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Journal of Financial Economics 63 (2002) 51–77

JOURNAL OF
Financial
ECONOMICS

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Does diversification destroy value? Evidence from the industry shocks[☆]

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Received 13 July 2000; accepted 21 February 2001

Abstract

Does corporate diversification reduce shareholder value? Since firms endogenously choose to diversify, exogenous variation in diversification is necessary to draw inferences about the causal effect. We examine changes in the within-firm dispersion of industry investment, or “diversity”. We find that exogenous changes in diversity, due to changes in industry investment, are negatively related to firm value. Thus diversification destroys value, consistent with the inefficient internal capital markets hypothesis. Measurement error does not cause this finding. We also find that exogenous changes in industry cash flow diversity are negatively related to firm value. © 2002 Elsevier Science S.A. All rights reserved.

JEL classification: G34

Keywords: Diversified firms; Internal capital markets

1. Introduction

Firms operating in multiple lines of business tend to have lower values than portfolios of similar focused firms, as shown in Berger and Ofek (1995), Lang and

[☆]We thank Raghuram Rajan, Henri Servaes, Luigi Zingales, an anonymous referee, and seminar participants at the American Economic Association, the NBER, and University of Chicago for helpful comments. Lamont gratefully acknowledges support from the Alfred P. Sloan Foundation, the Center for Research in Securities Prices at the University of Chicago Graduate School of Business, and the National Science Foundation.

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Stulz (1994) and Servaes (1996). This diversification discount has two explanations. First, it could be that diversification itself somehow destroys value. Second, it could be that diversification and lower value are not causally related, but merely reflect firms' endogenous choices. For example, perhaps low value firms choose to diversify, leading to a negative correlation between diversification and value. These two explanations are not mutually exclusive; it could be that low value firms choose to diversify, and this diversification lowers their value still further.

A measure of the degree of diversification is the within-firm dispersion of some characteristic, or "diversity". If diversification destroys value, and if diversity measures diversification, then diversity should be negatively correlated with firm value. For example, Berger and Ofek (1995) show that firms operating in unrelated businesses, defined as operating in different two-digit Standard Industrial Classification (SIC) codes, have lower values than firms operating in related businesses. Thus diversity in SIC codes is negatively correlated with value. In this paper, we test whether diversity in a variety of characteristics is negatively related to value. We focus specifically on diversity in investment opportunities.

To infer causation, one needs an exogenous instrument for the level of diversity. We use variation in diversity due to variation in industry characteristics. We relate changes in diversity to changes in value. Our identifying assumption is that the variation in industry characteristics is exogenous from the point of view of an individual diversified firm. Using this assumption, we define the exogenous change in diversity as the change due only to changes in industry characteristics. Using exogenous diversification allows us to study causality rather than correlation.

One specific explanation for the diversification discount is the inefficient internal capital markets hypothesis: diversified firms invest inefficiently, spending too little on their good segments and too much on their bad segments. Berger and Ofek (1995) find that diversified firms overinvest in segments with poor investment opportunities, and that this overinvestment is related to lower firm value. This explanation implies that diversity in investment opportunities destroys value, since diversity creates a situation in which the firm can inefficiently transfer funds from good segments to bad segments.

A variety of other evidence supports this cross-subsidization hypothesis. Lamont (1997) finds that when oil prices fall, oil firms lower their investment in non-oil segments. Shin and Stulz (1998) find that more generally, cash flow in one part of the firm affects investment in another part of the firm. Scharfstein (1998) tests predictions from Scharfstein and Stein (2000), and finds that diversified firms invest too much in low Q segments and too little in high Q segments, consistent with intrafirm "socialism". Rajan et al. (2000) present a model where resources flow to inefficient divisions, depending on their size and investment opportunities. They examine segment investment, segment size, and industry Q , and find evidence consistent with their theory. They also find that firm value is negatively related to diversity in investment opportunities. We test this last finding of Rajan et al. (2000), and in particular we test for a causal connection between diversity and value.

In addition to endogeneity, measurement error is a major issue when drawing inferences about the effect of diversification. Chevalier (1999) and Whited (2001)

study the effects of measurement error, and argue that it explains some of the evidence on the inefficient internal capital markets hypothesis. Measurement error is a particular concern when studying the relation between diversity and excess value, because both the diversity measure and the excess value measure are calculated using the same underlying segment and industry data.

For example, diversity in investment opportunities can be measured using the diversity of industry Q 's for each segment. However, the same industry Q 's are also used to calculate the dependent variable, excess value. Thus measurement error potentially produces a mechanical correlation between the dependent and independent variable, leading to spurious inferences. For this reason, we measure diversity in investment opportunities using diversity in industry investment, not industry Q 's. Industry investment should be correlated with industry investment opportunities, but less correlated with measurement error in industry Q . Since the variable used to generate diversity is different than the variable used to calculate excess value, hardwiring is less of a problem. We quantify the potential effect of measurement error, and find it to be small for our baseline specification.

The following example illustrates our empirical strategy of using industry shocks to identify the causal effect of diversity. Consider a diversified firm with two divisions of equal size, an aircraft division and an electronics division. Suppose the aircraft industry has much lower investment opportunities than the electronics industry, so that the firm has a high diversity in investment opportunities. We observe this diversity in investment opportunities by observing that focused firms in the aircraft industry have lower investment than focused firms in the electronics industry. According to the inefficient internal capital markets hypothesis, the diversified firm will spend too much on its aircraft division and too little on its electronics division, and this misallocation will cause the firm to have low value. Perhaps the firm follows a "fair" rule of splitting the capital expenditures evenly between the two divisions. Now suppose that, due to changing industry conditions, investment opportunities in the aircraft industry improve. This change will decrease the firm's diversity of investment opportunities, and as a result the "fair" allocation is less harmful. Thus an exogenous decrease in diversity, caused by industry shocks, leads to a decrease in misallocation and an increase in relative firm value.

To preview the results, we find that exogenous changes in investment diversity are negatively related to changes in excess value. Thus the observed diversification discount is not just a consequence of selection biases and endogenous choices by firms. Further, we show that measurement error is a very unlikely explanation for the negative effect of exogenous diversity. The contribution of this paper is to show the causal effect of diversification: diversification destroys value. This finding supports the inefficient internal capital markets hypothesis. We also find a negative relation between endogenous diversification and value. This finding is more ambiguous, but is consistent with the self-selection hypothesis that firms diversify in response to poor performance.

We also examine changes in diversity in industry leverage, sales growth, and cash flow. Changes in diversity in these other variables do not subsume exogenous changes in investment diversity, so in this sense the inefficient internal capital

markets hypothesis survives. We find evidence that cash flow diversity, but not leverage or sales growth diversity, destroys value. Investment diversity does not subsume cash flow diversity.

We further investigate the inefficient internal capital markets hypothesis by examining segment investment in diversified firms compared to investment in focused firms. We find that, consistent with the hypothesis, firms smooth investment across segments compared to the investment of focused firms in the same industry. Although this specific evidence cannot prove causality, it shows that the available evidence on segment investment is consistent with the hypothesis that capital expenditures are inefficiently allocated within the firm.

This paper is organized as follows. Section 2 describes previous research. Section 3 describes the sample and the construction of variables measuring exogenous and endogenous changes in diversity. Section 4 presents results for diversity in investment opportunities measured using industry investment. Section 5 explores diversity in other industry characteristics, including capital structure, profitability, and sales growth. Section 6 presents conclusions.

2. Previous research

In addition to the inefficient internal capital markets hypothesis, there are many general ways in which unrelatedness might reduce value. It could be that managers have limited expertise and cannot effectively manage diverse businesses, or that unrelated segments have conflicting operational styles or corporate cultures. This broader explanation also predicts that diversity of characteristics is negatively correlated with value.

Other theories predict a positive relation between diversity and value. In Lewellen (1971) diversity of cash flow variation is good if it allows greater tax benefits of leverage by reducing the volatility of cash flows and the probability of financial distress. Hadlock et al. (1999) argue that diversity might be good if managers' private information at the segment level washes out at the firm level, reducing information asymmetry. Another argument is that diversity in investment opportunities is good when internal capital markets function better than external markets, since it maximizes the scope of the internal market. Hubbard and Palia (1999) find evidence, using acquisitions in the 1960s, that gains are greatest when a financially unconstrained buyer acquires a constrained target. Thus diversity in financial constraints is good. Fulghieri and Hodrick (1997), Stein (1997), and Wulf (2000) also discuss the possible benefits of diversity.

