The Herfindahl-Hirschmann Index (HHI) Revisited

JULY 29, 2022

By TATENDA PASIPANODYA AND ANNE MARIE KNOTT

The Herfindahl-Hirschman Index (HHI) is one of the more commonly used measures in the Strategy and Economics literatures. While its principal uses are measuring market concentration or firm diversification, it has been extended beyond that. The measure has two properties that potentially affect empirical inference: 1) it is a compound measure--intentionally combining fewness and skewness; 2) any given HHI represents an infinite set of distributions. We assess whether these properties affect inferences in strategy research. To do so, we replicate a prior study which employs HHI to test the impact of geographic diversification on firm value. We find that results with HHI are not robust across samples and specifications. We further find that decomposing HHI into its fewness and skewness components resolves the robustness problem. In particular, firm value increases in the number of units, but decreases with dissimilarity across units. These results reinforce theories of related diversification.

* Pasipanodya: Washington University, One Brookings Drive, Campus Box 1133, St Louis, MO 63130 (email: m.pasipanodya@wustl.edu), Knott: Washington University, One Brookings Drive, Campus Box 1133, St Louis, MO 63130 (email: knott@wustl.edu)

I. Introduction

One of the more commonly used measures in the strategy and economics literatures is the Herfindahl-Hirschman Index (HHI). Its origins date to 1945, when Hirschman introduced it in the book, "National Power and the Structure of Foreign Trade" to measure market concentration. A very similar measure was reinvented by Herfindahl (1950) for the same purpose, and thus the measure has the compound name.

HHI entered the strategy literature when Song (1982) employed it to characterize the level of firms' diversification. Since that time, both the frequency and breadth of its use have grown, as shown in Figure 1. In the past decade alone, Giarratana and Santaló (2020) used HHI to examine how demand shocks affect diversification behavior in multiniche firms. Zahavi and Lavie (2013) used it to assess the performance implications of intra-industry diversification. Kaul and Wu (2016) used it in their analysis of acquisition target selection. Feldman, Gilson, and Villalonga (2014) used it to study how securities analysts help investors comprehend the value of diversification.

[Insert Figure 1 Here]

One concern with the measure is that an infinite variety of distribution shapes can have the same HHI. Most notably, for any value of HHI, there is both a uniform distribution and distributions which are highly skewed. This was by design—Hirschman wanted a measure that captured either "unequal distribution or fewness" (Hirschman, 1964), viewing the two dimensions as substitutes in capturing market concentration.

It's not clear these two dimensions are substitutes in other applications of HHI, however. In fact, the compound nature of HHI may actually inhibit insight. This is the second concern regarding the measure. Take for example, the use of HHI to measure corporate diversification. The compound nature makes it difficult to interpret what an increase in diversification actually means. More problematic is the possibility that the two dimensions of HHI may have different effects on firm value.

Finally, a third concern with HHI is that it is asymptotic. Because it is bounded by 1, a firm diversifying at a constant rate will appear to be decreasing its level of diversification over time.

This is a concern in empirics examining whether firms are becoming more or less diversified over time.

Our goal is to determine whether these properties of HHI affects empirical inferences. To do so, we replicate a prior study, Goetz, Laeven, Levine (2013) (hereforward GLL) which utilizes the HHI, plus three other measures, to examine the impact of geographic diversification on firm value. While there are numerous strategy applications of HHI, diversification is the most common. If results are sensitive to use of HHI here, it is likely they are elsewhere.

We first replicate the study's result that diversification decreases firm value. We then use the raw data, which the authors' generously shared, to construct five additional measures of diversification: count, entropy, dispersion, skewness and kurtosis. We construct all nine measures (four from GLL and five new ones) for the firms in our setting, then present pairwise comparisons of the measures to illustrate the extent to which they differ. We then employ the empirical model in GLL to test the relationship between each measure and firm value across a number of specifications and sample constructions.

We find first, that with the exception of count and the distributional shape measures dispersion, skewness and kurtosis, the coefficients on diversification measures change sign across specifications. Thus, choice of diversification measures does indeed affect inferences. Prior results concluding that diversification either increases or decreases performance are unlikely to be robust to specifications or sample restrictions.

We find second, that count is consistently positive, while the shape measures, which capture unit dissimilarity, are consistently negative. This is true in univariate fixed effects regressions, in regressions which combine count with other measures, and in instrumental variable regressions, where we instrument for count using state banking deregulations.

Taken together, the results indicate that the idiosyncratic properties of HHI that make it suitable for studies of market concentration, make it less suitable for at least one important application—diversification. Thus, researchers should confirm whether their application is closer to market concentration or diversification, before utilizing HHI.

While our primary goal was deductive--assessing the implications of HHI's properties for empirical design (measure choice), the results have implications for diversification theory as well. They suggest that while firm value increases in the number of units, it decreases with unit dissimilarity. This is consistent with expectations from Penrosian growth, where firms diversify to exploit slack in shared resources. Increases in the number of units, increases scale economies from shared resources, but unit dissimilarity increases the variety cost associated adapting the shared resources to disparate settings.

The paper proceeds as follows. First, we discuss the role of diversification. Next, we discuss the HHI measure, followed by a discussion of alternative diversification measures. Fourth and fifth, respectively, we discuss our empirical approach and results. Finally, we close with a discussion of implications.

II. What is Meant by Diversification

Diversification has long occupied a central place in strategy research. Penrose (1959) pioneered the idea that when faced with declining opportunities in their current market, firms could grow by diversifying into new markets that exploited slack resources. Chandler (1962) extended her thinking to define the organizational structure best suited to implement this resource-based growth. In particular, he advocated a multi-divisional form, with centralized control over strategic decisions, but decentralized control of operational decisions. Rumelt (1974) empirically tested the Penrose/Chandler view by first characterizing firms according to their organizational structure: single business, dominant-vertical, dominant-constrained, dominant-linked, dominant-unrelated, related-constrained, related-linked and unrelated. He next assessed the performance of firms with each structure, then compared across structures. He found that firms with related diversification structures had the highest performance, followed by those with a single business. Firms with unrelated diversification structures had the worst performance. These findings reinforced the Penrose/Chandler view that growth through diversification was valuable, but only when it exploited related resources.

While Rumelt utilized discrete measures of diversification (the eight structures), their construction required detailed analysis of firms' operations. Since then, strategy scholars have sought measures that were continuous as well as less labor intensive. Montgomery (1982) for example, used a slight variant of HHI to capture the categorical measures in Rumelt 1974. For all but two of the Rumelt categories, she found the correlations between the means of the continuous measure to be highly significant.

While the Penrosian motive for diversification is the most prevalent in strategy, it is worth noting that diversification is also thought to add value by risk-pooling, so as to minimize susceptibility to adverse changes in any given market. The risk pooling motive for diversification across markets mimics the motivation for diversification in investment portfolios. Markowitz (1952) argued that investors could achieve a given return at lower risk than that for any given stock, by choosing a portfolio of stocks for which the weighted sum of pairwise covariances in returns was minimized. Thus, for any level of tolerable risk, an investor should be able to construct a portfolio whose returns are higher than those of a single stock. Conversely, for any given level of returns, there should be a portfolio whose risk is lower than a single stock offering those returns.

