top managers act as investors evaluating business opportunities within the company. Given the important role that capital allocation plays in business strategy (see, e.g., Bower 1970; Gilbert and Bower 2005; Peteraf 1993; Dierickx and Cool 1989), it is surprising that this topic has received relatively little attention in the empirical strategy literature. A small number of finance papers are concerned with the question of whether internal capital markets allocate money efficiently. Some authors have explored the role of incentives, advancing theoretical agency models (e.g. Harris and Raviv 1996; Stein 1997). Others have investigated the financial criteria, such as net present value and hurdle rates, on which managers reportedly rely when making budget decisions (Graham and Harvey 2001). The purpose of this article is to offer a new, cognitive perspective on capital allocation decisions.

Recent research in corporate finance has documented robust empirical anomalies in capital allocations by firms among their divisions (for a review, see Stein 2003). In particular, several studies suggest that large multi-business firms engage in cross-subsidization of weaker divisions by stronger divisions. Berger and Ofek (1995) examined a sample of more than 3,000 diversified firms and documented overinvestment in divisions with limited opportunities and cross-subsidization of poorly-performing segments by better-performing ones. Likewise, Ozbas and Scharfstein (2007) examined a large sample of multi-business corporations and found that divisions in high-performing industries tend to receive less investment than their industry stand-

alone counterparts while divisions in poorly performing industries tend to receive more investment than their stand-alone counterparts.

Previous explanations for the subsidization of underperforming divisions have focused on agency and social dynamics within firms. Scharfstein and Stein (2000) attribute this phenomenon, which they call "corporate socialism," to agency conflicts in which rent-seeking divisional managers in poorly performing divisions are given larger capital allocations in order to deter them from wasting productive time lobbying for more resources. Rajan, Servaes and Singales (2000) advance a similar principal-agent account. Harris and Raviv (1996), in contrast, explain cross-subsidization in terms of information asymmetries in which corporate managers do not have access to full and accurate data concerning investment opportunities of the divisions, and managers of underperforming divisions have a strong incentive to overstate these opportunities.

In this paper we propose a simpler, cognitive account of the observation that corporations over-invest in underperforming divisions. Specifically, we argue that executives (and teams of executives) who make allocation decisions are susceptible to an unconscious bias toward even allocation. Such "naïve diversification" has been documented in employees' allocations among investment instruments in defined contribution retirement savings plans (Benartzi and Thaler 2001; see also Samuelson and Zeckhauser 1988, pp. 31-33; Langer and Fox 2005), and a number of consumer choice settings (Read and Loewenstein 1995; Fox, Ratner and Lieb 2005). Similarly, experts in decision analysis are biased toward assigning equal probabilities over all events that could occur (Fox and Clemen 2005) and equilibrium prices in experimental asset markets tend toward equal values over all exclusive and exhaustive events (Sonnemann et al. 2007). This bias toward even allocation could reflect a tendency to unconsciously anchor on

even allocations and adjust insufficiently in response to differentiating factors such as growth prospects and profitability, a tendency to "play it safe" by hedging toward even allocations, and/or overgeneralization of the principle that it is wise to diversify.

Our account of cross-subsidization as a manifestation of a more general cognitive bias yields two unique predictions. First, we expect to see management underweight not only differences in the quality of available investment opportunities among a firm's business units (cf. Ozbas and Scharfstein, 2007) but also other factors that would generally dictate uneven distributions among a firm's business units, such as differences in past performance, or even differences in size relative to each other. We note that previous studies of anomalies in capital allocation have focused mainly on the subsidization of low-quality business units by high-quality business units, where quality has typically been measured using Tobin's Q. Second, this tendency toward even allocation should persist even when budget decisions are made without political and social concerns, principal/agent conflicts, or informational asymmetries.

In this paper we test the first prediction using archival data to explore whether there is a general tendency to spread capital over all divisions after controlling for other relevant variables such as size, industry, and various firm characteristics. We test the second prediction using experiments in which we examine whether naïve diversification persists when experienced managers are asked to make simplified capital allocation decisions in an environment stripped of complicating organizational variables (e.g., the political relationships and principal/agent conflicts mentioned above).

Determining the causes of cross-subsidization is important for a number of reasons. First, it allows us to make more accurate predictions of the conditions under which biased or irrational allocations are most likely to occur and be most pronounced. Second, it can help us develop

more effective corrective procedures. For instance, to the extent that we attribute cross-subsidization to internal politics, then firms might develop organizational and/or incentive mechanisms that moderate corporate lobbying as well as divisional managers' misrepresentations of their business unit's investment opportunities. On the other hand, to the extent that we attribute cross-subsidization to a more general cognitive tendency of individual managers the firm might develop organizational design or decision analytic tools to help them diminish this bias.

In order to clearly demonstrate bias toward equal allocation, one must establish that the observed allocation is more equal than some normative standard of an ideal distribution of capital. The field studies reviewed above rely on strong methodological assumptions. For example, the notion that divisions embedded within multi-business corporations are comparable to stand-alone peers. They also rely on and strong behavioral assumptions, e.g. that managers can be viewed as primarily rent-seeking agents. In our study of archival data we investigate the impact of a variable that should not affect allocations to a target division (throughout the paper we call "target division" the division that is the focus of the allocation): the total number of business units into which the rest of the firm is divided, while controlling for relevant variables that might reasonably dictate allocations such profitability, growth and size, as well as the business' future opportunities (as represented by Tobin's Q). In this way we invoke the weaker normative assumption that the capital allocated to a target division should not be affected by the number of business units into which the rest of the firm has been partitioned. The naïve diversification account, in contrast, predicts that holding characteristics of the target division and rest of the firm constant, capital allocated to the target division will decrease with the total number of business units into which the rest of the firm is divided. Therefore, we predict that,

ceteris paribus, a division in a firm with three business units will receive a lower allocation than that same division would in a firm with two business units.

In our experimental studies we are able to exert greater control by holding firm characteristics constant and manipulating only the number of divisions over which participants are asked to allocate capital. This allows us to make more subtle predictions. We perform these experiments by presenting different groups of participants with identical information concerning divisions within firms that are hierarchically organized in different ways (e.g., by geographic region then product division or by product division then geographic region) or by asking them to allocate capital to different levels in the hierarchy (by division or business unit). We predict that in such situations executives' allocations will vary with these partitions of the firm.

To illustrate, consider a simple firm with three business units, one operating in the U.S., one in Europe, and one in Asia. The cognitive account predicts that if a manager is asked to allocate among three divisions, the final distribution will be biased toward one-third for each business unit. Now suppose instead that a manager is asked to allocate first between the domestic division (U.S.) and the international division (Europe and Asia), then later allocate international money between the European business unit and Asian business unit. The cognitive account predicts a bias toward one-half of capital allotted to the U.S. business unit (all of the domestic allocation) and one-quarter to the European and Asian business units (half to each of the international business units). We refer to this tendency for allocations to vary systematically with the suggested grouping of different investment projects or business units as "partition dependence."