Value destruction or creation can occur in two ways. The value of any asset is the sum of discounted future cash flows, so that value can change either due to changes in cash flows or changes in discount rates. Lamont and Polk (2001) show that a substantial fraction of the cross-sectional variance of diversification discounts is due to variation in expected returns; firms with high expected returns have low values, and firms with low expected returns have high values. Most existing empirical work has focused on potential cash flow effects of diversification (for example, studies of

profits or productivity in diversified firms). One could also imagine discount rate versions of existing explanations. For example, perhaps inefficient cross-subsidization involves taking excessively risky projects with high discount rates. We do not attempt to discriminate between these two sources of value destruction in this paper.

A variety of papers examine endogenous changes in diversity, in which firms choose to diversify (usually through an acquisition) or focus (usually through spinoffs or divestitures). Lang and Stulz (1994), Hyland (2000), Campa and Kedia (1999), and Graham et al. (1999) all test whether endogenous diversifying behavior leads to a negative correlation of diversity and value, by studying whether firms have low value and poor performance before diversifying.

A frequent finding is that refocusing raises firm value, as in Comment and Jarrell (1995) and John and Ofek (1995). Daley et al. (1997) find that spun-off segments experience improved performance, especially if they are unrelated (see also Kaplan and Weisbach, 1992). Gertner et al. (1999) find that the investment of spun-off segments changes in a way consistent with the inefficient internal capital markets hypothesis. Berger and Ofek (1996, 1999) find that takeovers, leveraged buy-outs, shareholder pressure, managerial turnover, and other largely external sources are the cause of much refocusing. These findings are consistent with the idea that diversification destroys value, and that the market for corporate control helps eliminate value-destroying diversification (for related work, see also Schlingemann et al., 1999; Peyer and Shivdasani, 2000).

If the decision to diversify reflects value-destroying managerial waste, one might expect endogenous increases in diversity to decrease value. Morck et al. (1990) and Maquiera et al. (1998) find that acquiring firm stockholders lose value in diversifying acquisitions. Schoar (1999) finds that firms that acquire plants in unrelated industries experience a subsequent decrease in total firm productivity. If in contrast, firms optimally choose to diversify as in Maksimovic and Phillips (1999) and Fluck and Lynch (1999), one might expect all endogenous changes in diversification to have a positive effect, reflecting firms moving closer to the optimum. Of course, since endogenous actions are taken in response to events that the econometrician cannot observe, the observed correlation between endogenous diversification and value that we measure can never be conclusive about whether firms are behaving optimally.

3. Sample and variable construction

3.1. Data

Our sample consists of firms reporting segment data in the Compustat Current and Research database, 1979–1997. The data sources and variables are described more fully in the appendix. Following Berger and Ofek (1995), we discard firm-years with segments in the financial services industry, total firm sales of less than \$20 million, or discrepancies in segment and firm data. We also require firms to have information on firm-level equity, debt, investment, capital stock, and sales growth. The only segment level data we use for the main empirical results are sales, assets,

and SIC codes for each individual segment (in Section 4.4 we briefly examine segment capital expenditures).

Our measure of excess value is based on market-book ratios. Q is the ratio of the market value of the firm (the market value of common stock plus the book value of total assets minus book equity minus deferred taxes) divided by the total book assets of the firm.¹ For each segment of a diversified firm, we find a group of matching focused firms with the same two-digit SIC code. We then calculate the median for each segment's industry, Q_{IND} . We drop every diversified firm that does not have at least five matching focused firms for each of its segments. We then form \bar{Q} , the imputed value ratio, for the entire diversified firm as the weighted average of the industry Q_{IND} 's:

$$\bar{Q} = \sum_{j=1}^n w_j Q_{\text{IND},j} = \sum_{j=1}^n w_j (\text{median}\{Q_1, Q_2, \dots, Q_{N_j}\}), \quad (1)$$

where w_j is the fraction of the firm's assets in segment j , Q_i is market-book for focused company i , segment j 's industry has N_j focused firms, and the firm has n segments. We measure excess value by taking the log ratio, $q - \bar{q} = \ln(Q/\bar{Q})$, as in Berger and Ofek (1995). Lower case letters indicate natural logs.

Our identification strategy requires using annual changes in variables. The change in excess value, $\Delta q - \Delta \bar{q}$, is the difference between excess value for a given diversified firm between year $t - 1$ and year t . For the purposes of defining our sample, we classify a firm as diversified in year t if it has multiple segments in year $t - 1$. This classification allows us to examine exogenous and endogenous changes in diversity for firms that decrease their number of segments between year $t - 1$ and year t . We classify a firm as focused if it has one segment in both year t and year $t - 1$. We discard firms that have one segment in year $t - 1$ and multiple segments in year t , because such firms have no exogenous change in diversity between year $t - 1$ and year t .

3.2. Endogenous and exogenous changes in diversity

Our measure of diversity of some characteristic is the within-firm standard deviation of the segment characteristics in a given year. The characteristics we examine are industry benchmarks that come from the matching sample of focused firms. Our main focus is on dispersion in investment opportunities within the firm, measured by dispersion in industry investment. For a given segment and year, we measure industry investment, I_{IND} , as that year's median investment to capital ratio among focused firms in the segment's two-digit industry. For each focused firm, investment to capital is year t capital expenditures divided by year $t - 1$ net capital stock (book value). For each diversified firm, we measure diversity in year t as σ_t , the standard deviation of I_{IND} for the different segments. The change in diversity is $\Delta \sigma_t$.

¹For convenience, we use the letter Q to describe this variable, although it is not precisely the same as the standard variable called Tobin's Q , which involves more complicated calculations of replacement value.

Neither sales nor assets at the segment level affect this definition of diversity. The diversity measure is based on two-digit SIC codes. A firm consisting of two segments that are both in the same two-digit industry has diversity of zero, since mechanically a constant has a standard deviation of zero.

Changes in diversity reflect both changes in the structure of the individual firm and changes in industry characteristics. We call changes due to industry characteristics alone “exogenous changes” (reflecting actions not taken by the individual firm) and changes due to reported corporate structure as “endogenous changes”. Let $structure_t$ be firm structure in year t , defined as the number and industry classification of segments. Let $benchmark_t$ be the set of industry characteristic values as of year t . Then the change in diversity is

$$\begin{aligned} \Delta\sigma_t &= \sigma_t - \sigma_{t-1} \\ &= \sigma(\text{structure}_t, \text{benchmark}_t) - \sigma(\text{structure}_{t-1}, \text{benchmark}_{t-1}) \\ &= [\sigma(\text{structure}_t, \text{benchmark}_t) - \sigma(\text{structure}_{t-1}, \text{benchmark}_t)] \\ &\quad + [\sigma(\text{structure}_{t-1}, \text{benchmark}_t) - \sigma(\text{structure}_{t-1}, \text{benchmark}_{t-1})] \\ &\equiv \Delta\sigma_N + \Delta\sigma_X. \end{aligned} \tag{2}$$

The exogenous change in diversity, $\Delta\sigma_X$, is the change in diversity between $t - 1$ and t that *would have taken place if the firm had not changed its structure* between $t - 1$ and t . Since this change is caused only by changes in industry characteristics (which we assume are not affected by actions taken by the firm), these changes are exogenous to the firm.

The endogenous change in diversity, $\Delta\sigma_N$, is the change in diversity that takes place due to changes in firm structure between $t - 1$ and t . In order for $\Delta\sigma_N$ to be nonzero, a firm must either add a new segment, delete an existing segment, or change the activities of an existing segment such that Compustat assigns it a new SIC code. An endogenous change in diversity can take place either because the firm changes its actual structure, or merely because the firm changes its reported structure. Either way, this change in reported structure reflects endogenous decisions by the firm.

The observed change in corporate structure reflected in $\Delta\sigma_N$ is probably a very noisy indicator of economic changes in structure. Segment data only loosely corresponds to major events such as acquisitions and divestitures. Hyland (2000) examines a sample of 227 firms that increase the number of segments, 1978–1992. He finds that 150 (66%) are due to acquisitions, 23 (10%) are due to internal growth, and 54 (24%) are due to reporting changes only (Graham et al. (1999) find similar results in a 1980–1995 sample). Berger and Ofek (1999) examine a sample of 295 firms decreasing their number of segments, 1984–1993, and find that 107 (36%) cases represent true refocusing as opposed to reporting changes.