Note that the two motives for diversification, resource exploitation and risk pooling appear to offer conflicting prescriptions. The resource exploitation motive implies greater performance when units are positively related; the risk-pooling motive implies greater performance when units are negatively related. This is not strictly true, of course. A firm's business units can be related along one dimension, while negatively correlated along another. The global cement company, Cemex, for example, is geographically diversified to minimize vulnerability to political and currency risk. However, operationally, all units produce the same commodity, which allows them to share centralized services, as well as technological and other forms of expertise.

Because these motives for diversification are so different, it's unlikely a single measure is appropriate for all forms of diversification. Indeed Gort (1962) advised that the "*choice of measure depends upon the problem one chooses to examine, to predict responses of output to fluctuations in the firm's primary industry, then you want a measure of how concentrated operations are in that industry,* e.g., *primary industries share of firm labor. Conversely, if you want to predict the likelihood of entering a more attractive industry, then a count of industries may be sufficient*" (Gort, 1962:10).

Accordingly, Gort tested three measures. The first measure was based on the share of payroll in the firm's primary industry; the second was based on the number of industries in which the firm produces; the third was a composite of the first two. This composite measure was the forerunner to use of HHI for measuring diversification. Gort used all three measures to characterize the level of diversification in a longitudinal panel of 111 large firms and a cross-section of 721 firms. The correlation between the share measure and the composite measure was 0.94, though Gort preferred the composite measure, because it was more stable across industry definition, e.g., 2-digit versus 4-digit SIC.

III. The Herfindahl-Hirschman Index (HHI)

What has come to be known as the Herfindahl-Hirschman Index (HHI) was developed by Herfindahl in his dissertation, "Concentration in the Steel Industry (1950).[1] The goal of the dissertation was to determine if the steel industry had become more or less monopolistic over time. To assess that, Herfindahl required a measure of monopoly power.

There were two approaches to measuring monopoly power at the time: measures of de facto power (such as the Lerner's (1934) index of price-cost margins), and concentration measures such as Crowder's (1937) percent of output controlled by the largest 4 firms in an industry (now referred to as the C-4 concentration ratio). While the Lerner measure "is a neat measure of the degree of monopoly power" (Herfindahl, 1950:22), reliable marginal cost data is rarely available. Thus, Herfindahl sought a measure constructed from readily available data that improved upon Crowder.

His two concerns with the Crowder measure were 1) it ignores the number of firms in the industry, and 2) it doesn't convey the extent of domination by the leading firms, which Herfindahl equated with inequality. Herfindahl felt the number of firms had an obvious bearing on the ability to collude, and while Crowder took the number of firms into account in his study, he did so separately from concentration. Herfindahl wanted a single measure of market power that captured both the number of firms and the distribution of output across them.

His measure, *C*, which here forward we refer to as HHI, is computed as the sum of the squares of firms' market shares:

$$C = \sum_{i=1}^{m} \left(\frac{x_i}{\sum_{i=1}^{m} x_i} \right)^2 = \sum_{i=1}^{m} (s)^2$$

where m is the number of firms, x_i is the output of the i^{th} firm, and s_i is its share of industry output.

One concern with HHI is that for any given value, there is an infinite variety of distributions that it represents. Herfindahl recognized this, and in fact constructed a table to show hypothetical distributions all sharing the same HHI. For example, an industry of two firms, each with 50%

[1] The measure became the Herfindahl-Hirschman index when it was discovered that Hirschman (1945) had earlier developed an almost identical measure for the same purpose. Hirschman (1964) describes the paternity of the index.

shares, has the same HHI (0.5) as an industry of five firms, with shares of 65%, 27%, 6.5%, 1.0% and 0.5%. (The corresponding C-4 measures would be 100% and 99.5%).

Relatedly, for any given HHI, there exists a uniform distribution with that HHI (though its count is not always an integer). In particular, the number of equal-sized firms that generate a given HHI is 1/HHI (Adelman 1969). Thus, the same HHI can capture a uniform distribution as well as a highly skewed distribution, as in Herfindahl's example.

A second, perhaps more important concern, is the compound nature of HHI. While fewness and skewness appear to be substitutes in gauging market power, it's unclear they are substitutes in other applications.

III. Use of HHI to Measure Diversification

The first use of HHI to measure diversification appears to be Berry (1971). Like Gort, he recognized that diversification should be gauged not just by the number of industries, but by the distribution of activity across industries, and cites Gort for that observation. Berry introduced "a more complete index of diversification", HHI, without discussing why HHI is more complete than Gort's. He then compared changes in the level of firms' diversification over time. He found that when using the count measure there had been a 48% increase in firms' diversification, but with HHI, there had only been 2.8% increase.

This is an artifact of an additional concern with HHI. It is asymptotic. Because it is bounded by 1 and 0, a firm diversifying at a constant rate will appear to be decreasing its level of diversification over time. For example, a firm which starts with 3 equal-sized units and grows that number by 20% each year, will have a diversification rate in year 15 that is less than half what it was in year 1 (Figure 2). This is a concern in empirics examining whether firms are becoming more or less diversified over time.

[Insert Figure 2 Here]

Another artifact of the asymptote problem occurred when Berry switched from a 4-digit to a 2-digit definition of industry. There he found the rate of diversification using HHI doubled, while the rate of diversification using count decreased by 60% (relative to the 4-digit rates).

Following Berry, diversification studies appear to have adopted HHI without much further discussion of the issues raised by Gort. This is true even for studies examining the risk pooling motive for diversification (Bettis 1981, Bettis and Hall 1982, Bettis and Mahajan 1985, Amit and Livnat 1988a, 1988b).

IV. Alternative Measures of Diversification

While HHI is the most common measure of diversification, there are others. Perhaps the most straightforward and long-lived measure of diversification is a simple count of a firm's business units (BU). These BUs can be defined by industry, as in Gort (1962) and Rumelt (1974), or by geographic market, as in Jacquemin and Berry (1979). While count captures the fewness aspect of diversification, it does not capture the share distribution across BUs.

This concern led to a commonly employed alternative to HHI, called the entropy measure (Jacquemin and Berry, 1979). Entropy is constructed in similar fashion to HHI—with the goal of expressing both the fewness and distribution of assets across units in a single continuous index. Not surprisingly, the entropy measure is highly correlated with HHI. Where it differs is in its weighting factor. Entropy is constructed as

(1) $$E = \sum_{i=1}^{n} s_i \ln\left(\frac{1}{s_i}\right)$$

where s_i denotes the ith subunit's share. Here a subunit's share is weighted by the logarithm of its inverse. Note that the weighting factor is increasing in s_i for HHI, while decreasing for entropy. Accordingly, while the value of HHI is principally influenced by large subunits, the opposite is true for entropy, it is principally influenced by small units. However, this difference notwithstanding, entropy is vulnerable to the same concerns we highlight for HHI—it is not unique. There is an infinite variety of distributions sharing any given value of entropy.

Four additional measures of a distribution's shape (similarity) seem relevant to diversification, though to our knowledge have not been used for that purpose: the standard (a distribution's 2nd moment), skewness (3rd moment) and kurtosis (4th moment). The standard deviation, σ, captures dispersion—how broad is the distribution; skewness, γ, captures the location of a distribution's peak relative to the center, while kurtosis, κ, captures the extent to which there is a peak. What distinguishes these measures from HHI and entropy is that they capture shape, while ignoring count.