The rest of this paper is organized as follows. Section 2 presents analysis of archival data to see whether capital allocations to target divisions decrease with the number of business units

into which the rest of the firm is partitioned. Section 3 presents experimental evidence of partition dependence in capital allocation decisions. Study 1 explores whether the nature of the allocation procedure gives rise to partition dependence. Study 2 examines whether the organizational structure of the firm gives rise to partition dependence. Finally, Study 3 tests whether partition dependence will persist when investments are very simple and participants receive incentive-compatible payoffs. In Section 4 we close with a general discussion of these results.

2. Field evidence.

As mentioned above, a small number of corporate finance studies have provided evidence of cross-subsidization by analyzing archival data collected from large samples of firms and business units. In this section, we analyze a similar dataset to see whether there is evidence of a more general pattern of naïve diversification. Our approach is to examine whether the number of business units into which the firm is partitioned has an effect on the investment in the target business when we control for all of the relevant business unit, firm, and industry variables. Thus, we test whether two businesses that have similar size, belong to similarly-sized firms, and operate in the same industry will nevertheless receive different allocations depending on the number of units into which the rest of the firm has been organized.

To illustrate this prediction, consider two firms depicted in Figure 1A. In both cases the assets of the target business units (represented by the horizontal dimension) are the same, and the aggregate assets of the remaining business units in each firm are also the same. The only difference is the number of business units into which the firms have been partitioned, with Firm A consisting of a single alternative business unit and Firm B consisting of three alternative

business units. Assuming that these firms attract approximately the same total amount of capital to invest and the target business units are comparable in most relevant respects (e.g., in the same industry, face similar investment opportunities), the naïve diversification account predicts that the capital allocation to the target division will be biased toward 1/2 for firm A and 1/4 for firm B.

'Insert Figure 1A about here'

2.1 Data and method

To test our predictions, we obtained a large sample of business unit financial data from the COMPUSTAT database (sample statistics shown in Table 1), which included 7,432 business units-years from 638 multi-business firms (average number of business units = 2.82, range = 2 to 10). We confined our analysis to a fifteen-year period (1979-1993). We also limited our sample to non-financial business units[1]. Our dependent variable was capital expenditures by each business unit *i* belonging to corporate parent *j* for each year *t*, normalized by business unit lagged assets (Capx_{ijt} / Asset_{ijt-1}). Our independent variables included the proportion of sales that the focal business unit represents within the firm (SALESHARE), the total number of business units in the target firm (N_{jt}) and a vector of dummy variables corresponding to year fixed effects. Moreover, we included several variables that control for the perceived "attractiveness" of a certain business unit. Specifically, we control for the growth rate of each business as the slope

[1] Including financial firms in the sample does not significantly alter our main results although we think that the relationship between investment and assets (the latter an important part of our model) in those firms is fundamentally different than the one in the rest of the economy. Similar treatment of financial industries can be found in the related literature (e.g. Ozbas and Scharfstein, 2007).

coefficient of a 5-year moving window exponential function of business unit sales[2]. We also control for differences in profitability by using an estimate of the business unit's rate of return, measured as the operating profit minus the cost of assets, all normalized by sales. We also included a control for the median level of investment that each business experiences in its own industry. We measure this as the (lagged one period) median of our dependent variable (capital spending over assets) for each industry defined at the 3-digit SIC code level. As an additional control for the quality of the investment opportunities available to each business unit in the sample we include an estimate of Tobin's Q in the regression. Because it is not possible to obtain Tobin's Q for each segment directly, we computed the median Q for all the stand-alone firms in every industry (at the 3-digit SIC code level) and assigned them to each business unit in a multi-business firm as proxy values of Q.[3] Finally, we used firm cash flow (normalized by firm sales) as a control for systematic differences in the amount of capital available across firms.

'Insert Table 1 about here'

2.2. Results

Table 2 (Models 1, 2 and 3) presents the results of the aforementioned regression for our sample. First, as expected, investment increases significantly with business unit growth, as well

[2] For each business unit-year, we fitted an exponential curve using the sales figures of the 5 years previous to the current year and used a simple linear regression to obtain the slope coefficient of that curve. This procedure reduces the noise contained in the yearly business unit sales figures reported by COMPUSTAT.

[3] One well-known limitation of COMPUSTAT segment data is the different criteria used by firms in deciding what constitutes a business unit. Moreover, the same firm might report business units differently over time. We decided to use a unifying criterion to avoid this problem. We used SIC codes to aggregate reported segments at the three-digit SIC code industry level. Thus, in our sample a firm has as many businesses as industries at the three-digit level. We note that consolidating segments using SIC codes is common in other segment-based studies of capital investment (e.g. Lamont,1997; Ozbas and Scharfstein 2007). Also, estimating Tobin's Q for multi-business firm segments using industry medians based on single-business firms is a standard practice in the literature (e.g. Rajan, Servaes and Zingales, 2000; Ozbas and Scharfstein, 2007)

as industry median investment. Second, there is a positive effect of Tobin's Q on business unit investment, a result that is consistent with previous studies that explore this relationship (e.g. Ozbas & Scharfstein, 2007).

Third, investment decreases with the size of the focal business unit with respect to the rest of its firm. This pattern is also consistent with the naïve diversification account, which predicts that a cognitive tendency toward even allocations would underweight differences in relative size among the business units that merit an increased allocation to larger units and thus, we would observe smaller average allocations to the larger divisions, as is the case. It is obvious that, in general, capital allocations to any business are going to be strongly correlated with its size. However, it is not so obvious why capital allocations should be correlated with the relative size of that business within its corporation. Why should an otherwise perfectly good business be shortchanged in its capital investment just because it coexists with much smaller divisions in the same company? Of course, a 1/n bias among all the divisions in a corporation predicts equal allocations to all of them, thus ignoring size differences among the divisions. For instance, a firm with only two divisions, one being significantly larger than the other, would have a bias toward allocating half of the budget to each one. Thus, after controlling for overall size and some other relevant factors, we might expect to observe a tendency toward 1/n in the form of more money for divisions with smaller relative size and less money for divisions with larger relative size.[4]

[4] On the other hand, relative size can help us to distinguish between the agency and the cognitive accounts that explain inefficient allocations. The variable size is not present at all in the models that attribute inefficiency to agency conflicts between headquarters and rent-seeking managers. For example, Scharfstein and Stein's (2000) key point is that managers in *weaker* divisions have a higher incentive to engage in rent-seeking behavior. However, it is hard to think how managers of *relatively smaller* divisions would have a higher incentive to rent-seek. Those relatively smaller divisions could have an excellent set of investment opportunities and thus their managers would not worry too much about lobbying. In fact, one could argue that relatively larger divisions should, on average, get a bigger share in the political squabbling due to their bigger clout within the corporation. Therefore, where the agency

'Insert Table 2 about here'

To illustrate this point, consider the two firms depicted in Figure 1B. In both cases, the assets of the target business units are the same and both firms have the same number of business units. The only difference is that the aggregate assets of the remaining business units are larger for Firm A than Firm B. Assuming that the target business units are comparable in most other relevant respects (e.g., in the same industry, face similar business opportunities), the naïve diversification account predicts that the capital allocation to the target division will be biased toward 1/2 in both cases so that the allocation will be larger to the target business unit in Firm A than Firm B because Firm A will have more capital to go around.