Table 1 shows an example from our data set. In 1996, Northrop Grumman had two segments, an aircraft segment with industry investment of 17.6%, and an electronics segment with industry investment of 33.2%. Since industry median investment to capital ratios (reflecting investment by focused firms) were quite different for aircraft and electronics in 1996, by our measure Northrop Grumman was a fairly diverse firm. It also had a sizable discount of 29%, as its Q was below its

Table 1

Structure, value, and diversity for Northrop Grumman Corp, 1996–1997

Q is the market-book ratio of the firm, calculated as the ratio of the market value of the firm (the market value of common stock plus the book value of total asset minus book equity minus deferred taxes) divided by the total book assets of the firm. Q_{IND} is the median Q among focused firms in the segment's industry. \bar{Q} is the imputed value ratio of the firm, calculated as the weighted average of the Q_{IND} 's for each of the firm's segments, where the weights are the book assets of the segments. I_{IND} is the median investment to capital ratio among focused firms in the segment's industry, where investment to capital is year t capital expenditures divided by year $t - 1$ net capital stock. σ is diversity, the within-firm standard deviation of I_{IND} . Lower case letters indicate natural logs. $\Delta\sigma_X$ is the exogenous change in the standard deviation of I_{IND} , defined as σ (year t structure, year t benchmarks) minus σ (year $t - 1$ structure, year t benchmarks). $\Delta\sigma_N$ is the endogenous change in the standard deviation of I , $\Delta\sigma_N = \Delta\sigma - \Delta\sigma_X$.

	1996		1997		
	Aircraft	Electronics	Aircraft	Electronics	Information technology and services
SIC	37	38	37	38	73
Book assets	2387	5970	2386	5451	559
% total	0.29	0.71	0.28	0.65	0.07
Q_{IND}	1.283	1.872	1.474	1.990	2.357
I_{IND}	0.176	0.332	0.250	0.352	0.629
<i>Firm level variables</i>					
Q		1.275			1.515
\bar{Q}		1.703			1.868
$q - \bar{q}$		-0.290			-0.209
Δq					0.173
$\Delta \bar{q}$					0.092
$\Delta q - \Delta \bar{q}$					0.081
σ		0.110			0.196
σ using 1996 structure and 1997 investment					0.072
$\Delta\sigma$					0.086
$\Delta\sigma_X$					-0.038
$\Delta\sigma_N$					0.124

imputed value. In 1997, Northrop Grumman changed its structure to include a third segment, Information Technology and Services. This change in segment reporting reflects both an acquisition in 1997 and a reclassification of existing assets (largely from the electronics division) into the new segment.

Northrop Grumman's diversity measure changed in two ways between 1996 and 1997. First, an increase in aircraft industry investment caused an exogenous decrease in diversity as aircraft and electronics investment became more similar (Table 1 also shows that aircraft industry Q also rose substantially). Had the firm not added a new

segment, the changes in aircraft and electronics alone would have resulted in a decrease in diversity, from 11% to 7.2%. Thus the exogenous change in diversity is -3.8% . Second, the addition of a third segment with very high industry investment increased diversity, to a total of 19.6%. Thus the endogenous change in diversity is the difference between 7.2% and 19.6%, or 12.4%.

Table 2 shows summary statistics and cross-correlations for the sample of diversified firms. The sample contains 11,974 annual observations for 1,987 different diversified firms in the 18 year period of 1980–1997. The average number of segments per firm is 2.7. The number of firms per year declines over time, from a high of 872 in 1981 to a low of 482 in 1997. Average and median excess values are negative at -2.8 and -6.1% .² Since the standard deviation of exogenous diversity change is 0.040 and the standard deviation of total diversity change is 0.045, most (80%) of the variation in diversity change is due to exogenous industry shocks. A statistic that is not shown in Table 2 is the correlation of industry investment and industry Q . Across industry-years, the correlation is 0.332, a moderately high positive correlation.

4. Diversity in investment

Table 3 shows basic results for regressions of changes in excess value on changes in diversity in industry investment. The regression is simple pooled OLS; the standard errors have been adjusted for correlation of the residuals within years, and for heteroskedasticity. The robust standard errors allow for clustered sampling (dependence of observations within each year), following Rogers (1993). The first column shows that the coefficient on the change in diversity is negative and significant. The coefficient implies that a one standard deviation increase in diversity lowers excess value by 1.1%.

One can use the coefficient on $\Delta\sigma$ to calculate the potential contribution of diversity in explaining the average level of the diversification discount. Mechanically, a focused firm has a σ of zero. Since the mean of σ is 0.049, the average level of diversity explains an average discount of $-0.25*0.049$ or 1.2%. Since the average discount in this sample is 2.8%, investment diversity alone can explain more than 40% of the level of the average discount.

Column (2) shows the results using the exogenous change in diversity. Exogenous changes in diversity have a negative and significant effect on excess value. This finding is the major result of this paper: diversification is negatively correlated with value not just due to selection biases and endogenous choices by firms, but also because higher levels of diversification somehow cause value destruction.

Column (3) shows that both exogenous and endogenous changes in diversity are negatively related to changes in excess value. Thus, as often hypothesized, an

²In interpreting the values it is important to note that the natural logarithm is a concave function. Since firm-level variables are more volatile than industry-level variables, average log ratios tend to be negative. For example, mean Q is above mean \bar{Q} , but mean $q - \bar{q}$ is negative. Looking at excess value without logs, the mean of $Q - \bar{Q}$ is 3.9% and the median is -6.8% .

Table 2

Summary statistics

Statistics for the sample of 11,974 firm-year observations from 1,987 diversified firms. Q is the market-book ratio of the firm, calculated as the ratio of the market value of the firm (the market value of common stock plus the book value of total asset minus book equity minus deferred taxes) divided by the total book assets of the firm. \bar{Q} is the imputed value ratio of the firm using the segment's industry Q 's, where the industry Q 's are median Q 's for single segment firms in the same two-digit industry as the segment, and the weights are the book assets of the segments. σ is diversity, the within-firm standard deviation of industry median investment to capital ratios. $\Delta\sigma_X$ is the exogenous change in the standard deviation of industry investment, defined as σ (year t structure, year t benchmarks) minus σ (year $t-1$ structure, year t benchmarks). $\Delta\sigma_N$ is the endogenous change in the standard deviation of industry investment, $\Delta\sigma_N = \Delta\sigma - \Delta\sigma_X$. Lagged $q - \bar{q}$ is excess value in year $t-1$. Lagged σ is the standard deviation of industry investment in year $t-1$. Lower case letters indicate natural logs. The sample period is 1980–1997.

	Mean	Median	Std	Min	Max
Q	1.338	1.149	0.660	0.350	12.998
\bar{Q}	1.299	1.242	0.293	0.711	5.054
$q - \bar{q}$	-0.028	-0.061	0.351	-1.863	1.848
Δq	0.012	0.016	0.220	-2.179	2.083
$\Delta \bar{q}$	0.022	0.032	0.126	-0.592	1.060
$\Delta q - \Delta \bar{q}$	-0.010	-0.006	0.214	-2.239	2.042
σ	0.049	0.037	0.051	0.000	0.652
$\Delta\sigma$	-0.002	0.000	0.045	-0.618	0.525
$\Delta\sigma_X$	0.001	0.000	0.040	-0.618	0.525
$\Delta\sigma_N$	-0.003	0.000	0.026	-0.474	0.194

Correlation matrix							
	Δq	$\Delta \bar{q}$	$\Delta q - \Delta \bar{q}$	$\Delta\sigma$	$\Delta\sigma_X$	$\Delta\sigma_N$	Lagged $q - \bar{q}$
$\Delta \bar{q}$	0.332						
$\Delta q - \Delta \bar{q}$	0.831	-0.249					
$\Delta\sigma$	-0.055	-0.007	-0.052				
$\Delta\sigma_X$	-0.043	-0.014	-0.036	0.822			
$\Delta\sigma_N$	-0.029	0.009	-0.036	0.472	-0.113		
Lagged $q - \bar{q}$	-0.269	0.053	-0.307	0.010	0.004	0.011	
Lagged σ	0.022	-0.012	0.029	-0.464	-0.403	-0.185	-0.038

important reason for the negative correlation of diversification and value is endogenous diversifying behavior by firms. Unlike the coefficient on exogenous diversity, however, one cannot interpret the coefficient on endogenous diversity as evidence that diversification destroys value. The coefficient could reflect several possibilities: value-destroying diversification, value-creating diversification in response to some unobserved negative shock to the firm, or a tendency of diversified firms to divest high value businesses or to acquire low value businesses as in Graham et al. (1999).