Looking first at standard deviation, σ, it captures the breadth of a distribution—to what extent do units differ from one another. To minimize the impact of scale, we normalize σ by the mean of the distribution, μ, to form the coefficient of variation, *CV*:

(2) $$CV = \frac{1}{\bar{x}}\sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{(n-1)}}$$

where x_i is the firm's assets in unit *I*, and $\bar{x}$ is the firm's mean assets across all its units. Note this computation is only feasible for firms with at least three subunits (else the denominator is zero).

Looking next at skewness, left-skewed distributions (negative values of skewness), are characterized by long left tails, with the bulk of observations on the right. In contrast, right-skewed distributions— (positive values of skewness)—have long right tails, with the bulk of observations on the left. If a distribution is perfectly symmetrical, such that the mean is equal to the median, then its skewness is zero.

We follow Joanes and Gill (1998) in our construction of skewness, γ. In addition, since we are principally concerned with the extent of skew, rather than its directionally, we take the absolute value of skewness as our measure of diversification. Finally, since we don't have a full population of firms, we utilize the sample form of skew, given in Equation 3.

(3) $$S = \left| \frac{n}{(n-1)(n-2)} \sum_{i=1}^{n} \left(\frac{x_i - \bar{x}}{s} \right)^3 \right|$$

where σ is the sample standard deviation of the firm's assets across all units. Note this computation is only feasible for firms with at least three subunits (else the denominator is zero).

Next, we consider kurtosis, κ, which captures the flatness or peakedness of a distribution. Again, we follow Joanes and Gill (1998) in our construction, and normalize the measure so it captures not the raw value of kurtosis, but "excess kurtosis"—the peakedness or flatness beyond that in a normal distribution. A firm's diversification, measured as the excess kurtosis of its asset distribution, is thus given by equation 3.

(4) $$K = \left[\frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum_{i=1}^{n} \left(\frac{x_i - \bar{x}}{s} \right)^4 \right] - \frac{3(n-1)^2}{(n-2)(n-3)}$$

where x_i is the firm's assets in the ith location, $\bar{x}$ is the firm's mean assets across all its locations, and s is the standard deviation of the firm's assets across all locations.

In our context, kurtosis reflects how evenly assets are distributed across U.S. states: higher values denote more peaked distributions, lower (negative) values denote flatter distributions. For illustrative purposes,

To provide better intuition for these measures, we do two things. First, we provide a series of pairwise comparisons of the measures across all firms in our sample in Figure 3. These comparisons suggest that the various diversification measures appear to be capturing distinct phenomena.

[Insert Figure 3 Here]

In addition to the pairwise comparisons for the entire sample, we also present the evolution of each measure for the firm in our sample with the highest level of diversification. Figure 4a shows the introduction and evolution in scale for each subsidiary within the firm, while Figure 4b sows the corresponding evolution in each of the diversification measures over time. We don't display count, because it is obvious from Figure 4a. What you can see by comparing Figures 4a and 4b is that while entropy seems to track the growing diversity, HHI suggests there is little difference between the diversification in 1994, when there were five units and 2007, when there were 54 units. This is the asymptote problem with HHI captured in Figure 2.

Looking next at the shape measures, we see that CV is highly sensitive, when there are relatively few units (1991-1998), but thereafter the firm is maintaining a fairly constant level of breadth in unit size--the CV is less than twice the mean. The skew and kurtosis measures indicate the distribution is increasingly peaked and skewed. Figure 4a explains why. Units are increasingly clustering at the lower end of the size distribution.

IV. Empirical Approach

We now examine whether the differences in diversification measures captured in Figures 3 and 4 affect empirical inferences in strategy research.

A. Precedent paper

To assess whether the measure differences affect empirical inferences, we begin by replicating a prior paper, Goetz, Laeven, and Levine (2013) (GLL). GLL employs quarterly data on U.S. bank holding companies (BHC), to test the impact of geographic diversification on firm value using the following model:

$$q_{ist} = \beta D_{ist} + X'_{ist}\rho + \delta_i + \delta_t + \varepsilon_{ist}, \tag{4}$$

where q_{ist} (measured as *Tobin's q*), denotes firm value of BHC i, headquartered in state s, during quarter t. D_{ist} denotes the level of geographic diversification, captured using alternative measures in separate models, X'_{ist} is a matrix of conditioning information, and δ_i and δ_t are BHC and quarter fixed effects, respectively.

Because GLL have concerns similar to ours, they employ four alternative measures of diversification: (1) a *diversification dummy* equal to 1 if the BHC has subsidiaries (banks) in more than one state, and zero otherwise; (2) the *fraction of assets held out-of-state*; (3) the *HHI* of the BHC's assets across states, inverted to 1 – Herfindahl-Hirschman index, so that higher values correspond to higher levels of diversification; and (4) *Mean distance*, measured as the natural logarithm of the average distance between a BHC's headquarters and its subsidiaries. While we discuss the GLL results in greater detail in our replication, their main finding is that across all four measures, geographic diversification reduces BHC value. The authors interpret this as evidence that diversification intensifies agency problems within BHCs.

B. Efforts to control for firm choice to diversify

Equation 6 is a firm fixed effects specification. Thus, in principle it ties changes in firm value to changes in levels of diversification. Having said that, there may be firm characteristics that jointly drive firm value and diversification, and thus firm value increases (or decreases) along with diversification, but not because of it. We employ two approaches to address that possibility. Because our diversification measures are continuous, rather than discrete, it is difficult to use a matching approach like that in Villalonga (2004). Accordingly, we follow GLL in using an instrumental variable (IV) approach.[2] Our IV is the year in which each state enacted laws allowing out-of-state BHCs to hold in-state banks. Note that the Riegle-Neal Interstate Banking and Branching Efficiency Act was a federal effort to remove restrictions on interstate banking and create uniformity across states, but by then 48 states allowed some form of interstate banking.

B. Data

The GLL dataset, which we employ, is drawn from two sources. The first source is the Consolidated Financial Statements for Bank Holding Companies (FR Y-9C report), collected by the Federal Reserve from domestic BHCs. These reports provide quarterly data obtained from balance sheets, income statements, and detailed supporting schedules. The second source is the Reports of Condition and Income (Call Reports) available through the Federal Financial Institutions Examination Council (FFIEC), also collected on a quarterly basis. While the FR Y-9C report is at the BHC level, Call Reports are at the bank level (BHC subsidiary). GLL were generous in sharing the data used for their tests, as well as the code for matching the FR Y-9C and Call Report data.

Following GLL, we merged the banking data with information on stock prices from the Center for Research in Security Prices (CRSP) and calculated *Tobin's q* as the sum of market capitalization, total liabilities, and perpetual preferred stock divided by the value of total assets.

While we began with the GLL dataset, we needed to add subsidiary data to form the new diversification measures. These data included detailed information on 125,216 subsidiary-quarter observations for 993 unique BHCs, covering the same period as the GLL. With this new file we

[2] Note that GLL also employ a difference in differences (DiD) approach. In particular, they examine firm value leading up to and following the time the firm first diversifies, and find that there is no pre-trend, but that there is a significant decrease in firm value following first diversification. Because we are interested in assessing continuous measures of diversification, the DiD approach wasn't feasible.

generated the five new diversification measures and replicated the existing four measures in GLL, then aggregated the data to the BHC-quarter level. Following GLL, we omitted observations with outlier values for *Tobin's q* (the bottom and top 1% of the distribution). Once aggregated, the "recreated dataset" comprised 31,830 BHC-quarter for 950 unique BHCs (versus 992 in the GLL dataset) from the third quarter of 1986 to the fourth quarter of 2007. Summary statistics for the data are provided in Table 1.