Finally, and most central to the present analysis, we observe that investment on the focal business unit decreases as the number of business units in the firm increases. This result reflects "partition dependence" in capital allocation and was predicted by our cognitive account in which managers tend toward naïve diversification of capital expenditures over business units in real firms.

In order to control for the possibility that the effect of the number of business units is mainly driven by firms that are diversifying their activities (and thus reallocate large amounts of capital from large profitable divisions to small new ones) we included a measure of specialization (Rumelt, 1974) consisting of the percentage of sales of the overall firm that the

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account predicts no effect of size in capital allocations (or even an advantage for relatively larger divisions), the cognitive account predicts an advantage for relatively smaller divisions.

largest business represents[5]. Specifically, we were interested in seeing whether the coefficient for N remained unchanged in the presence of this control variable. Model 3 in Table 2 shows that this is the case, lending additional consistency to our claim that the number of business units N affects capital allocations in a way that is not justifiable from economically rational grounds. To control for the possibility that our main result was just an artifact of the data we established a comparison between the multi-business firms in our sample and their stand-alone peers, using two samples. The first sample, which we call "Real," is made up of a number of multi-business firms in the COMPUSTAT files in the years mentioned. The second sample, which we call "Virtual," was obtained by randomly finding, for each one of the business units in the Real sample, a COMPUSTAT single-segment firm of similar size and industry[6]. Thus, the Virtual sample matched the major characteristics of the Real sample except that it lacked a layer of corporate management allocating capital over multiple business units. By construction, one would expect the number of segments *N* to have no effect for the firms in the Virtual sample. Using stand-alone firms as a benchmark for multi-business firms is a common device in the capital budgeting literature (e.g., Berger and Ofek 1995; Ozbas and Scharfstein 2007). Table 3 shows the basic regression estimates for each sample. We observe that N has no effect on investment in the "Virtual" sample, which is consistent with the notion that diversification bias requires the hand of management.

'Insert Table 3 about here'

[5] We use this measure because most of other standard diversification measures (e.g. Palepu, 1985) use the number of businesses in the firm as a basic part in its calculation and thus would correlate with our independent variable of interest (N).

[6] The matching by industry was made using 3-digit SIC codes. The matching by size was made by pairing businesses that were within 30% of the original business unit assets. Subject to these constraints we selected matching stand-alone business units at random.

In sum, the results of this regression analysis support the present interpretation of cross-subsidization in terms of naïve diversification over business units into which a firm is organized and extend the observation of cross-subsidization based on divisional performance to cross-subsidization based on size and number of units. Naturally, units with better business opportunities (as reflected by higher measures of growth and profitability rates) and larger business units (in terms of sales) tend to attract greater investment in both real and virtual firms.[7] However, when one holds these factors constant, there is a tendency for the focal business units to attract greater investment when they share corporate membership with larger businesses (so that there is more capital to spread around) and when they share corporate membership with fewer business units (so that there are fewer units with whom to share capital).

We acknowledge that there are inherent limitations to any analysis based on field data as we cannot cleanly manipulate the independent variables of interest. Moreover, although the present results were predicted by our cognitive account and generalize previous findings of cross-subsidization it may be possible to accommodate them by modifying previous accounts based on principal-agent conflicts and information asymmetries. For instance, in light of our results one might argue that every business unit manager lobbies relatively equally regardless of unit performance, or that corporate management defers relatively equally to the superior information available to managers of all business units. In order to further investigate the necessity of agency- and information-based explanations of cross-subsidization effects, we next turn to an experimental investigation of naïve diversification and partition dependence in which

[7] We note that the significance level of the size coefficient is much lager than that of the number coefficient. We suggest that this is largely due to methodological constraints: size has a valid objective measure in terms of total assets whereas the number of business units had to be inferred from the SIC industry codes which provide an imperfect measure of the actual divisional structure that corporate managers observe when making allocations.

we can cleanly manipulate the number of business units and hierarchical structure into which the firm is partitioned and isolate managers from social/political factors and information asymmetries.

3. Experimental Evidence.

In this section we present three experimental studies that test the naïve diversification account of internal capital allocations by examining whether finance-trained executive MBA students making hypothetical budgeting decisions are susceptible to partition dependence. Studying how individuals allocate capital in a simplified environment accomplishes two goals. First, it allows us to exert greater control by holding firm characteristics constant and manipulating only the number of divisions over which participants are asked to allocate capital. Thus, these experiments test the robustness of the results obtained in the previous section. Second, because the experimental capital budgeting task is stripped of any social or political context, a finding of partition dependence would suggest that agency conflicts and informational asymmetries are not *necessary* to produce the cross-subsidization pattern observed in the finance literature that we attribute to an individual cognitive bias. In each our experiments, we ask two groups of executives to allocate capital among the business units of a hypothetical firm. Each group faces a different partition of the business units within that firm. Thus, any differences in allocations between experimental conditions would provide evidence of a bias toward even

allocation without relying on any assumptions concerning normatively appropriate criteria for allocation.

Study 1: Centralized versus Decentralized Allocation

In the first study we test for partition dependence using a stylized capital allocation task that mimics an important feature of real organizational budgeting: its level of centralization. Some firms are characterized by a centralized capital investment process in which headquarters determine budgets for all investment projects throughout the firm, whereas other firms are characterized by a decentralized process in which headquarters only allocate among top level divisions and allow divisional managers to subdivide investment resources (Bower 1970). The present account suggests that the hierarchical level to which a manager's attention is drawn (top divisions versus business units) will influence the allocation of capital when there are a different number of business units under the major division. To illustrate, consider a firm in which one division is composed of three business units, one is composed of two business units, and one has a single business unit (i.e. six total business units). In this case, a bias toward even allocation in *decentralized* budgeting implies a bias toward one-third allocation to each of the three major divisions whereas *centralized* budgeting implies a bias toward 1/2 allocation to the first division (i.e., 1/6 to each of the three business units that comprise it), 1/3 allocation to the second division (1/6 to each of its two business units), and 1/6 allocation to the final division. We refer to these values to which allocations are biased as "ignorance prior" allocations because prior to learning something about each division or business unit even allocations might seem like a natural starting point. Of course, such even allocations cannot be easily defended on normative grounds.

Method

We recruited 64 participants in the Executive MBA program at the Australian Graduate School of Management to complete a 15-minute in-class survey. As payment, two participants were selected at random from the group to receive expensive ($100) bottles of wine. We presented participants with a four-page anonymous survey that included general instructions, information concerning the divisions of the firm, a request for a budget allocation, and a request to explain one's answers. We asked participants to complete the survey one page at a time and in the order that was given. Instructions and information concerning the company are reproduced in Appendix I.

We asked each participant to take the role of the top manager in charge of capital allocation in a hypothetical international consumer products company (see Figure 2A) with three main divisions (Home Care, Beauty Care and Health Care). Each division had a different number of geographical business units (Home Care was in the U.S., Europe and Latin America; Beauty Care was in the U.S. and Europe; and Health Care was only in the U.S.). Respondents in the *centralized allocation* condition (n = 32) were asked to allocate funds directly among all six business unit. Respondents in the *decentralized allocation* condition (n = 32), were asked to allocate capital only among the three main divisions (Home Care, Beauty Care and Health Care).