Column (4) adds to the regressions the year $t-1$ level of excess value, the year $t-1$ level of investment diversity, and year and firm fixed effects. The year and firm fixed effects are separate dummy variables for each of the 18 years and each of the 1987 firms. Including the lagged levels of excess value and diversity is meant to

Table 3

Basic regression of change in excess value on change in diversity

The dependent variable is $\Delta q - \Delta \bar{q}$, the change in excess value. $\Delta \sigma$ is the change in the standard deviation of industry investment. $\Delta \sigma_X$ is the exogenous change in the standard deviation of industry investment, caused only by changes in industry characteristics. $\Delta \sigma_N$ is the endogenous change in the standard deviation of industry investment, caused only by change in corporate structure including number and SIC code of segments. Lagged $q - \bar{q}$ is excess value in year $t - 1$. Lagged σ is the standard deviation of industry investment in year $t - 1$. The number of observations is 11,974; the sample period is 1980–1997. “Year and firm dummies” indicate separate intercepts for each of 18 years and each of the 1987 firms. The standard errors, in parentheses, are calculated allowing for both heteroskedasticity and for the residuals to be correlated within each of the 18 years, 1980–1997.

	(1)	(2)	(3)	(4)
$\Delta \sigma$	-0.250 (0.052)			
$\Delta \sigma_X$		-0.193 (0.066)	-0.217 (0.062)	-0.302 (0.069)
$\Delta \sigma_N$			-0.338 (0.120)	-0.324 (0.124)
Lagged $q - \bar{q}$				-0.470 (0.027)
Lagged σ				-0.197 (0.095)
Constant	-0.010 (0.007)	-0.010 (0.007)	-0.010 (0.007)	
R^2	0.003	0.001	0.003	0.366
Year and firm dummies	N	N	N	Y

capture predictable mean reversion in these variables. The negative coefficient on lagged excess value reflects the fact that excess value tends to move towards its mean. Economically, this mean reversion can occur because firms with high excess values invest more (so that their book value goes up and the ratio of market to book falls), or because they tend to have low subsequent returns (so their market value goes down), as in Lamont and Polk (2001).

Including the lagged level of diversity helps to control for predictable movements in diversity. As seen in Table 2, exogenous changes in diversity are quite predictable using the lagged level of diversity, since the correlation between the two variables is -0.40. Expected changes in diversity (due to expected changes in industry conditions) should already be reflected in market values as of year $t - 1$. Since we are interested in examining the effects of industry shocks on value, we purge changes in diversity of their expected component by putting the lagged level of diversity into the regression.

These additional control variables do not change the basic result that both exogenous and endogenous changes in diversity are negatively related to firm value. The coefficient on exogenous changes rises somewhat, while the coefficient on endogenous diversity is little changed. We use column (4) as our baseline regression.

4.1. *Effects of measurement error*

Measurement error is an issue in Table 3 since both the dependent variable and the independent variable are constructed using the same segment information and

industry characteristics. If the segment information (such as SIC codes) or the characteristics are observed with error, this measurement error can lead to faulty inferences. In the case of industry characteristics, the most relevant source of measurement error is probably inappropriate matching of focused firms with diversified firm segments. Chevalier (1999) provides evidence supporting this conclusion. If focused firms are fundamentally different from diversified firms, or if there is some noise in the process of matching focused firms to diversified firms, then industry characteristics will be noisy measures of firm value and of segment characteristics.

Other sources of measurement error include Compustat coding errors, a major issue in the segment database. Lamont (1997) examined segment data for 26 firms between 1985 and 1987 and found coding errors in four (15%). Hyland (2000) found examined segment data for 243 firms between 1978 and 1992, and found coding errors in 29 (12%), of which 16 involved backfilling of segment data.

The same measurement error appearing in both the dependent and independent variables can lead to spurious results. In interpreting the regression coefficients in columns (1) and (2) of Table 3, the following simple framework is helpful. Suppose the true relation is

$$\Delta q - \Delta \bar{q}^* = \alpha + \beta \Delta d^* + \varepsilon, \quad (3)$$

where \bar{q}^* is the true log imputed value ratio for the firm and d^* is the true diversity measure. We observe noisy measures of the true variables

$$\Delta \bar{q} = \Delta \bar{q}^* + u, \quad (4)$$

$$\Delta d = \Delta d^* + v. \quad (5)$$

Since both $\Delta \bar{q}$ and Δd are constructed using the same underlying variables, in general both $\text{cov}(\Delta \bar{q}^*, \Delta d^*)$ and $\text{cov}(v, u)$ will be non-zero. If one regresses $\Delta q - \Delta \bar{q}$ on Δd , the estimated coefficient (assuming that the measurement errors, u and v , are uncorrelated with the disturbance term ε) is

$$b = \frac{\beta \text{var}(\Delta d^*) - \text{cov}(v, u)}{\text{var}(\Delta d^*) + \text{var}(v)} = \beta \frac{\text{var}(\Delta d^*)}{\text{var}(\Delta d^*) + \text{var}(v)} - \frac{\text{cov}(v, u)}{\text{var}(\Delta d^*) + \text{var}(v)}. \quad (6)$$

Measurement error induces a biased coefficient in two ways. First, the familiar attenuation effect $\text{var}(\Delta d^*)/(\text{var}(\Delta d^*) + \text{var}(v))$ moves the coefficient towards zero. Second, the covariance term $-\text{cov}(v, u)/(\text{var}(\Delta d^*) + \text{var}(v))$ causes b to be biased either positively or negatively. We call this second term ‘‘covariance bias’’, and consider it separately from attenuation.

While we cannot directly observe the covariance bias, we can observe $c = ((\text{cov}(v, u) + \text{cov}(\Delta \bar{q}^*, \Delta d^*))/(\text{var}(\Delta d^*) + \text{var}(v)))$, which is the coefficient in a regression of $\Delta \bar{q}$ on Δd . With a further assumption about the measurement error, we can bound the covariance bias. Let ρ be the fraction of $\text{cov}(\Delta \bar{q}, \Delta d)$ that is due to measurement error, $\rho = \text{cov}(v, u)/\text{cov}(\Delta \bar{q}, \Delta d)$. The covariance bias is then $-\rho c$. A natural extreme value of ρ is one, which corresponds to a scenario in which the matching procedure is completely useless and measurement error is so large that either the diversity measure or \bar{q} (or both) are complete noise. Although any value of

Table 4

Robustness to measurement error and outliers

In regressions (1)–(3), the dependent variable is $\Delta\bar{q}$, the change in the natural log of \bar{Q} . \bar{Q} is the imputed value ratio, the weighted average of the segment's industry Q 's. $\Delta\sigma$ is the change in the standard deviation of industry investment ratios. $\Delta\sigma_X$ is the exogenous change in the standard deviation of industry investment ratios, caused only by changes in industry characteristics. $\Delta\sigma_N$ is the endogenous change in the standard deviation of industry investment ratios, caused only by change in corporate structure. Lagged $q - \bar{q}$ is excess value in year $t - 1$. Lagged σ is the standard deviation of industry investment in year $t - 1$. In regressions (4)–(6), the dependent variable is $\Delta q - \Delta\bar{q}$, the change in excess value. “No outliers” discards observations of $\Delta q - \Delta\bar{q}$, $\Delta\sigma_X$, and $\Delta\sigma_N$, that are in the top or bottom 0.5% of their distributions. “Year and firm dummies” indicate separate intercepts for each year and firm. The number of observations is 11,974 (except for column (6), which is 11,624); the sample period is 1980–1997. The standard errors, in parentheses, are calculated allowing for both heteroskedasticity and for the residuals to be correlated within each year.

	$\Delta\bar{q}$ on left-hand side			$\Delta q - \Delta\bar{q}$ on left-hand side		
	(1)	(2)	(3)	(4)	(5)	No outliers (6)
$\Delta\sigma$	-0.020 (0.117)					
$\Delta\sigma_X$		-0.045 (0.146)	0.024 (0.107)	-0.212 (0.072)	-0.289 (0.071)	-0.277 (0.095)
$\Delta\sigma_N$			-0.003 (0.065)		-0.326 (0.103)	-0.337 (0.056)
Lagged $q - \bar{q}$			0.049 (0.012)		-0.444 (0.024)	-0.399 (0.028)
Lagged σ			-0.139 (0.060)		-0.272 (0.085)	-0.239 (0.088)
$\Delta\bar{q}$				-0.423 (0.039)	-0.535 (0.045)	
Constant	0.022 (0.021)	0.022 (0.021)		-0.000 (0.008)		
R^2	0.000	0.000	0.555	0.064	0.411	0.340
Year and firm dummies	N	N	Y	N	Y	Y

ρ is possible, values between zero (corresponding to no measurement error) and one (corresponding to huge measurement error) seem most reasonable. We leave it to the readers to choose ρ as they see fit.

Columns (1) and (2) in Table 4 show estimates of the coefficient c . Consider the regression in column (2) of Table 3, which shows a coefficient of -0.193 for exogenous changes in diversity. Column (2) of Table 4 shows that for this regression, c is -0.045 . Thus if ρ is between zero and one, the true coefficient actually has a higher magnitude than the estimated coefficient, as both attenuation bias and covariance bias move the estimate towards zero. Thus measurement error cannot explain the negative and significant coefficient in column (2) of Table 3.