[Insert Table 1 Here]

V. Results

A. Replication of GLL

Results for tests of equation 6 for the original GLL measures along with the new measures are reported in Table 2. Models 1-4 comprise the replication of GLL Results for the replication match those in GLL, indicating we have faithfully reproduced their data and empirical estimation.[3] As in GLL, we find a negative relationship between geographic diversification and firm value for each of their measures.

The remaining models in Table 2 introduce the alternative diversification measures (count entropy, dispersion, skew and kurtosis. Results with the new measures are less consistent than the GLL measures. The coefficient estimates indicate that firm value increases with the count of states in which the BHC is active, as well as with entropy. However, it decreases with each of the shape measures. Thus, inferences about the impact of diversification on firm value vary substantially across diversification measures.

[Insert Table 2 Here]

To further explore the sensitivity of results to choice of diversification measure, we restrict the set of observations to those BHC-quarters in which the BHC is operating in at least two states (the number required to form *CV*). Only 21% of observations meet this criterion. This "almost-

[3] Note we cluster standard errors at the BHC, while GLL cluster at the state-quarter. As a consequence, while are coefficient estimates are identical, their coefficients are reported as significant, while ours are not.

balanced"[4] panel allows us to see if changes in coefficient estimates across measures are due to sample restrictions necessitated by some measures, versus due to the measures themselves. Results with this panel are reported in Table 3. The coefficients on all the measures other than the shape measures (CV, skew, kurtosis), are now positive. This likely reflects the fact that at this level of diversification, each of the measures is largely registering increases in extent of diversification (number of states), rather than dissimilarity across states. The coefficients the shape measures continue to be negative, though *skew* and *kurtosis* are unchanged because their sample is unchanged from Table 2. The li

[Insert Table 3 Here]

Because count and shape appear to have competing effects, we conduct an additional test, where we replicate Table 2, but add *count of states* to each model. This allows us to see the relative contributions of the two components of diversification that Herfindahl intentionally combined: unequal distribution and fewness. These results are reported in Table 4. In all models, the coefficient for *count of states* is positive and significant, while the coefficients for all other diversification measures are negative.

[Insert Table 4 Here]

The results across Tables 2-4 indicate that the relationship between diversification and firm value is actually twofold: *Tobin's q* is consistently and significantly increasing in the *count of states* in which a BHC is active, but decreasing in all measures of dissimilarity. This strategically important nuance is obscured when using compound measures, such as HHI and entropy. More importantly, the results suggest that HHI is not useful as a measure of diversification—count and shape aren't substitutes for capturing diversification as they are for capturing concentration.

[Insert Table 4 Here]

[4] Skewness restricts observations to those in which the BHC operates in at least three states, which Kurtosis restricts it to 4 states. Since only 5.6% of the sample fits this requirement, we used a panel that was balanced other than for those two measures.

C. Models Controlling for Selection Effects

The results in Tables 2-4 are derived from firm fixed effects specifications. Thus, in principle they tie changes in firm value to changes in levels of diversification. However, it is possible, that some other factor drives both firm value and diversification. GLL address this concern by employing a dynamic difference in differences (DiD) approach, in which they examine firm value ten quarters prior to and ten quarters following the year in which a firm first establishes an out of state subsidiary. They find there is no pre-trend in *Tobin's Q* prior to diversification, but that *Tobin's Q* decreases in each quarter thereafter. We can't use a DiD approach for our purposes, because our measures are continuous—we look at extent of diversification rather than whether a firm diversifies. Nevertheless, the GLL results are useful in that they provide fairly convincing evidence against an underlying factor that is driving both firm value and diversification.

GLL also employ another approach to dealing with selection effects--an instrumental variable (IV) which should have no influence on firm value other than through its effect on diversification. Their IV is time since the BHC's headquarters' state enacted laws allowing out of state bank holding companies to hold in-state banks.

Note that the Riegle-Neal Interstate Banking and Branching Efficiency Act was a federal effort to remove restrictions on interstate banking and create uniformity across states, but by then 48 states allowed some form of interstate banking.

We follow GLL in employing the same instrumental variable. In the first stage, we model the *count of states* in which a BHC has subsidiaries as a function of time since the BHC headquarters' state deregulated banking. In the second stage, we model the impact of *count* and other measures of diversification on firm value. While econometrically, it would be feasible to use any of the diversification measures in the first stage, to solve the selection problem, we want the measure to reflect what firms are choosing in response to deregulation. Of our diversification measures, the most obvious choice was *count of states*. This most closely reflects a decision to further diversify. The other measures seem implausible. Firms don't attempt to optimize mean distance, HHI, entropy, dispersion, skewness or kurtosis.

Results for the IV model are presented in Table 5. These match results in Table 4 after accounting for the firm choice to diversify. Firm value is increasing in *count* but decreasing in all other measures of diversification when controlling for *count.*

[Insert Table 5 Here]

Thus, the main results as well as those from efforts to address selection effects, indicate that results with HHI are not robust. More importantly, the results indicate that the compound nature of HHI is inappropriate for measuring diversification, because the two components, fewness and skewness are not substitutes. In fact, they seem to compete with one another. While increasing *count* increases firm value, that value decreases in the level of dissimilarity, at least in this setting and for this form of diversification.

C. Inductive Exploration of Results

While our primary goal was deductive--assessing the implications of HHI's compound nature and non-uniqueness for empirical design (measure choice), the result that count was positive and significant in specifications, while shape (dissimilarity) was negative has potential implications for diversification theory. This led to inductive exploration of how unit similarity might increase the value of expansion into new markets.

The most obvious reason similarity might increase value is that when units are similar, it is more likely they can share resources. This is most apparent for chains, such as the banks in our setting, where unit scale determines the number of products/services offered, their layout, their management structure, their capital and labor requirements, as well as their operational routines. In addition, similarity makes it more likely that units can share HQ services such as advertising, legal, information systems.

While chains principally employ a geographic diversification strategy, we believe greater ability to share resources when divisions are similar likely also holds for product market diversification. Cisco, for example, entered into new products/services that complemented its router (Brueller and Capron, 2010). This allowed "one stop shopping" for their IT clients. Thus, product similarity allowed Cisco's product lines to share sales force, distribution, and service networks on the back end, and likely R&D on the front-end. Note that in the case of chains the most useful dimension of similarity is likely scale, as was used in the analysis here. In the case of Cisco, the dimension of similarity might be customer base.

We attempt to capture this equivalence between geographic and product market diversification in Table 6. What the table conveys is that product market diversification and geographic diversification are essentially inverses. What one holds constant, the other varies.

[Insert Table 6 Here]

An alternative reason similarity might appear to increase firm value in our setting is a simple optimal scale story. When firms enter new markets in Penrosian fashion to exploit slack resources, we expect those units to be small initially, such that the slack resources can create value. In this instance, dissimilarity merely represents deviations from optimal scale. Moreover, increasing similarity increases firm value, because it represents convergence toward optimal scale. In this case, similarity isn't valuable in an of itself, it merely represents having achieved efficient scale. In an effort to tease apart these two explanations for the correlation between firm value and unit similarity, we examine a single case.