'Insert Figure 2A about here'

All participants were provided with a two-sided information sheet (a random side was face-up) that contained a brief description of each line of business and each geographical region as well as tables with financial figures. On one side of the information sheet, data were arranged

by line of business first and by geographical region second (in a hierarchical manner). On the other side of the information sheet, the order was reversed (first by region and then by line of business). In those tables, we provided respondents with the most basic financial figures regarding past performance (revenues, costs, profit margin and assets in the previous year) and a measure of expected future performance (Internal Rate of Return) that has been identified by managers as particularly relevant when making capital investment decisions (Graham and Harvey 2001). Some of the information provided to participants is shown in Appendix II.

Results

Results accorded with our prediction that allocations would be biased toward 1/3 for each division in the decentralized condition and toward 1/6 × the number of business units for each division in the decentralized condition (see Table 4). The present account predicts that respondents will exhibit partition dependence in their allocations of capital across divisions. In particular, allocation to the Health Care division should be higher in the decentralized condition (in which the ignorance prior allocation is 1/3) than in the centralized condition (in which the ignorance prior allocation is 1/6), the allocation to Home Care should be lower in the decentralized condition (in which the ignorance prior allocation is 1/3) than in the centralized condition (in which the ignorance prior is 1/2), and the allocation should be roughly equal across conditions for the Beauty Care division (in which the ignorance prior is 1/3 for both conditions). All three of these predictions were borne out in the data. The t-statistics for the difference between allocations in the decentralized versus centralized conditions were $t(45) = 5.71$, $t(53) = -4.07$, and $t(62) = -0.08$, for Health Care, Home Care, and Beauty care divisions, respectively.

'Insert Table 4 about here'

A casual inspection of Table 4 suggests that participants did not adhere strictly to the ignorance prior distribution on average. For instance, they allocated significantly less than 1/6 of the funds to the Home Care – Europe business unit ($t(31) = -4.22$) and significantly more than 1/6 to the Home Care – Latin America business unit ($t(31) = 5.26$). Furthermore, it is clear that participants in *both* elicitation conditions allocated more money than the corresponding ignorance prior to the Home Care division (the division with the highest average IRR) and less than the corresponding ignorance prior to the Beauty Care division (the division with the lowest average IRR), suggesting a tendency to rely on both the ignorance prior and a consideration of how the divisions differ. To examine this effect more carefully, we regressed mean allocations for each division on the corresponding ignorance prior and (mean divisional) IRR, obtaining $F(2,63) = 7.72$, $p < .001$, $R^2 = .38$, with significant weight on both the ignorance prior ($t(63) = 236$, $p<.001$) and IRR ($t(63)=2.88$, $p =.005$).

An internal analysis of responses provides further evidence that the results were not driven merely by a tendency of some participants to uncritically allocate precisely the ignorance prior distribution: no participant did so in the centralized condition and only 2 out of 32 participants did so in the decentralized condition. Omitting these responses does not qualitatively change any of the results reported above.

Finally, as noted earlier, we asked participants to provide a brief explanation of their decisions. Two hypothesis-blind judges coded each participant's explanation according to the categories into which it fell; each explanation could be characterized by more than one category. We recorded categories on which the judges agreed (they agreed on coding an average of 86% in

each category and we randomly resolved the disagreements). The results of this analysis are presented in Table 4b. It is worth noting that although nearly every participant (60 of 64) described at least one criterion in their explanation only 2 out of 64 respondents (3.1% of the total) explicitly mentioned use of a diversification rule. On the other hand, close to half the participants cited IRR as the main criterion for their allocations and more than half cited "potential for growth." Thus, it appears that while participants were aware of several criteria that they were using to vary allocation among divisions they were not aware of their bias toward even allocation[8].

'Insert Table 4b about here'

Study 2: Product versus Geographic Hierarchies

The previous study provides evidence of partition dependence among experienced managers in hypothetical capital allocation decisions. In particular, we found that allocations vary systematically with the budgeting procedure (centralized versus decentralized). We next turn to a replication of this result in a situation where all allocations are centralized and all firm information is held constant, but the administrative organization of the firm varies. Also, we wished to invoke a wider range of ignorance priors. Specifically, we used the same hypothetical firm as in Study 1, but this time we varied whether the firm was organized by geographic

[8] Also, we took the absolute difference between allocations and ignorance priors for each observation and took the average for each respondent. The median of those averages is **5.83%** for Study 1 and **5.93%** for Study 2, further supporting the idea that participants did not make 1/n allocations due to ignorance about the task or/and lack of motivation

division then product business unit or by product division then geographic business unit (see Figure 2B). This implies a range of ignorance prior allocations that vary from 1/9 to 1/3.

Method

We recruited a new sample of 40 Executive MBA students at the Australian Graduate School of Management in Sydney to complete a 15-minute survey in exchange for a chance to win a bottle of expensive ($100) wine. We discarded 3 of the surveys because of incomplete data. The procedure was identical to that of Study 1 with one important difference. Participants in the *geographic partition* condition (n = 18) were asked to indicate first the percentage of available capital they would allocate to each geographic division (U.S., Europe, Latin America) and then (on the following page) the percentage they would allocate to each product business unit (except for the case where there was a single product business unit). Participants in the *product partition* condition (n = 19) were asked to indicate first the percentage of available capital they would allocate to each product division (Home Care, Beauty Care, Health Care) and then (on the following page) the percentage they would allocate to each geographic business unit (except for the case where there was a single geographic business unit). The present account predicts that allocations to each business unit should be biased toward 1/3 times the reciprocal number of business units comprising the relevant parent division. Thus, for example, Health Care—U.S. should receive a larger allocation in the functional partition condition (ignorance prior = 1/3 x 1) than in the geographic partition condition (ignorance prior = 1/3 x 1/3 = 1/9), see Figure 2B.

Results

Results of Study 2 are displayed in Table 5 and accord closely with our predictions. In particular, it is evident that mean allocations closely track predicted ignorance prior distributions implied by even allocation at the level of divisions then business units within a division. First, as expected, allocations differed dramatically and significantly when ignorance priors differed most between conditions (Health Care – U.S. and Home Care – Latin America, ignorance priors of 1/3 versus 1/9). Second, as expected, allocations differed less dramatically, but significantly where ignorance priors differed less dramatically (Beauty Care – U.S. and Home Care – Europe, ignorance priors of 1/6 and 1/9). Finally, as expected, we observed no significant difference when ignorance priors were identical between conditions (Beauty Care – Europe and Home Care – U.S.). Plotting the difference in mean allocations across experimental conditions against the difference between ignorance priors (Figure 3) shows a close correspondence, with a Pearson correlation of 0.994.

'Insert Table 5 about here'

'Insert Figure 3 about here'

As with Study 1, we regressed allocations on ignorance prior and IRR, obtaining a significant fit of the model, $F(2, 36) = 25.23$, $R^2 = .33$, with a highly significant coefficient for the ignorance prior ($t(36) = 7.07$, $p < .001$) and a significant coefficient for IRR ($t(36) = 2.02$, $p = .05$).