Column (3) of Table 4 shows the multiple regression version with change in log imputed value as the dependent variable and our baseline variables on the right hand side. The coefficient for exogenous diversification is now positive but low at 0.024 . This positive coefficient with $\Delta\bar{q}$ as the dependent variable obviously tends to produce a negative coefficient when $\Delta q - \Delta\bar{q}$ is the dependent variable. Compared to the coefficient of -0.302 in column (4) of Table 3, however, the coefficient of 0.024 seems basically irrelevant.

Columns (4) and (5) of Table 4 show the effect of adding $\Delta\bar{q}$ to the right-hand side of the regressions. First, column (4) adds change in imputed value to the two-variable regression. Using the measurement error framework, in this regression the covariance bias is positive if ρ is greater than 0.42 .³ Despite a potentially positive bias when measurement error is extreme, exogenous changes in diversity still have a negative and significant effect. Including $\Delta\bar{q}$ in the baseline specification, in column (5), slightly lowers the coefficient on exogenous changes in diversity, but the coefficient is still negative and significant.

The last column of Table 4 discards extreme observations, defined as any observation which is in the top 0.5% or bottom 0.5% of the distribution of $\Delta q - \Delta\bar{q}$, $\Delta\sigma_N$, and $\Delta\sigma_X$. The coefficient on the exogenous changes in diversity is slightly lower than the baseline results, but is still negative and significant.

In summary, our results are very unlikely to be driven by measurement error. As we will see later, however, measurement error can be an important concern when using other measures of diversity in investment opportunities.

4.2. Alternative specifications

Table 5 explores the stability of our main results. Since our main interest is the causal role of diversity, we focus on the coefficient on exogenous diversity change.

³Using the measurement error framework, the coefficient on exogenous change in diversity is

$$\frac{\beta \text{var}(\Delta d^*) + \text{cov}(\Delta\bar{q}^*, \Delta d^*) - \text{cov}(\Delta q, \Delta\bar{q})\text{cov}(\Delta\bar{q}, \Delta d) / \text{var}(\Delta\bar{q})}{\text{var}(\Delta d^*) + \text{var}(v) - [\text{cov}(\Delta\bar{q}, \Delta d)]^2 / \text{var}(\Delta\bar{q})}$$

The bottom of this fraction is positive. The sign of the covariance bias depends on the sign of $\text{cov}(\Delta\bar{q}, \Delta d)(1 - \rho) - \text{cov}(\Delta q, \Delta\bar{q})\text{cov}(\Delta\bar{q}, \Delta d) / \text{var}(\Delta\bar{q})$. Plugging in numbers, the sign of the bias is negative as long as ρ is less than 0.42 .

Table 5

Alternative specifications

The dependent variable in regressions (1) and (3) through (5) is $\Delta q - \Delta \bar{q}$, the change in excess value. $\Delta \sigma_X$ is the exogenous change in the standard deviation of industry investment, caused only by changes in industry characteristics. $\Delta \sigma_N$ is the endogenous change in the standard deviation of industry investment, caused only by change in corporate structure. Lagged variables are as of year $t - 1$. Column (1) restricts the sample to diversified firms with all segments in manufacturing industries, defined as two-digit SIC codes 20 through 39. In column (2), the dependent variable is $\Delta m - \Delta \bar{m}$, the change in excess value measured using market-sales ratios, defined as the log ratio of the total market value to total firm sales. In column (3), diversity in industry investment is defined as the coefficient of variation of industry investment. CV is the coefficient of variation for industry investment, defined as the standard deviation of industry investment divided by the mean of industry investment. Lagged variables are as of year $t - 1$. ΔCV_X is the exogenous change in the coefficient of variation of industry investment, defined as CV (year t structure, year t benchmarks) minus CV (year $t - 1$ structure, year t benchmarks). ΔCV_N is the endogenous change in the standard deviation of industry investment, $\Delta CV_N = \Delta CV - \Delta CV_X$. Column (4) uses Fama-Macbeth estimation. Column (5) repeats the baseline specification using four-digit SIC codes instead of two-digit SIC codes in calculating all variables, and allowing the industry benchmarks to come from as few as one firm (instead of requiring at least five firms). The sample period is 1980–1997. “Year and firm dummies” indicate separate intercepts for each year and firm. The standard errors in columns (1)–(3), and (5), in parentheses, are calculated allowing for both heteroskedasticity and for the residuals to be correlated within each year.

	Manufacturing only	Dependent variable is $\Delta m - \Delta \bar{m}$	Diversity measured with coefficient of variation	Fama-Macbeth estimation	Four-digit SIC codes, no five firm minimum
	(1)	(2)	(3)	(4)	(5)
$\Delta \sigma_X$	-0.461 (0.081)	-0.397 (0.118)		-0.213 (0.066)	-0.020 (0.003)
$\Delta \sigma_N$	-0.274 (0.225)	-0.935 (0.305)		-0.217 (0.118)	-0.243 (0.093)
Lagged $q - \bar{q}$	-0.457 (0.037)		-0.470 (0.027)	-0.175 (0.021)	-0.571 (0.031)
Lagged σ	-0.223 (0.069)	-0.340 (0.135)		0.006 (0.048)	-0.009 (0.022)
Lagged $m - \bar{m}$		-0.480 (0.023)			
ΔCV_X			-0.064 (0.017)		
ΔCV_N			-0.063 (0.027)		
Lagged CV			-0.049 (0.019)		
Lagged $Q - \bar{Q}$					
R^2	0.375	0.365	0.365		0.433
Firm and year dummies	Y	Y	Y	N	Y
Observations	6438	11974	11974	11974	6119

Column (1) shows the results of discarding diversified firms that have any segments in nonmanufacturing industries. One might expect measurement error in diversity to be lower in this regression, since investment to capital ratios are less well-behaved in nonmanufacturing industries such as services, mining, and agriculture. Column (1), which has a sample size of about half the baseline sample, shows the coefficient on exogenous change in diversity becomes more negative and remains significant.

Column (2) shows a version of the baseline regression replacing Q everywhere with M , the ratio of the market value to the total sales of the firm. The relation between excess value and exogenous diversity is again stronger compared to the baseline results. The coefficient on endogenous diversity is much higher but is estimated imprecisely. Column (3) measures diversity using the coefficient of variation of industry investment (the ratio of standard deviation to mean), rather than the standard deviation of industry investment. Again, the exogenous change in diversity has a significant negative effect (the coefficient is different from the baseline regression because the units of the diversity change variable are different). Column (4) uses Fama-Macbeth estimation; the coefficients on the exogenous change in diversity remain negative and significant.

Column (5) shows the effects of redoing the analysis using industry benchmarks (for both excess value and diversity) based on the four-digit SIC code of the individual segment, instead of two-digit SIC codes used elsewhere. Unfortunately, this increase in precision comes at the cost of reducing the number of observations, since it is more difficult to find five matching four-digit firms for each segment of the firm. To maintain a large sample size, we relax the constraint of a minimum of at least five matching focused firms, and instead require a minimum of only one matching firm. In other words, we allow the industry benchmark to consist of a single firm or the median of multiple firms. Thus the benchmarks underlying column (5) have better matching by industry, but also have greater noise due to firm-specific random variation. As a result, the diversity change variable has a much greater variance, presumably due to greater measurement error. Despite this noise, the coefficient on exogenous diversity change is still negative and significant.

In summary, our results are robust to alternate specifications, and are especially strong for manufacturing firms. This robustness to alternate specifications further suggests that measurement error or misspecification is not the driving factor.

4.3. Alternate measures of diversity in investment

Here we explore two alternate measures of investment diversity that incorporate information about the relative size of the various segments. The first measure we examine is diversity in resource-weighted investment. Rajan et al. (2000) present a theory in which both the diversity in segment resources and in segment investment opportunities determines investment allocation. They use a measure involving the standard deviation of investment opportunities multiplied by relative segment size (we examine their specific measure in the next section).