Figure 4a, introduced previously to capture differences across measures, showed the evolution in scale (total assets) of each bank in a single BHC. What we now call attention to is the fact that when banks are added to the BHC they initially have trivial scale. The banks all grow substantially. While there is some evidence that the size of some banks plateau, this is certainly not true of all banks. In fact, the largest banks, appear to be the least likely to plateau. Thus, there doesn't appear to be an optimal scale, rather it appears that banks whose scale plateaus, may be in saturated markets.

We investigate that further by comparing Figure 4a to Figure 5. While Figure 4b tracked the evolution in diversification measures for the BHC in Figure 4a, Figure 5 tracks how firm value responds to the evolution in units. The figure indicates that *Tobin's Q* is inversely related to dispersion across units (CV=sigma/mu). As CV decreases from 1990-1995, Tobin's Q increases, but as CV increases from 1995 to 1999, Tobin's Q decreases. This cycle repeats itself from 1999 to 2007. Taken together, the figures suggest that the value of diversification for this BHC seems to stem from scale-free resources that are more easily shared across similar units, or that subsidiary banks are easier to manage when they are similar.

VI. Discussion

Our goals in this paper were two-fold. First, we wanted to remind researchers that *HHI* intentionally confounds fewness (count) and skewness (shape or dissimilarity). As a consequence, for any given value of HHI, there is an infinite variety of distributions it captures. Second, we wanted to assess the implication of this compounding for empirical inferences in strategy.

To conduct our assessment, we replicated an existing test of the impact of geographic diversification on firm value. We then expanded the replication to include additional diversification measures, a number of sample restrictions, as well as a decomposition of the compound measures into its two components: count and shape.

This set of tests produced three notable insights. First, we found that results with all measures, other than count and shape, changed sign across the full sample (Table 2), and a balanced panel (Table 3). Second, we found that decomposing diversification measures into their count and shape components led to more reliable results. In particular, count was positive and significant in all specifications, while shape was negative and significant, when controlling for count. Firm value increases in the number of units but decreases in their dissimilarity. Thus, we suggest that at least for diversification applications, count and shape be considered separately. These results were robust to efforts to control for selection effects through use of an instrumental variable.

While we intended our main contribution to be for empirical design—understanding the implications of using HHI for empirical inferences, we believe our results offer theoretical insights for strategy as well. In particular the results reinforce the resource-based view of value creation through related diversification that exploits slack resources.

While we neither know, nor measure, what resources are shared in our setting, the fact that BHC value increases with the number of banks (states), suggests the shared resources are ones subject to scale economies—most likely scale-free resources. Details from a Banc One case (Uyterhoeven and Hart 1993) identify a number of centralized services with this character: regulatory compliance, market research, electronic transaction processing, financial reporting and management, as well as R&D.

While these shared services merely require scale (count) to add value, the similarity result suggests that some shared resources also require subsidiary banks to be similar. One such resource is bank-level operational routines, such as which customers to serve and how to serve them.

Another is innovation, in that innovations developed at one bank are more likely applicable to other banks, the more similar the banks.

Finally, when units are similar, they are more readily compared to one another. The most obvious benefit of comparison is that it facilitates monitoring—identifying laggard units. However, a more powerful benefit is that comparisons facilitate continuous improvement, as in the case of Banc One (Knott and Turner 2019). Each month, banks are compared on their financial performance. Laggard banks are required to contact the leader banks to learn (and implement) their superior practices. Because bank president compensation is tied to relative performance, this imitation of best practices by laggards triggers innovation by leaders to regain their performance advantage.

Beyond the empirical contribution regarding measures, and the theoretical contribution regarding the organizational sub-structure that best supports a related diversification strategy, our results offer managerial prescription as well. To increase firm value, managers should increase the number of units, while maintaining similarity across them. Such prescriptions aren't possible when using HHI as the measure of diversification, because each value of HHI confounds count and shape.

There are caveats to our results and conclusions, of course. First, we look only at one application for diversification measures—geographic diversification. It is possible that results are more consistent across samples and specifications for other applications, such as diversification to reduce risk (Markowitz 1952). Similarly, we look only at one context for geographic diversification—U.S. banks. Results may differ in other industries or other countries. Finally, we used the dollar value of assets to capture differences across units (banks). There are numerous other dimensions of business unit relatedness, such as market demographics, shared inputs/outputs, and underlying technology. Results may differ for these other dimensions.

Rather than recommending tests in these alternative applications and settings, we recommend that scholars think carefully about the mechanism of diversification likely to create value in a given context and choose the measure best matching that mechanism. When the mechanism is utilization of slack resources, it is likely the most robust results will come from examining count and shape separately.

Note that our results say nothing about the implications of using HHI for studies of market concentration. Theoretical work indicates that at least under Cournot competition, fewness and skewness are substitutes, and thus combining them in a single measure makes sense (Spiegel

2020). Indeed, this was the logic of both Hirschman and Herfindahl when creating the HHI measure. Nor do our results say anything about employing HHI for the other strategy purposes in Figure 1, such as technological focus, ownership concentration and team diversity. However, the results do suggest that researchers consider the relationship between count and shape for their phenomenon of interest. Are count and shape substitutes, as they are in capturing market concentration, or are they independent, as in our setting. Moreover, the results suggest the need for robustness checks of HHI in these other applications.

We believe our main insights hold regardless of setting. Measures like HHI that combine count and shape limit our understanding of how diversification influences firm behavior and performance. Perhaps most importantly, results with HHI are not robust across specifications and sample restrictions.

REFERENCES

Adelman, M.A. (1969) Comment on the "H" Concentration Measure as a Numbers-Equivalent, *The Review of Economics and Statistics*, *51*(1), 99-101.

Brueller, N and L. Capron (2010). Cisco Systems: New Millennium - New Acquisition Strategy?, Harvard Business Publishing INS121-PDF-ENG

Chandler, A. D. (1962). *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. MIT Press.

Crowder, W.R. (1937) The Concentration of Production in Manufacturing in Thorp, W.L. and W.R Crowder and Associates, eds., *The Structure of Industry*, TNEC monograph No. 27.

Feldman, E., S. Gilson, and B. Villalonga, (2014). Do analysts add value when they most can? Evidence from corporate spin-offs. *Strategic Management Journal,* 35(10), 1446-1463.

Giarratana, M. and R. Santaló (2020) Product-market competition and resource redeployment in multi-business firms. *Strategic Management Journal*, 41(10): 1799-1836.

Goetz, M. R., Laeven, L., & Levine, R. (2013). Identifying the Valuation Effects and Agency Costs of Corporate Diversification. *Review of Financial Studies*, *26*(7), 1787–1823.

Gort, M. (1962). *Diversification and integration in American industry: a study by the National Bureau of Economic Research*. Princeton University Press.

Helfat, C. E., & Eisenhardt, K. M. (2004). Inter-temporal economies of scope, organizational modularity, and the dynamics of diversification. *Strategic Management Journal*, 25(13), 1217-1232.

Herfindahl, O (1950) *Concentration in the Steel Industry*, Unpublished Doctoral Dissertation.

Hirschman, A. (1945) *National Power and the Structure of Foreign Trade*. University of California Press.

Hirschman, A. (1964) *The Paternity of an Index*, American Economic Review, *54*(5), 761.

Jacquemin, A. P., & Berry, C. H. (1979). Entropy Measure of Diversification and Corporate Growth. *The Journal of Industrial Economics*, *27*(4), 359–369.