As in Study 1, we asked participants to provide reasons for their answers and coded these responses using the same method. Again, we found that very few participants (less than 8%)

cited a desire to spread out their allocations evenly among the criteria they mentioned. Moreover, partition dependence does not appear to have been driven by a subset of participants who allocated budgets precisely evenly: only 2 people out of 37 used an exact 1/*n* split in their allocations. Moreover, there was high variance in these allocations; for instance, when allocating among the three main geographic regions participants' responses ranged from 10% to 70% of the total budget (ignorance prior = 1/3).

Study 3: Financial Incentives

In our first two studies finance-trained executive MBA students were presented highly simplified organizational capital allocation decisions and exhibited a pronounced degree of partition dependence in their allocations. We have interpreted these results as evidence of a cognitive bias in hypothetical capital allocation decisions. We have asserted that an individual experimental context can help us rule out the necessity of political and informational factors underlying the tendency toward cross-subsidization. However, it is possible that in the first two studies some participants considered the hypothetical fairness of allocations, implicitly invoking an "equality heuristic" (Messick, 1992) as the desire to maintain harmony of intergroup relationships and improve morale has been shown to drive people toward equal social allocations (Stake 1985; Leung and Park 1986). We note that none of the written protocols seemed to cite such an explanation. By introducing a financial incentive we hoped to further rule out the necessity of such a social account. In Study 3 we sought to test the robustness of partition dependence to an even more simplified allocation task involving a company with only two divisions and four business units in which we offered participants incentive-compatible payoffs.

Method

We recruited 63 Chilean executives enrolled in an Executive MBA program at UCLA, during a lecture on decision making. Participants were asked to take the role of the top management at a large firm that operates four business units in four geographical regions (Chile, U.S., Europe and Japan) and allocate $20 million of investment capital among these four divisions. To simplify the task and to link the task to real-world events, returns on the portfolio of projects in each division were to precisely track the performance of a prominent regional stock index the day following administration of the survey. The Chile division was linked to the Chilean IPSA index, the U.S. division to the Dow Jones Industrial Average, the Europe division to the German DAX index, and the Japan division to the Nikkei (see Appendix II). In particular, participants were told that the capital allocated to a division would yield a 20% return if the corresponding stock index went up in the following day and 0% if that index went down.

We randomly assigned participants to two groups. Participants in the *non-hierarchical* partition condition were asked to allocate, using percentages, the $20M among the four divisions in a single step. Participants in the *hierarchical* partition condition were asked to perform the allocation task in two steps. First, they were asked to divide the capital between a Domestic unit, which included only the Chile division, and a Foreign unit, which included the other three divisions. In the second stage, subjects had to subdivide the amount allocated to the Foreign unit among the three divisions (U.S., Europe and Japan). The order of presentation of business units was counterbalanced. We told participants that we would select two people at random and pay them the actual return of their total investment divided by 100,000. Thus, any individual had an opportunity to earn as much as $40 (or as little as nothing) for completing this fifteen-minute task.

Results

One respondent did not complete the survey and two other respondents had allocations that did not add up to 100% so these responses were omitted from further analysis. The results again provide strong evidence of partition dependence (see Table 6). The mean investment to Chile in the hierarchical condition was 43% (close to the ignorance prior of 1/2) whereas the mean investment in Chile in the non-hierarchical condition was only 26% (close to the ignorance prior of 1/4), a statistically significant difference ($t(51) = 3.83$, $p < 0.01$). Thus, partition dependence in allocation decisions extends to highly simplified situations with incentive-compatible payoffs.

'Insert Table 6 about here'

4. General Discussion.

In this paper we have provided evidence that the pattern of cross-subsidization of underperforming business units by better performing business units studied in the literature is more general than has been previously supposed. The analysis of archival data presented in Section 2 suggests that, holding relevant business unit and firm factors constant (e.g., assets of the focal and remaining business units, Tobin's Q of the focal industry), capital allocation to the focal business decreases with the number of business units into which the rest of the firm is partitioned. Moreover, holding the number of business units constant, we observed that the capital allocation to the focal business increases with the aggregate assets of the rest of the firm. Both of these patterns are consistent with a tendency of multi-business firms to naively diversify

their assets over all business units (i.e., a bias to allocate 1/*n* of the capital to each of *n* units). We attribute this pattern to a more general cognitive tendency to spread out allocations over all identified options, which has been observed in numerous studies of judgment and choice in the behavioral decision making literature.

In section 3, we turned to a set of experimental studies in which finance-trained executive MBA students performed capital allocations over alternative partitions of the same firm. Study 1 demonstrates that the bias toward equal allocation can give rise to investment in major divisions that varies dramatically depending on whether that investment is done on the level of major divisions (i.e., decisions are made in a decentralized manner) or on the level of business units (i.e., decisions are centralized). Study 2 extends the observation of partition dependence to show that investment to business units can vary systematically with normatively irrelevant adjustments to the organizational chart that prompt alternative partitions of the firm. In particular, allocations varied dramatically depending on whether participants allocated to product divisions then geographic business units or the other way around. Moreover, Study 2 shows that differences in the amount invested in business units closely track differences predicted by multi-stage naïve diversification. Study 3 shows that partition dependence is robust to even more simplified firms and to incentive-compatible payoffs.

Although one can legitimately argue that the survey-based experimental approach is a gross simplification of real-world capital allocation, this methodology provides several advantages that complement the analysis of archival data. First, by examining simplified decisions by individual managers we are able to eliminate the possibility of agency conflicts or informational asymmetries between divisional management and headquarters. Second, by using alternative partitions of the same firm, we are able to clearly observe naïve diversification while

remaining agnostic concerning what constitutes an "ideal" allocation. Third, by simplifying the information load on participants and offering summary measures such as IRR or stock index movements as predictors of investment outcomes, we are able to demonstrate the robustness of over-diversification beyond situations in which information is vague or inconsistent (as it often is in the real-world). Fourth, this methodology allows us to show the robustness of naïve diversification and partition dependence to situations where managers' incentives are aligned to maximize the returns of their investment allocations.

One might wonder the extent to which partition dependence would be observed if participants were more accountable for their decisions as they are in real-world contexts. Several previous studies have found that manipulations of accountability moderate a number of judgment and decision making biases (see e.g., Tetlock et al. 1989; Brown 1999). Individuals who are made to feel more accountable by being asked to justify their decisions in front of an audience often behave differently than those whose responses are kept confidential. To investigate whether we might observe such a pattern we replicated Study 1 using 144 students from an Executive MBA course. Participants in the "low-accountability" condition were told "your responses will remain confidential" whereas participants in the "high-accountability" condition were told "you might be selected to explain and justify your choices in front of the class" (this manipulation was modeled after Tetlock et al. 1989). If executives rely more heavily on socially accepted criteria for distinguishing among divisions (e.g., IRR) when they know they must justify their decisions publicly, then we would expect to observe less reliance on the ignorance prior distribution and less partition dependence in the "high accountability" condition. However, contrary to this prediction we found that participants in the "high accountability" condition made

allocations that were virtually indistinguishable from participants in the "low accountability" condition (see Table 7).