Table 6

Alternative measures of investment diversity

The dependent variable is $\Delta q - \Delta \bar{q}$, the change in excess value. $\sigma 1$ is the standard deviation of asset-weighted industry investment. $\sigma 2$ is the weighted standard deviation of industry investment.

$$\sigma 1 = \sqrt{\frac{1}{n-1} \sum_{j=1}^n \left(w_j I_{INDj} - \left[\frac{1}{n} \sum_{i=1}^n w_i I_{INDi} \right] \right)^2} \quad \text{and}$$

$$\sigma 2 = \sqrt{\frac{n}{n-1} \sum_{j=1}^n w_j \left(I_{INDj} - \left[\sum_{i=1}^n w_i I_{INDi} \right] \right)^2}$$

where w_j is the fraction of the firm’s assets in segment j , I_{INDj} is industry investment for segment j , and the firm has n segments. $\Delta\sigma_{1X}$ is the exogenous change in the standard deviation of asset-weighted industry investment and $\Delta\sigma_{1N}$ is the endogenous change. $\Delta\sigma_{2X}$ is the exogenous change in the weighted standard deviation of industry investment and $\Delta\sigma_{2N}$ is the endogenous change. $\Delta\sigma_X$ is the exogenous change in the standard deviation of industry investment and $\Delta\sigma_N$ is the endogenous change. Lagged variables are as of year $t - 1$. The number of observations is 11,974. All regressions include separate intercepts for each year and firm. The standard errors, in parentheses, are calculated allowing for both heteroskedasticity and for the residuals to be correlated within each year.

	(1)	(2)	(3)	(4)
$\Delta\sigma_{1X}$	-0.439 (0.168)	-0.377 (0.163)		
$\Delta\sigma_{1N}$	-0.102 (0.066)	-0.019 (0.062)		
$\Delta\sigma_{2X}$			-0.348 (0.085)	-0.140 (0.219)
$\Delta\sigma_{2N}$			-0.461 (0.164)	-0.508 (0.300)
$\Delta\sigma_X$		-0.258 (0.067)		-0.194 (0.166)
$\Delta\sigma_N$		-0.332 (0.127)		0.040 (0.209)
Lagged $q - \bar{q}$	-0.471 (0.028)	-0.472 (0.027)	-0.470 (0.027)	-0.470 (0.027)
Lagged $\sigma 1$	-0.244 (0.080)	-0.218 (0.077)		
Lagged $\sigma 2$			-0.195 (0.105)	0.139 (0.290)
Lagged σ		-0.174 (0.095)		-0.311 (0.261)
Joint significance of both exogenous changes (p -value)		0.000		0.000
R^2	0.366	0.368	0.366	0.367

Our analog is the standard deviation of weighted investment, $\sigma 1$:

$$\sigma 1 = \sqrt{\frac{1}{n-1} \sum_{j=1}^n \left(w_j I_{INDj} - \left[\frac{1}{n} \sum_{i=1}^n w_i I_{INDi} \right] \right)^2}, \tag{7}$$

where again w_j is the fraction of the firm’s assets in segment j , I_{INDj} is industry investment for segment j , and the firm has n segments. $\sigma 1$ is diversity in asset-weighted investment. According to $\sigma 1$, a firm can have high diversity even if industry investment is the same for each segment, as long as it has segments of different size.

Our second alternate measure of investment diversity takes the opposite approach with segment size. The weighted standard deviation is σ_2 :

$$\sigma_2 = \sqrt{\frac{n}{n-1} \sum_{j=1}^n w_j \left(I_{\text{IND}j} - \left[\sum_{i=1}^n w_i I_{\text{IND}i} \right] \right)^2}. \quad (8)$$

In calculating diversity, σ_2 gives more weight to bigger segments. Consider a firm with 99% of its assets in one segment and 1% of its assets in another segment. *Ceteris paribus*, while σ_1 would view this firm as extremely diverse, σ_2 would view this firm as not at all diverse and almost the same as a focused firm.

Table 6 shows results for the effect of diversity on excess value, again decomposing the change in diversity into an exogenous component reflecting changes in industry investment and an endogenous component reflecting changes in structure (which now include changes in segment assets). We show the diversity measures by themselves, and then in conjunction with our baseline diversity measure. As before, we include the lagged level of the particular diversity measure.

Column (1) shows the regression using σ_1 , diversity in asset-weighted investment. As with the baseline specification, exogenous changes in diversity have a negative and significant effect on excess value. Column (2) adds changes in baseline diversity. The coefficient on $\Delta\sigma_X$ is slightly lower than the coefficient in the baseline specification, and the coefficient on $\Delta\sigma_{1X}$ falls somewhat. Both exogenous changes are individually significant. Measurement error does not appear to be a problem in column (2), as the regression (not shown) of $\Delta\bar{q}$ on column (2)'s right-hand side variables results in a coefficient of 0.14 on $\Delta\sigma_{1X}$ and -0.01 on $\Delta\sigma_X$. Thus there is evidence that exogenous changes in asset-weighted diversity (in addition to unweighted diversity) destroy firm value. We interpret this surprising result as a victory for the resource-weighted approach Rajan et al. (2000) advocate.

Column (3) shows the results using σ_2 , the weighted standard deviation of investment. The coefficients are similar to the baseline specification. Column (4) shows the effect of adding σ . It turns out that $\Delta\sigma_X$ and $\Delta\sigma_{2X}$ have a correlation of 0.95, so that multicollinearity plagues column (4). Although neither $\Delta\sigma_X$ nor $\Delta\sigma_{2X}$ are individually significant, they are strongly significant jointly. Thus we conclude from columns (3) and (4) that it is impossible to tell whether $\Delta\sigma_X$ and $\Delta\sigma_{2X}$ have separate effects on value, and that it does not much matter whether one uses the simple standard deviation or the weighted standard deviation in measuring investment diversity.

4.4. Direct measures of firm investment diversity

The evidence so far is consistent with the inefficient internal capital markets hypothesis. Here we provide more direct evidence using actual investment at the segment level, instead of just industry investment. Although this evidence cannot show causality, it also supports the hypothesis. Consistent with the results of Scharfstein (1998), Gertner et al. (1999), and others, we find that diversified firms allocate capital expenditures in a socialistic manner.

Table 7

Direct evidence from segment capital expenditures

Summary statistics and regression results for actual segment investment and investment of matching focused firms. C/S is the ratio of capital expenditures to sales for the individual segment or focused firm. $\sigma_{C/S\text{-Segment}}$ is the standard deviation of segment C/S for each diversified firm, and $\sigma_{C/S\text{-Focus}}$ is the standard deviation of matching firm C/S for each diversified firm. The sample is limited to diversified firms for which all segments have at least \$20 million in sales. For means, the p -value is from a T -test, and for medians, the p -value is from a Wilcoxon signed-rank test. The number of observations is 7,514 for summary statistics, and 7,002 for regression results. For the regression results, the standard errors, in parentheses, are calculated allowing for both heteroskedasticity and for the residuals to be correlated within each year.

Summary statistics			
	$\sigma_{C/S\text{-Segment}}$	$\sigma_{C/S\text{-Focus}}$	Difference
Mean	0.058	0.064	-0.006 p -value = 0.011
Median	0.022	0.031	-0.009 p -value = 0.000
Regression results			
Dependent variable: $\Delta\sigma_{C/S\text{-Segment}} - \Delta\sigma_{C/S\text{-Focus}}$			
Constant	-0.003	(0.002)	
$\Delta\sigma_{C/S\text{-Focus}}$	-0.978	(0.028)	
R^2	0.429		

The inefficient internal capital markets hypothesis implies that within-firm diversity in segment investment rates should be lower than measures of diversity based on focused firm investment rates, since diversified firms socialistically smooth investment across segments. To test this implication, we briefly examine segment investment, defined as the ratio of segment capital expenditures to segment sales. We use this ratio, denoted C/S, instead of the ratio of capital expenditures to capital stock, since capital stock is not available at the segment level (Lamont (1997) and Scharfstein (1998) also study C/S). Diversity in segment investment is the standard deviation of C/S within the firm, denoted $\sigma_{C/S\text{-Segment}}$. We restrict the sample to diversified firms where every segment has at least \$20 million in sales, so that the focused firms and segments have the same minimum size.

In order to compare segment investment and focused firm investment, it is not appropriate to use industry medians (which we use elsewhere in this paper) because median C/S will generally have a lower variance than C/S. To make segment C/S and focused firm C/S comparable, we match each segment with an individual focused firm. We match by finding the focused firm in the same industry that has firm sales closest to the sales of the target segment. We then take the standard deviation of C/S for the matching focused firms, and for each diversified firm we calculate $\sigma_{C/S\text{-Focus}}$. $\sigma_{C/S\text{-Focus}}$ is the simulated diversity level of a diversified firm that invests in the same way that focused firms do.