Joanes, D. N., & Gill, C. A. (1998). Comparing Measures of Sample Skewness and Kurtosis. *Journal of the Royal Statistical Society: Series D, 47*(1), 183-189.

Kaul, A and B. Wu (2016) A Capabilities-Based Perspective on Target Selection in Acquisitions. *Strategic Management Journal* 37: 1220-1239

Knott, A.M. and S. Turner (2019). "An Innovation Theory of Headquarters Value in Multibusiness Firms", *Organization Science* 30(1): 19-39

Lerner, A. P. (1934) The Concept of Monopoly and the Measurement of Monopoly Power, *Review of Economic Studies*, *1*(3): 157-175.

Lieberman, M., G. Lee and T. Folta (2017) Entry, Exit and the Potential for Resource Redeployment, *Strategic Management Journal*, *38*(3), 526-544.

Lubatkin, M., Merchant, H., & Srinivasan, N. (1993). Construct Validity of Some Unweighted Product-Count Diversification Measures. *Strategic Management Journal*, *14*(6), 433–449.

Markowitz, H. M. (1952). Portfolio Selection. *The Journal of Finance*, *7*(1), 77-91.

Penrose, E. T. (1959). *The Theory of the Growth of the Firm*. John Wiley & Sons.

Rumelt, R. P. (1974). *Strategy, Structure, and Economic Performance*. Harvard Business School Press.

Sakhartov, A. and T. Folta (2014) Resource Relatedness, Redeployability and Firm Value. *Strategic Management Journal*, *35*(12), 1781-1797.

Song, J. H. (1982). Diversification Strategies and the Experience of Top Executives of Large Firms. *Strategic Management Journal*, *3*(4), 377-380.

Spiegel, Y. (2020) The Herfindahl-Hirschman Index and the Distribution of Social Surplus. *Journal of Industrial Economics*, forthcoming.

Uyterhoeven, Hugo, and Myra M. Hart. 1996. "BANC ONE - 1993." Harvard Business School Case 394-043.

Villalonga, B. (2004). Does Diversification Cause the "Diversification Discount"? *Financial Management, 33*(2), 5-27.

Zahavi, T. and D. Lavie (2013) Intra-industry diversification and firm performance. *Strategic Management Journal*, 34(8): 978-998.