'Insert Table 7 about here'

Our results suggest a few prescriptive recommendations. First, top managers in charge of capital allocation might want to consider using more than one partition of the firm in their decision-making process. This can help them discover strong discrepancies in the amounts allocated to the same division, like the ones we observe in our experiments. Second, a firm could make the allocation process more focused on projects as opposed to business units as a whole. This would reduce the dependence on any specific partition. Third, naïve diversification will tend to favor small under-performing business units by giving them an allocation biased (upwards) toward 1/n. Thus, corporate managers should carefully revise the investment made in such businesses, as it is likely to be excessive given the quality and size of the business unit.

Despite the strengths of the present field- and experiment-based methodologies, we acknowledge several limitations in interpreting the present results. First, our experimental studies model the capital allocation process using a number simplifying assumptions: namely, that such decisions are made anew in a periodic and structured fashion by individual managers. Naturally, real-world capital allocations usually take into account past allocations, can be made in a continuous iterative fashion, and involve deliberation of multiple managers. It would be instructive to follow up the present results with experimental investigations of the role of past allocations on managers' decisions, the effects of making adjustments on tentative allocations, and the impact of making allocation decisions in groups. Clearly, any of these modifications

could potentially exacerbate or mitigate naïve diversification and partition dependence. Second, there is an inherent limitation in the precision of our measure of the number of divisions in our field data analysis. Using SIC codes at the 3-digit level as a proxy for what constitutes a business unit is admittedly an imperfect measure of N. On the other hand, we do not see how the error in this measure would correlate with our results in any meaningful way. Furthermore, the results of our comparison between the virtual and the real samples virtually rules out SIC code noise as the explanation of our findings.

Despite these limitations we are struck by the robustness of partition dependence using our simplified experimental paradigm. We are also struck by the fact that we were able to find evidence of this phenomenon in archival data of real-world decisions that encompass all of these factors and require us to make an educated guess concerning how managers frame the partition of their firms (by 3-digit industry SIC codes). In sum, whether one looks at capital allocations to a cross-section of real firms in a complex natural environment or to hypothetical firms in a controlled experimental environment, the result is the same: allocations are biased toward equality over the business units into which the firm happens to be partitioned.

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APPENDIX I. Instructions to Participants in Studies 1 and 2.

On a separate page, you will find information about an international consumer products firm, including descriptions of lines of business and geographical regions where it operates. Last year's financial figures for each line of business and region are also provided.

In addition to those numbers, you will find each division's Internal Rate of Return (IRR), which is the company's estimation of the future returns of the projects available in each line of business or region. The higher the IRR, the better the expectations for each division.

We would like you to take the role of the manager in charge of capital allocation for the entire firm. In the following pages of this survey, you must decide how to allocate the capital available for investment this year among the different divisions. Note that this is not the operational budget (advertising, etc) but rather the funds to be used for investment in developing new products, plant expansions, production technology improvements, etc.

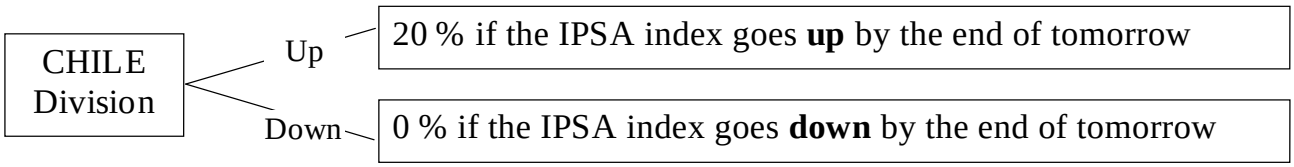
	Health Care		***Beauty Care***			***Home Care***			
	Total	*U.S.*	***Total***	*Europe*	*U.S.*	***Total***	*Latin America*	*Europe*	*U.S.*
Total Revenues	**8,370**	8,370	**10,420**	5,920	4,500	**12,130**	5,100	4,700	2,330
SG&A	**1,504**	1,504	**2,035**	1,035	1,000	**1,360**	410	450	500
Net Income	**1,640**	1,640	**2,020**	975	1,045	**2,310**	1,110	650	550
Total Assets	**3,245**	3,245	**4,750**	2,000	2,750	**5,105**	1,005	2,100	2,000
Net Income Margin	**20%**	20%	**19%**	16%	23%	**19%**	22%	14%	24%
IRR	**16%**	16%	**14%**	13%	15%	**15%**	17%	15%	13%

	Latin America		***Europe***			***United States***			
	Total	*Home Care*	***Total***	*Beauty Care*	*Home Care*	***Total***	*Health Care*	*Beauty Care*	*Home Care*
Total Revenues	**5,100**	5,100	**10,620**	5,920	4,700	**15,200**	8,370	4,500	2,330
SG&A	**1,504**	1,504	**1,485**	1,035	450	**3,004**	1,504	1,000	500
Net Income	**1,110**	1,110	**1,625**	975	650	**3,235**	1,640	1,045	550
Total Assets	**1,005**	1,005	**4,100**	2,000	2,100	**7,995**	3,245	2,750	2,000
Net Income Margin	**22%**	22%	**15%**	16%	14%	**21%**	20%	23%	24%

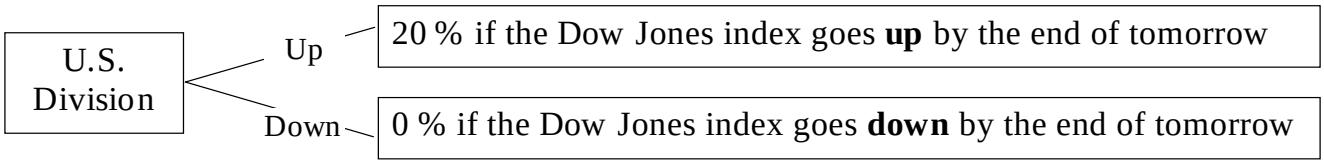
APPENDIX II. Instructions for Study 3.

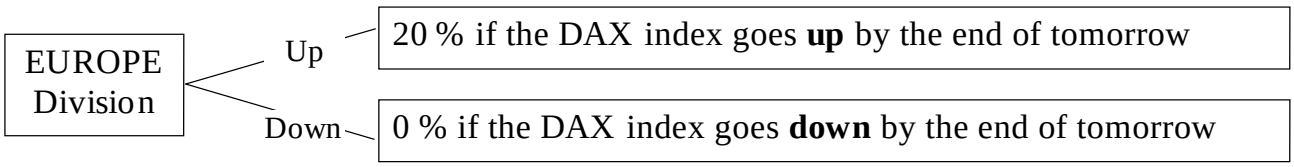
For each division, the aggregate expected returns of the portfolio of projects are presented below. For example, any amount of capital invested in the division that operates in Chile will yield a 20% return if the Chilean IPSA stock index goes up by the end of today and 0% return if it goes down.