Table 8

Diversity in asset-weighted Q

The dependent variable is $\Delta Q - \Delta \bar{Q}$. RSZ is diversity in asset-weighted Q , defined as the standard deviation of asset-weighted Q , divided by $\bar{Q}_{EW} = (1/n) \sum_j Q_{INDj}$, the equal-weighted average of Q_{INDj} .

$$RSZ = \frac{1}{\bar{Q}_{EW}} \sqrt{\frac{\sum_{j=1}^n (w_j Q_{INDj} - [(1/n) \sum_{i=1}^n w_i Q_{INDi}])^2}{n-1}}$$

where w_j is the fraction of the firm's assets in segment J , and Q_{INDj} is the benchmark Q for segment J 's industry. ΔRSZ_X is the exogenous change in RSZ, caused only by changes in industry characteristics. ΔRSZ_N is the endogenous change in RSZ, caused only by change in corporate structure including number and SIC code of segments and weights. $\Delta \ln(\text{Sales})$ is the log change in total firm sales. $\Delta \sigma_X$ is the exogenous change in the standard deviation of industry investment ratios, caused only by changes in industry characteristics. $\Delta \sigma_N$ is the endogenous change in the standard deviation of industry investment ratios, caused only by change in corporate structure. The number of observations is 11,974. All regressions include separate intercepts for each year and firm. The standard errors, in parentheses, are calculated allowing for both heteroskedasticity and for the residuals to be correlated within each year.

	$\Delta Q - \Delta \bar{Q}$ on left-hand side			$\Delta \bar{Q}$ on left-hand side	
	(1)	(2)	(3)	(4)	(5)
ΔRSZ	-0.116 (0.047)				
ΔRSZ_X		-0.664 (0.156)	-0.459 (0.138)	0.906 (0.127)	1.290 (0.064)
ΔRSZ_N		-0.076 (0.052)			0.036 (0.010)
$\Delta 1/\bar{Q}_{EW}$	0.947 (0.140)	0.985 (0.147)			-1.667 (0.080)
$\Delta \ln(\text{Sales})$	-0.082 (0.044)	-0.084 (0.044)			0.003 (0.007)
Constant			-0.015 (0.012)	0.028 (0.028)	
R^2	0.223	0.225	0.001	0.030	0.861
Firm and year dummies	Y	Y	N	N	Y

Table 7 shows summary statistics for the diversity of segment investment. As predicted by the inefficient internal capital markets hypothesis, actual segment investment is smoother than the investment of focused firms in the same industry. Although the two measures of diversity are positively correlated (the correlation is 0.197), both mean and median $\sigma_{C/S\text{-Focus}}$ are significantly higher than $\sigma_{C/S\text{-Segment}}$.

Another implication of the inefficient internal capital markets hypothesis is that $\sigma_{C/S\text{-Segment}}$ should not move one-for-one with $\sigma_{C/S\text{-Focus}}$. This implication is central to our tests using exogenous changes in diversity, as excess values increase when diversity decreases due to shocks to industry benchmarks. In Table 7, we report evidence from segment investment supporting this implication. We test whether the difference in $\sigma_{C/S\text{-Focus}}$ and $\sigma_{C/S\text{-Segment}}$ fluctuates when $\sigma_{C/S\text{-Focus}}$ fluctuates. If $\Delta \sigma_{C/S\text{-Segment}}$ is uncorrelated with $\Delta \sigma_{C/S\text{-Focus}}$, then a regression of $\Delta \sigma_{C/S\text{-Segment}} - \Delta \sigma_{C/S\text{-Focus}}$ on $\Delta \sigma_{C/S\text{-Focus}}$ should result in a coefficient of negative one. Table 7 shows that the coefficient is not significantly different from negative one. However, we note that measurement error (along the lines discussed previously) is a major concern in

this regression. Random noise in individual firm investment tends to drive the coefficient towards negative one.

In addition to the problem of measurement error, Table 7 suffers from selection biases, since it examines endogenously chosen investment levels. Nevertheless, it at least shows that the available evidence on segment investment is consistent with the hypothesis that capital expenditures are inefficiently allocated within the firm. Taken together with the evidence shown previously on the causal channel between investment diversity and excess value, Table 7 provides direct evidence on how this causal channel operates. It appears that at least part of the value destruction we show occurs because internal capital markets are inefficient.

5. Diversity of different characteristics

Table 8 examines the diversity measure of Rajan et al. (2000), which we call RSZ. RSZ is the diversity in asset-weighted Q , and is defined as:

$$\text{RSZ} = \frac{\text{stdev}(w_j Q_{\text{IND } j})}{\bar{Q}_{\text{EW}}} = \sqrt{\frac{\frac{\sum_{j=1}^n (w_j Q_{\text{IND } j} - [(1/n) \sum_{i=1}^n w_i Q_{\text{IND } i}])^2}{n-1}}{(1/n) \sum_j Q_{\text{IND } j}}} \quad (9)$$

\bar{Q}_{EW} is equal-weighted industry Q . As in our measure σ_1 , the RSZ measure involves diversity in segment size measured by book assets.

Column (1) of Table 8 reproduces basic results on excess value using a first-differenced version of the specification in Rajan et al. (2000). In addition to the measure of diversity, their specification also includes the log of firm size and the inverse of the equal-weighted Q across the segments. The dependent variable is the first difference in excess value, measured without logs. The regression is not exactly the same as theirs because Rajan et al. (2000) use levels instead of differences, have a shorter time period, match by three digit SIC codes instead of two, use a more complex measure of Tobin's Q rather than the market-book ratio, and Winsorize the variables. Nevertheless, the results are broadly similar, as the coefficient of -0.116 (with t -statistic of 2.5) on diversity corresponds to the estimate of -0.276 (with t -statistic of 5.7) in Rajan, Servaes, and Zingales.

Column (2) splits the change in RSZ into exogenous and endogenous components, where as before the endogenous change reflects changes in corporate structure and the exogenous change reflects changes in industry characteristics. Column (2) shows that the effect of diversity comes largely through exogenous changes in diversity, as the coefficient on the exogenous change in RSZ is large and significant. Thus column (2) shows that endogeneity is not a major concern for the Rajan et al. (2000) results.⁴

⁴In the working paper version, Rajan et al. (1998) perform a robustness test that is somewhat similar to our exogenous/endogenous distinction. They show that their results survive after dropping firms for which individual segments experience large changes in asset value. They also control for the number of segments. However, these robustness tests are performed for a regression examining segment investment, not for a regression involving excess value.

The major concern in Table 8 is measurement error, since industry Q 's now enter directly into the diversity measure as well as the dependent variable. Thus measurement error in industry Q 's has a greater potential to produce spurious results. To gauge the effects of measurement error, we start by putting the exogenous change in RSZ diversity into a two-variable regression. Column (3) shows the coefficient is still large and significant at -0.459 . Column (4), however, shows the coefficient c is 0.906 in this setting. Thus with a ρ of 0.51 , measurement error can completely explain the estimated coefficient on exogenous change in RSZ. Of course the value of ρ is a judgement call that the reader must make. Readers who believe measurement error is not a problem should set $\rho = 0$; conservative readers who want to avoid false inferences should set ρ higher.

The full specification Rajan et al. (2000) use includes as a control variable the inverse of average industry Q for the firm's segments. Column (5) shows that this control variable does not eliminate the covariance bias. In the analogous multiple regression with the change in \bar{Q} as the dependent variable, the coefficient of 1.290 in column (5) is large, and could easily account for the coefficient of -0.664 in column (2).

Thus Table 8 shows that one must be careful in interpreting the empirical results using the RSZ measure of diversity, since the results are quite sensitive to assumptions about measurement error. "Hard-wiring" in the construction of the independent and dependent variables can lead to spurious results. Rajan et al. (2000) present a variety of evidence that measurement error is not driving their results, although most of their robustness tests involve other regressions with different dependent and independent variables (since explaining excess value with diversity is not their main focus). For these other regressions, they perform simulations, experiment with different control variables, and try alternative ways of constructing the variables. Based on Table 8, we conclude that the Rajan, Servaes, and Zingales results on the relation between excess value and diversity are not convincing evidence in favor of their hypothesis, but this conclusion is a matter of opinion.

Despite these measurement error issues, we view our basic result, that diversity lowers firm value, as supporting the central premise of Rajan et al. (2000). And, as shown in Table 6, there is evidence that resource-weighting, as advocated by Rajan, Servaes, and Zingales, helps explain this value destruction.