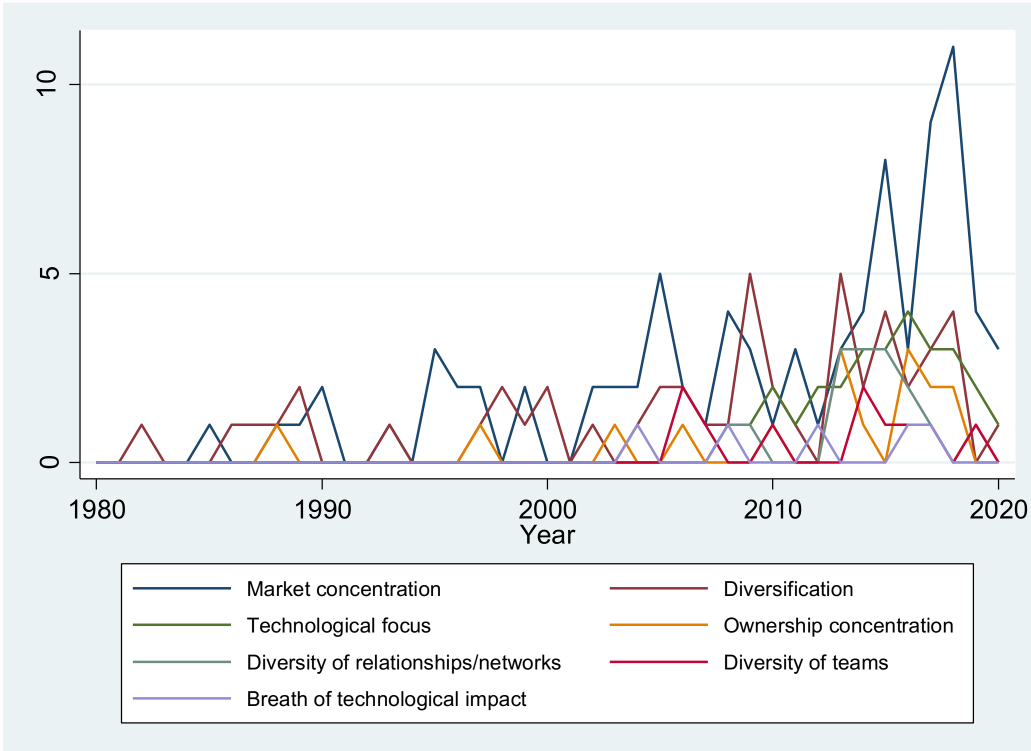

FIGURE 1. HERFINDAHL MAJOR USES ACROSS TIME, 1980-2020

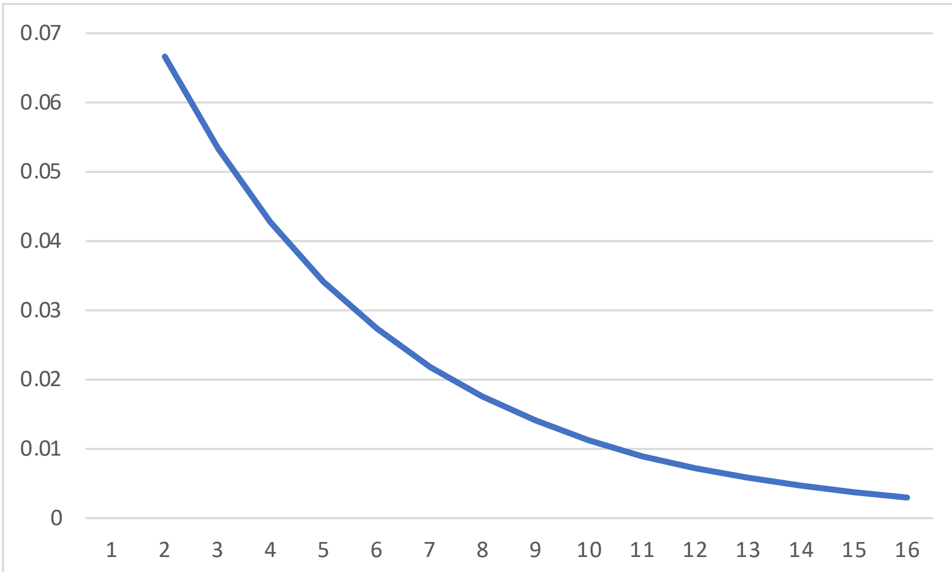

FIGURE 2. CHANGE IN 1-HHI FOR FIRM WITH CONSTANT 20% GROWTH IN NUMBER OF UNITS

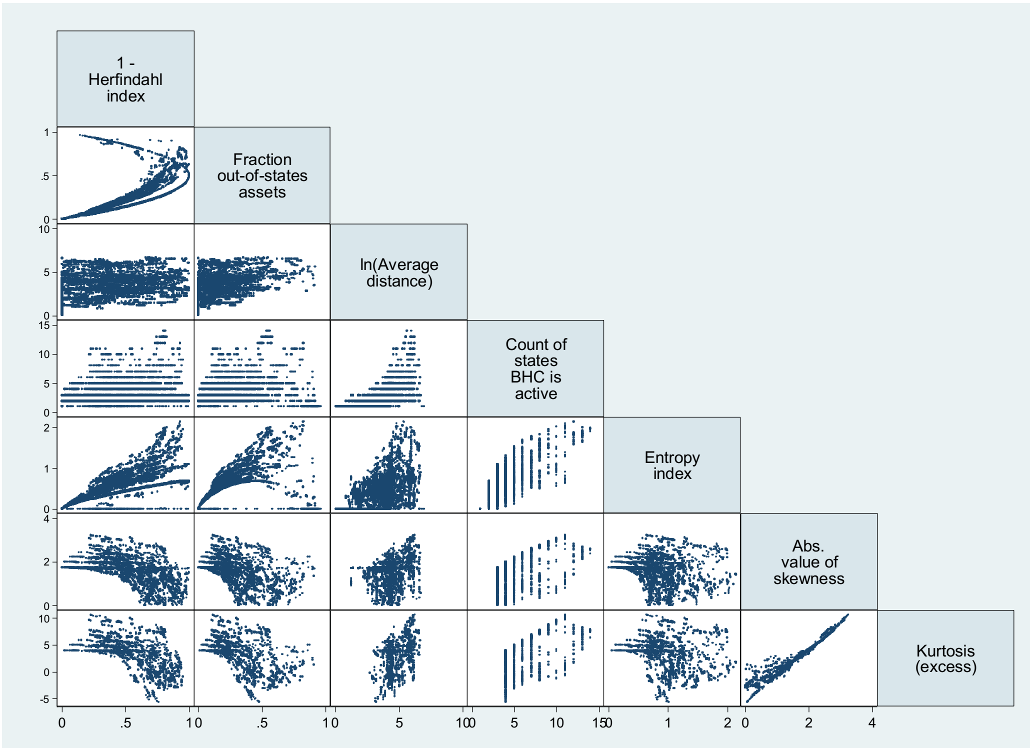

FIGURE 3. CORRELATIONS BETWEEN DIVERSIFICATION MEASURES

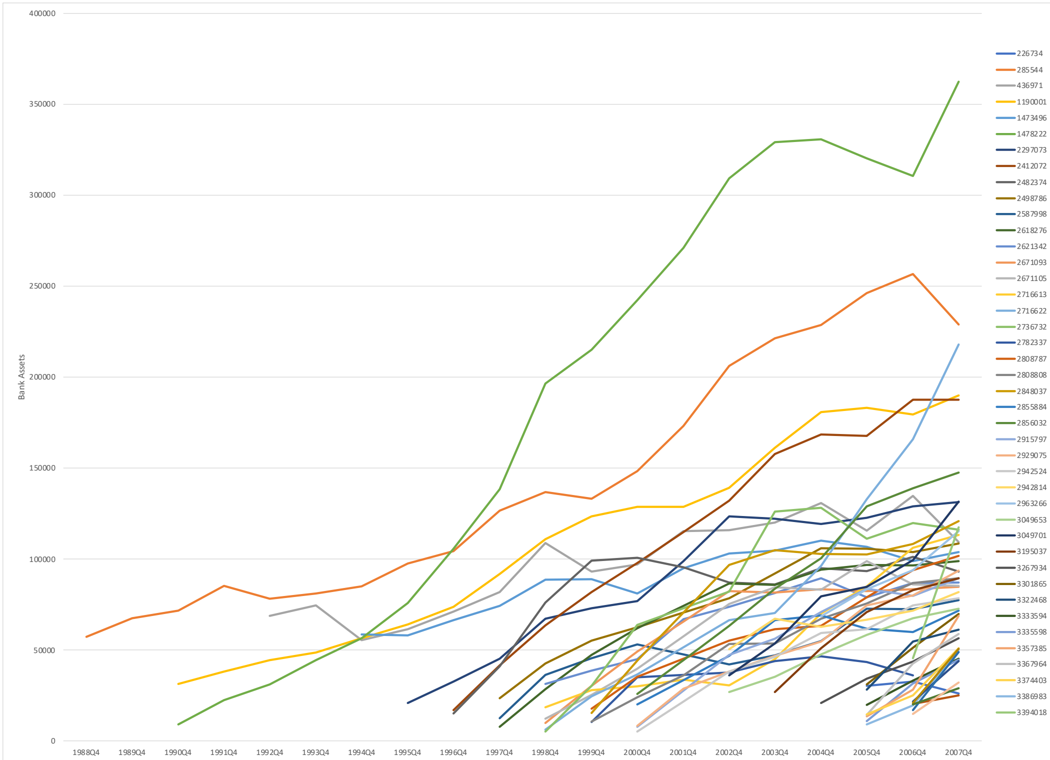

FIGURE 4A. EVOLUTION IN BANK SCALE (TOTAL ASSETS) FOR BHC1247334.