Domestic Unit



Foreign Unit





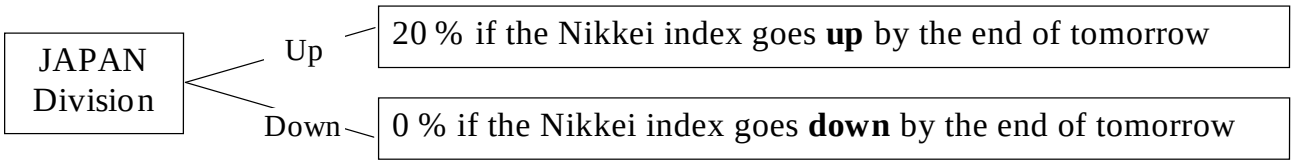


TABLE 1. Summary Statistics.

Variables	Mean	Median	St.Dev.	Min	Max
Investment (Dep. Var.)	0.090	0.062	0.132	0.00	4.99
Tobin's Q	1.045	0.969	0.297	0.50	3.46
BU Growth	0.046	0.048	0.170	-1.77	2.97
Industry Investment	0.060	0.054	0.034	0.00	0.56
BU Profitability	-0.018	0.015	0.395	-4.72	14.30
Saleshare	0.483	0.449	0.309	0.01	1.00
N	2.828	3.000	1.073	2.00	10.00
Diversification	0.625	0.656	0.251	0.01	1.00
Firm Cash-flow	0.086	0.114	0.434	-4.87	4.88

Correlation Matrix

	1	2	3	4	5	6	7	8
1 Tobin's Q	1							
2 BU Growth	0.025	1						
3 Industry Investment	-0.045	0.036	1					
4 BU Profitability	0.023	0.079	-0.030	1				
5 Saleshare	-0.019	0.041	0.058	0.046	1			
6 N	-0.090	-0.007	0.042	0.016	-0.353	1		
7 Diversification	-0.022	0.008	0.083	-0.029	0.626	-0.373	1	
8 Firm Cash-flow	-0.081	0.078	0.123	0.020	0.017	0.065	-0.016	1

TABLE 2. Estimating the effect of N on investment.

The dependent variable is yearly business unit capital expenditures over lagged business unit assets. Tobin's Q in the regression is the median Q for all the stand-alone firms in each business unit's industry (at the 3-digit SIC code level). BU Growth Rate of each business is measured as the slope coefficient of a 5-year moving window exponential function of business unit sales. Industry Investmetn is measured as the (lagged one period) median of our dependent variable (capital spending over assets) for each industry defined at the 3-digit SIC code level. BU Profitability is measured as the operating profit of a business unit minus the cost of its assets, all normalized by business unit sales. SALESHARE is the proportion of sales that each business unit represents within its firm. N is the total number of business units in each focal business unit's firm. Diversification is the "Specialization Ratio" proposed by Rumelt (1974), measured as the proportion of sales that the largest business in the focal business unit's firm represents. Coefficients for the time dummies not reported. All regressions include controls for error clustering within firms.

	(1)	(2)	(3)
Tobin's Q	0.02	0.021	0.021
	(3.00)**	(3.19)**	(3.25)**
Saleshare	-0.028	-0.039	-0.049
	(3.27)**	(4.84)**	(3.96)**
N	-0.003	-0.006	-0.005
	(2.00)*	(3.50)**	(3.30)**
Firm Cash-flow	0.026	0.013	0.013
	(5.79)**	(3.29)**	(3.31)**
Industry Investment		1.164	1.153
		(12.79)**	(12.76)**
BU Growth		0.065	0.065
		(4.86)**	(4.94)**
BU Profitability		0.006	0.007
		(1.67)	(1.81)
Diversification			0.023
			(1.54)
Constant	0.092	0.022	0.01
	(8.35)**	(1.97)*	(0.86)
Fixed Effects	Year	Year	Year
Observations	7432	7432	7432
R-squared	0.101	0.103	0.104

Robust t-statistics in parentheses

* significant at 5% level; ** significant at 1% level

TABLE 3. Real Firms vs. Virtual Firms.

The dependent variable is yearly business unit capital expenditures over lagged business unit assets. Tobin's Q in the regression is the median Q for all the stand-alone firms in each business unit's industry (at the 3-digit SIC code level). BU Growth Rate of each business is measured as the slope coefficient of a 5-year moving window exponential function of business unit sales. Industry Investment is measured as the (lagged one period) median of our dependent variable (capital spending over assets) for each industry defined at the 3-digit SIC code level. BU Profitability is measured as the operating profit of a business unit minus the cost of its assets, all normalized by business unit sales. SALESHARE is the proportion of sales that each business unit represents within its firm. N is the total number of business units in each focal business unit's firm. Coefficients for the time dummies not reported. All regressions include controls for error clustering within firms.

	Virtual	**Real**
Tobin's Q	-0.004	0.019
	(1.15)	(2.35)*
Relative Size	-0.005	-0.026
	(0.80)	(3.68)**
N	-0.001	-0.004
	-0.44	(3.19)**
Firm Cash-flow	-0.002	0.042
	(0.21)	(4.25)**
Industry Investment	1.025	1.163
	(14.59)**	(11.39)**
BU Growth	0.167	0.088
	(7.50)**	(5.49)**
BU Profitability	-0.002	0.006
	(1.43)	(1.15)
Constant	0.007	0.026
	(1.01)	(1.96)
Observations	5043	5127
R-squared	0.18	0.12

Robust t-statistics in parentheses

* significant at 5% level; ** significant at 1% level

TABLE 4. Mean responses for Study 1 (Centralized vs. Decentralized allocations).

	Decentralized Partition		Centralized Partition		t-test for the difference between means
	Ignorance prior	Mean	Ignorance prior	Mean	
Home US			*17%*	*16%*	
Home Europe			*17%*	*12%*	
Home Latin America			*17%*	*26%*	
Total Home	*33%*	*39%*	50%	54%	-4.07
Beauty US			*17%*	*15%*	
Beauty Europe			*17%*	*13%*	
Total Beauty	*33%*	*27%*	33%	27%	-0.08
Health US			*17%*	*19%*	
Total Health	*33%*	*33%*	17%	19%	5.71

TABLE 4b. Percentages of participants claiming use of each allocating criterion,

IRR	1/n Rule	Perceived potential to expand/growth	Perceived capability for innovation	Geographic presence	Revenue	Other criteria	No response
44.60%	3.10%	50.80%	27.70%	20.00%	15.40%	41.50%	6.20%

TABLE 5. Mean responses for Study 2 (Product vs. Geographical Hierarchies).

	Product Partition		Geographical partition		Difference between ig. priors	Difference between means	t-test for the diff. between means
	Ignorance prior	Mean allocations	Ignorance prior	Mean allocations			
Health Care - U.S.	33%	32%	11%	11%	22%	20%	7.85
Beauty Care - U.S.	17%	15%	11%	9%	6%	7%	5.66
Beauty Care - Europe	17%	14%	17%	14%	0%	0%	-0.91
Home Care - U.S.	11%	12%	11%	9%	0%	2%	1.77
Home Care - Europe	11%	10%	17%	14%	-6%	-4%	-2.53
Home Care - Latin America	11%	17%	33%	40%	-22%	-23%	-4.65

TABLE 5b. Percentages of participants claiming use of each allocating criterion.