5.1. Diversity in other characteristics

Berger and Ofek's (1995) finding that excess values are lower for firms in unrelated businesses is consistent with the inefficient internal capital markets hypothesis, but is also consistent with the general notion that unrelated diversification is value destroying. Unrelated diversification could be bad due to greater scope for inefficient cross-subsidization, but it could also be bad for other reasons, such as limited managerial talent. Since different industries have different levels of investment, diversity in industry investment could be proxying for more general diversity. Broadly, each year we would expect different industries to be different along many measurable dimensions, such as profitability, capital structure, and sales growth. The

Table 9

Diversity in leverage, cash flow, and sales growth

The dependent variable is $\Delta q - \Delta \bar{q}$, the change in excess value. Leverage is the book value of debt divided by the sum of market value of equity and the book value of debt. Sales growth is net sales in year t divided by net sales in year $t - 1$. Cash flow is income before extraordinary items plus depreciation in year t divided by capital stock in year $t - 1$. $\Delta\sigma_X$ is the exogenous change in the standard deviation of industry investment ratios, caused only by changes in industry characteristics. $\Delta\sigma_N$ is the endogenous change in the standard deviation of industry investment ratios, caused only by change in corporate structure. $\Delta\sigma_{Z_X}$ is the exogenous change in the standard deviation of industry variable Z , caused only by changes in industry characteristics. $\Delta\sigma_{Z_N}$ is the endogenous change in the standard deviation of industry variable Z , caused only by change in corporate structure. Lagged variables are as of year $t - 1$. All regressions include separate intercepts for each year and firm. The number of observations is 11,974; the sample period is 1980–1997. The standard errors, in parentheses, are calculated allowing for both heteroskedasticity and for the residuals to be correlated within each year.

	Leverage: $Z = \frac{D_t}{E_t + D_t}$		Sales growth: $Z = \frac{S_t}{S_{t-1}}$		Cash flow: $Z = \frac{CF_t}{K_{t-1}}$	
$\Delta\sigma_{Z_X}$	-0.122 (0.081)	-0.095 (0.085)	-0.015 (0.101)	0.086 (0.112)	-0.151 (0.043)	-0.126 (0.040)
$\Delta\sigma_{Z_N}$	-0.264 (0.070)	-0.184 (0.081)	-0.447 (0.126)	-0.263 (0.145)	-0.241 (0.051)	-0.229 (0.064)
$\Delta\sigma_X$		-0.251 (0.076)		-0.296 (0.082)		-0.210 (0.069)
$\Delta\sigma_N$		-0.187 (0.143)		-0.210 (0.154)		-0.045 (0.139)
Lagged $q - \bar{q}$	-0.470 (0.028)	-0.471 (0.027)	-0.469 (0.028)	-0.470 (0.027)	-0.470 (0.028)	-0.470 (0.027)
Lagged σZ	-0.183 (0.034)	-0.132 (0.040)	-0.209 (0.114)	-0.097 (0.124)	-0.161 (0.038)	-0.145 (0.038)
Lagged σ		-0.130 (0.100)		-0.153 (0.099)		-0.053 (0.094)
Joint significance of $\Delta\sigma_{Z_X}$ and $\Delta\sigma_{Z_N}$ (p -value)	0.000	0.074	0.002	0.136	0.000	0.000
R^2	0.366	0.367	0.365	0.367	0.367	0.368

greater the diversity in these values in a given year, the greater the degree of unrelated diversification.

Table 9 examines diversity in characteristics other than investment. For each characteristic, we express diversity as the standard deviation in the industry characteristic. Table 9 examines each characteristic by itself and then in combination with investment diversity.

The first variable is leverage, the ratio of book debt to the sum of book debt and market equity. Lang et al. (1996) show that firm leverage is negatively related to capital expenditures of noncore segments, suggesting that high leverage prevents segments from taking advantage of investment opportunities, and that combining segments with high optimal leverage and low optimal leverage results in value destruction. Table 9 shows that by itself, endogenous changes in leverage diversity are negatively related to firm value. There is no evidence that leverage diversity causes lower values, since the exogenous change in leverage has a near zero effect. Finally, when adding the leverage diversity variables to our baseline regression, the coefficient on exogenous changes in investment diversity remains negative and significant.

This pattern is repeated for diversity in sales growth, where sales growth is year t net sales divided by year $t - 1$ net sales. Without investment diversity, only endogenous sales growth diversity has a negative and significant coefficient, and with investment diversity, both types of sales growth diversity are insignificant.

Cash flow diversity, however, does have a strong negative effect. Cash flow is the ratio of income before extraordinary items to prior year capital stock. Without investment diversity, both endogenous and exogenous changes in cash flow diversity have negative and significant coefficients. With investment diversity, the cash flow diversity coefficients are little changed. Compared to the baseline results, the coefficient on the exogenous change in investment diversity is somewhat lower at -0.210 instead of -0.302 , and the coefficient on endogenous diversity changes falls dramatically. Exogenous investment diversity changes still have a significant effect, therefore cash flow diversity does not subsume exogenous investment diversity.

How should one interpret the results on cash flow diversity and investment diversity? Berger and Ofek (1995) use the presence of a segment with negative cash flow (where the cash flow being used is actual segment cash flow, not industry cash flow) as a marker for cross-subsidization. In this sense, low segment cash flow is similar to low segment investment opportunities in that it indicates a potential for draining resources from the good segments to spend on the bad segments. Thus one interpretation of the negative effect of cash flow diversity is that it supports the inefficient internal capital markets hypothesis, since cash flow diversity creates a situation where good segments can subsidize bad segments. When the bad segments get worse and the good segments get better, the cross-subsidization problem becomes more severe.

In summary, other measures of diversity do not subsume investment diversity. Cash flow diversity has an independent exogenous effect, however, which could be consistent with the inefficient internal capital markets hypothesis, but could also reflect the more general idea that unrelatedness is bad.

6. Conclusions

Diversification destroys value. Our results show that exogenous increases in the diversity of a firm's investment opportunities reduce firm relative value. Since we look at exogenous changes due to industry shocks, our results show that selection biases and endogenous diversifying behavior are not entirely responsible for the observed diversification discount. We also study the effect of measurement error, and find that although measurement error can cause spurious results for some specifications, our specification is relatively immune. These results support the inefficient internal capital markets hypothesis: diversified firms have low value because they allocate capital inefficiently across their different parts.

Our analysis has limitations. It does not imply that if one randomly aggregated focused firms into diversified firms, value would be destroyed. What we show is that exogenous increases in diversity destroy value, *conditional* on already being diversified.

We find that when firms endogenously choose to become more diversified, their excess value declines as well. In this case, however, the negative correlation between endogenous diversification and value may or may not be causal. Firms may be destroying value by diversifying or firms may be diversifying in response to value decreases.

Our paper is similar in spirit to using natural experiments to identify causality rather than correlation. Natural experiments, defined as episodes with large identifiable economic shocks that are plausibly outside of the control of the firm, are hard to find. When one does find an experiment, sample sizes are often low (Blanchard et al. (1994) have 11 firms, while Lamont (1997) has 26). In contrast, our paper provides a general technique to isolate causation in a wide variety of circumstances.

Future research could use this exogenous instrument in several ways. For example, Scharfstein (1998) and Palia (1999) find that diversified firms with higher CEO pay-for-performance sensitivity have higher values and appear to engage in less inefficient cross-subsidization. Denis et al. (1997) find that the level of firm diversification is negatively related to equity ownership of managers and outside blockholders. One could test whether these results hold true for shocks to diversity: do exogenous shocks to diversity have a less negative effect in firms with better incentives? If so, the results would support an agency explanation.

Appendix

Our data on segments comes from several Current and Research segment files obtained from Wharton Research Data Services in April 1999. Our firm-level Compustat and Center for Research in Securities Prices (CRSP) data comes from the University of Chicago's database in December 1999. In our calculation of market value, we use CRSP market equity. For firms with multiple classes of stock, in calculating market equity, we aggregate all separate classes of stock together into one value-weighted portfolio.

We define Q as {market capitalization (from CRSP) + book assets (data item 6) – book equity (data item 60) – deferred taxes (data item 74)} / book assets (data item 6). The investment to capital ratio is capital expenditures (data item 128) divided by prior year net stock of property, plant, and equipment (data item 8). The market-sales ratio, M , is (total debt + market capitalization) / net sales (data item 12). Leverage is total debt / (total debt + market capitalization) where total debt is defined as long-term debt (data item 9) + debt in current liabilities (data item 34) + redemption value of preferred stock (data item 56). The cash flow is the sum of income before extraordinary items (data item 18) and depreciation and amortization (data item 14), divided by prior year net stock of property, plant, and equipment (data item 8).

We drop firm-years if any of the following conditions hold: it has missing or nonpositive firm sales or firm assets; missing or nonpositive (for any segment) segment sales or segment assets; has any segment that Compustat assigns an one-digit SIC code of zero, six (financial), or nine (largely “NO OPERATIONS”); the sum of segment sales is not within 1% of the total sales of the firm; the firm changes the month of its fiscal year-end such that in December of year $t - 1$ our latest information is from year $t - 2$. We also drop firms (such as GM) who report multiple firm totals for the same year (firms which report different Compustat total sales for the same CRSP permanent company identifier number).

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