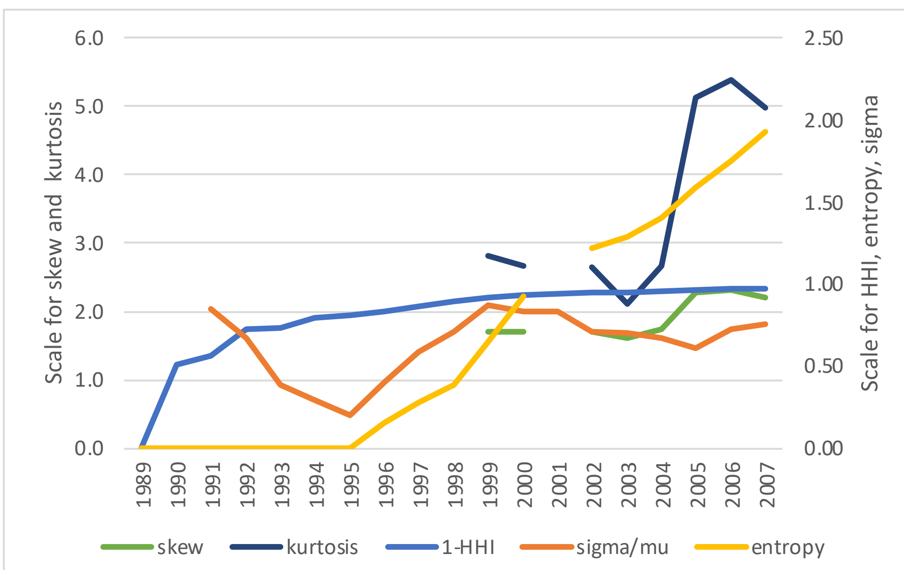

FIGURE 4B. CORRESPONDING EVOLUTION IN MARKET VALUE AND MEASURES OF DIVERSIFICATION

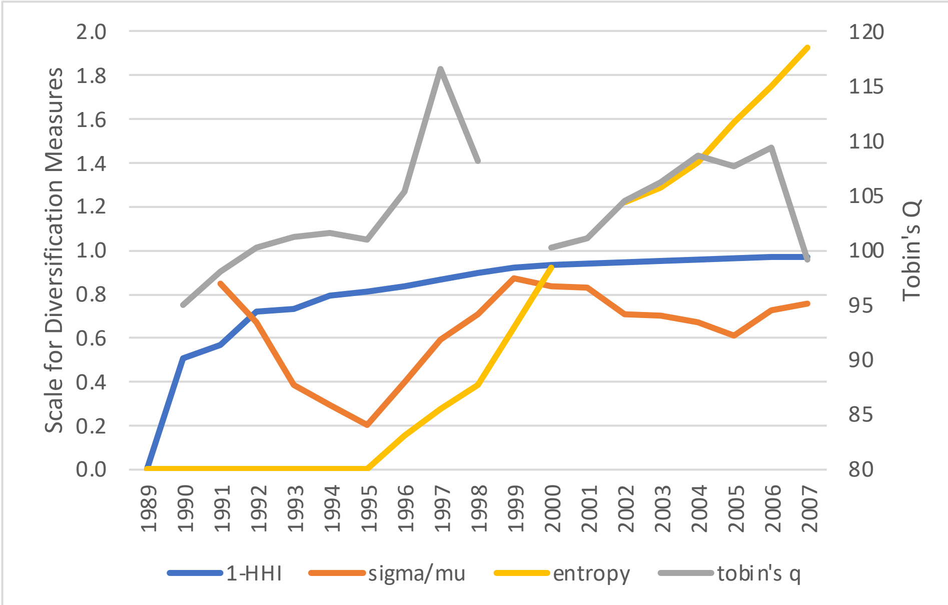

FIGURE 5. RELATIONSHIP BETWEEN TOBIN'S Q AND DIVERSIFICATION MEASURES FOR SINGLE BHC

TABLE 1. SUMMARY STATISTICS

Variable	Obs	Mean	StDev	Min	Max
1 - HHI of assets across states	33,211	0.10	0.22	0.00	1.00
Diversification dummy	34,115	0.22	0.41	0.00	1.00
Fraction of assets out-of-state	33,211	0.05	0.13	0.00	0.96
ln(Mean distance between HQ and subsidiaries)	32,414	25.98	71.83	0.06	1040.42
Number of states BHC has subsidiaries	34,132	1.47	1.24	1.00	14.00
Entropy index of assets across states	34,122	0.12	0.28	0.00	2.14
Normalized StDev of assets across states	14,351	0.56	0.47	0.00	2.61
Absolute value of sample skewness	3,689	1.63	0.59	0.00	3.24
Sample kurtosis	1,957	3.30	2.84	-5.63	10.60
Tobin's q	31,847	105.59	5.73	94.70	128.68

TABLE 2. EMPIRICAL ESTIMATION

	Tobin's Q								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Diversification dummy	-0.200								
	(0.334)								
Fraction of assets out-of-state		-0.595							
		(0.836)							
1 - HHI of assets across states			-0.357						
			(0.522)						
ln(Mean distance between HQ and subsidiaries)				-0.115					
				(0.114)					
Number of states BHC has subsidiaries					0.108				
					(0.089)				
Entropy index of assets across states						0.246			
						0.414			
Normalized StDev of assets across states							-4.67E-07*		
							(2.4E-05)		
Absolute value of sample skewness								-0.189	
								(0.286)	
Sample kurtosis									-0.155**
									(0.072)
Observations	31847	33847	31838	31365	31830	31830	6848	3543	1844
R-squared (overall)	0.315	0.316	0.316	0.316	0.321	0.319	0.460	0.536	0.588
BHC FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered by BHC) in parenthesis
**** p<0.01, ** p<0.05, * p<0.1*

TABLE 3. ESTIMATION WITH BALANCED PANEL

	Tobin's Q							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fraction of assets out-of-state	2.483***							
	(1.423)							
1 - HHI of assets across states		2.957***						
		(1.628)						
ln(Mean distance between HQ and subsidiaries)			-0.003					
			(0.006)					
Number of states BHC has subsidiaries				0.055				
				(0.135)				
Entropy index of assets across states					1.216			
					(0.920)			
Normalized StDev of assets across states						-4.66E-07		
						(4.26E-05)		
Absolute value of sample skewness							-0.714**	
							(0.344)	
Sample kurtosis								-0.155**
								(0.072)
Observations	1861	1861	1807	1861	1844	1844	1844	1844
R-squared (overall)	0.578	0.577	0.577	0.582	0.585	0.594	0.586	0.588
BHC FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered by BHC) in parenthesis
**** p<0.01, ** p<0.05, * p<0.1*

TABLE 4. DECOMPOSING DIVERSIFICATION INTO COUNT AND SHAPE

	Tobin's Q							
	(1)	(2)	(3)	(4)	(6)	(7)	(8)	(9)
Number of states BHC has subsidiaries	0.184*	0.205	0.233**	0.186*	0.148	0.125	0.161	0.113
	0.094	0.110	0.095	0.096	0.133	0.092	0.121	0.143
Diversification dummy	-0.479							
	0.364							
Fraction of assets out-of-state		-1.546						
		0.999						
1 - HHI of assets across states			-1.020*					
			0.578					
ln(Mean distance between HQ and subsidiaries)				-0.005*				
				(0.003)				
Entropy index of assets across states					-0.232			
					0.666			
Normalized StDev of assets across states						-4.8E-05*		
						(2.4E-05)		
Absolute value of sample skewness							-0.311	
							(0.296)	
Sample kurtosis								-0.176**
								(0.075)
Observations	31846	31838	31838	31364	31829	6848	3543	1844
R-squared (overall)	0.317	0.321	0.320	0.319	0.320	0.464	0.528	0.583
BHC FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered by BHC) in parenthesis

**** p<0.01, ** p<0.05, * p<0.1*

TABLE 5. INSTRUMENTAL VARIABLE REGRESSION

A. STAGE 2

	Tobin's Q							
	(1)	(2)	(3)	(4)	(6)	(7)	(8)	(9)
Number of states BHC has subsidiaries (instrumented in Stage 1)	1.330***	2.436**	3.852***	2.466***	7.333**	0.494	0.618	0.588
	(0.521)	0.883	1.343	0.742	3.489	0.413	0.671	0.568
Fraction of assets out-of-state		-11.154***						
		(4.041)						
1 - HHI of assets across states			-12.059***					
			(3.811)					
ln(Mean distance between HQ and subsidiaries)				-0.019***				
				(0.005)				
Entropy index of assets across states					-24.076**			
					(11.277)			
Normalized StDev of assets across states						-3.8E-05*		
						(2.4E-05)		
Absolute value of sample skewness							-0.608	
							(0.647)	
Sample kurtosis								-0.296*
								(0.179)
Observations	29143	29142	29142	28732	29143	6377	3307	1844
R-squared (overall)	0.306	0.270	0.206	0.264	0.155	0.452	0.477	0.583
BHC FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors (clustered by BHC) in parenthesis
**** p<0.01, ** p<0.05, * p<0.1*

B. STAGE 1

	Number of States with subsidiaries
	(1)
Years since state deregulated	0.139***
	(0.032)
(Years since state deregulated)squared	-0.011***
	(0.003)
ln(Total operating income)	0.230***
	(0.077)
Growth in total operating income	0.249***
	(0.077)
Capital asset ratio	0.004
	(0.008)
Return on equity	-0.010**
	(0.005)
Income diversification	-0.992***
	(0.252)
Asset Diversification	0.005***
	(0.079)
Observations	29818
R-squared (overall)	0.292
BHC FE	Yes
Year effects	No

Robust standard errors (clustered by BHC) in parenthesis
**** p<0.01, ** p<0.05, * p<0.1*

TABLE 7—COMPARING PRODUCT MARKET AND GEOGRAPHIC DIVERSIFICATION

	Product market (CISCO 1980s)	Geographic market (CEMEX)
Shared	Customers/economic conditions	Production function
Varied	Technology/product	Customers/economic conditions