IRR	1/n Rule	Perceived potential to expand/growth	Perceived capability for innovation	Geographic presence	Revenue	Other criteria	No response
28.90%	7.90%	50.00%	21.10%	15.80%	36.80%	7.90%	26.30%

TABLE 6. Mean responses for study 3 (Financial Incentives Study).

	Hierarchical partition		**Non-hierarchical partition**		**Difference between ign. priors**	**Difference between means**	**t-test for diff. between means**
	Ignorance prior	Mean allocations	Ignorance prior	Mean allocations			
Chile	50%	43%	25%	26%	25%	17%	3.83
U.S.	17%	21%	25%	26%	-8%	-5%	-2.20
Europe	17%	20%	25%	26%	-8%	-6%	-2.39
Japan	17%	15%	25%	21%	-8%	-6%	-2.12

TABLE 7. Mean responses for study 4 (Accountability Study).

	Centralized Partition		Decentralized Partition	
	High Account.	**Low Account.**	**High Account.**	**Low Account.**
Home US	*12.8%*	*12.9%*		
Home Europe	*12.6%*	*12.8%*		
Home Latin America	*20.5%*	*21.2%*		
Total Home	45.9%	46.9%	*35.0%*	*33.6%*
Beauty US	*18.2%*	*15.8%*		
Beauty Europe	*13.3%*	*15.0%*		
Total Beauty	31.5%	30.8%	*30.6%*	*28.3%*
Health US	*22.6%*	*22.7%*		
Total Health	16.7%	18.7%	*34.4%*	*38.1%*

FIGURE 1: A Schematic Illustration of Tests of Naïve Diversification in Capital Budgeting. Panel A illustrates the effect of the number of business units. Panel B illustrates the effect of the relative size of the rest of the firm.

Figure 1A

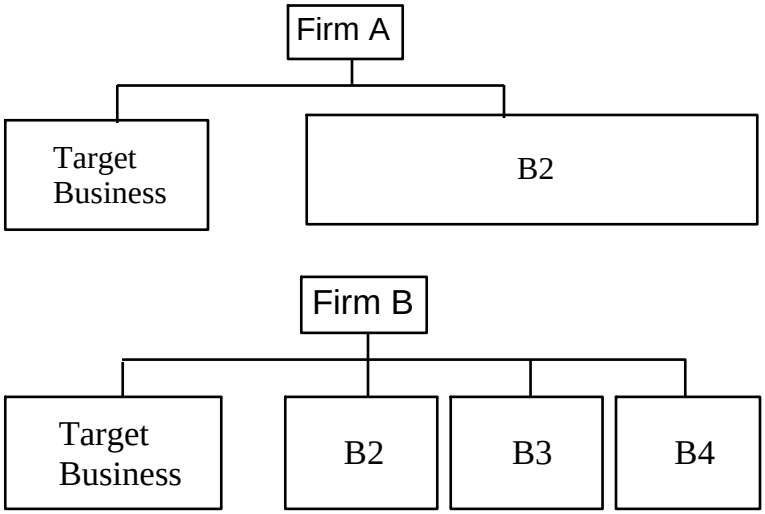


Figure 1B

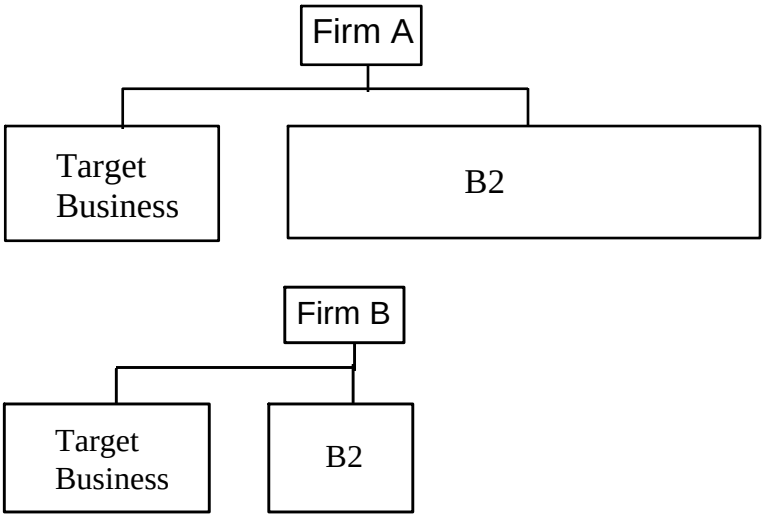


FIGURE 2: Schematic representation of experimental manipulations of firm partitioning.

Figure 2A displays the organization of the firm used in Study 1 in which one group of participants made a centralized allocation to the level of major divisions and the other group of participants made a decentralized allocation at the level of business units. Figure 2B displays the second version of the organizational chart implied by the instructions of Study 2. One group made allocations to product divisions then geographic business units (as represented in Figure 2A) whereas the other group made allocations to geographic divisions then product business units. Further instructions for both studies are given in the Appendix.

Figure 2A

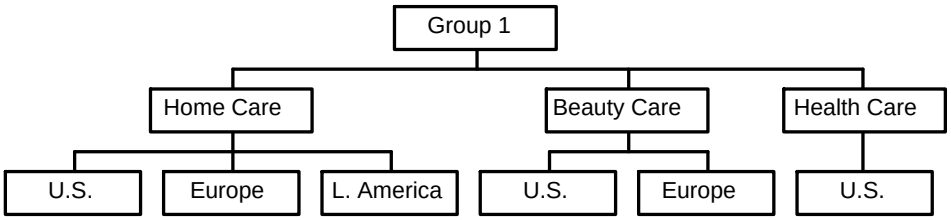


Figure 2B. First Product then Geographic

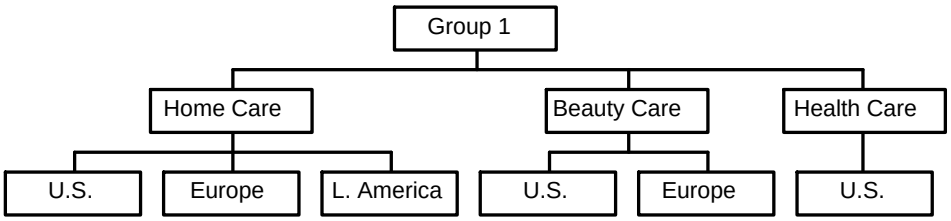


Figure 2B. First Geographic then Product

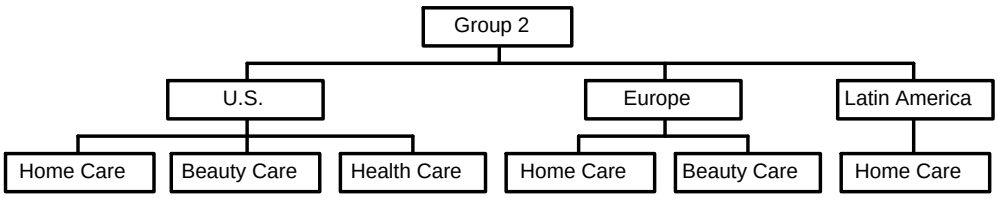


FIGURE 3. Correlation between differences in ignorance priors and differences in mean responses across the two conditions.