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WHAT DOES A SMALL CORPORATE EFFECT MEAN? A VARIANCE COMPONENTS SIMULATION OF CORPORATE AND BUSINESS EFFECTS

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In a widely cited paper, Rumelt (1991) presents estimates of the relative influence of corporate, business unit, and other influences on business unit profitability and finds the corporation explains almost none of the variability in business unit profitability. Using a Monte Carlo simulation, we examine the relation of variance component magnitudes to other indicators of the importance of a particular effect. Our results demonstrate that variance components can be an extremely nonlinear indicator of importance. We also question whether Rumelt's corporate effect represents the possible contributions of corporate strategy to business unit performance. This addresses a puzzle raised by Rumelt (1991) concerning the small effect of corporations in explaining performance, and suggests that Rumelt's findings should not be seen as demonstrating the insignificance of corporate strategy. © 1997 by John Wiley & Sons, Ltd.

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INTRODUCTION

In a widely cited paper, Rumelt (1991) estimates the variance components of corporate, business unit, and other effects on business unit profitability. These estimates are particularly surprising because they show that the variance component of the corporate effect is very small. If we take these results at face value as others have, they suggest that the field's concern with corporate strategy is in fact misplaced; corporate strategy just doesn't matter (Hoskisson, Hill, and Kim, 1993; Ghemawat and Ricart i Costa, 1993; Carroll, 1993).

Rumelt (1991) discusses the small corporate effect, which he finds in common with Schmalensee (1985), as a conundrum. He finds it 'surprising to find vanishingly small corporate effects

in these data' given the extent of the literature on corporate strategy, corporate culture, the number of corporate management consulting firms, and the focus on senior corporate leaders in the business world (Rumelt, 1991: 182). While Rumelt (1991) states this formally in terms of the magnitude of his estimated corporate variance component, he suggests, and it has been interpreted by others, that corporate strategy may be relatively unimportant for explaining firm performance. These discussions assume that importance is roughly proportional to the relative size of estimated variance components. However, such an interpretation may be erroneous.

Since Rumelt's statistical technique has not been widely used in strategy research, we decided to examine its properties. We use a simulation to ask to what extent variance component estimates can be interpreted as reflecting importance. We construct data with *important* corporate effects and then analyze that data using variance components. We find small estimated variance components in data where there are substantial corporate effects. Furthermore, the parameter esti-

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mates vary substantially across simulation runs with the same parameters: the estimates of the variance components have serious reliability problems. In short, this paper contributes to the interpretation of variance component analysis, in particular when applied to understanding the relative importance of business unit and corporate effects.

THEORY DEVELOPMENT

Corporate and business unit effects

Schmalensee (1985) seeks to resolve a conflict within industrial economics between economists who emphasize a classical focus on industry and market power as a primary determinant of profitability and a revisionist school that emphasizes efficiency of firms (Demsetz, 1973). He estimates an analysis of variance model with firm, industry, and market share effects (as a proxy for business unit effects) and finds that firm effects don't exist, industry effects exist and are important, explaining 19 percent of variance of rates of return, and finally market share effects exist and explain little variance. Schmalensee (1985: 349) says the absence of firm effects 'merely means that knowing a firm's profitability in market A tells nothing about its likely profitability in a randomly selected market B'. Finding important industry differences supports the classical focus on industry-level analysis, while it is agnostic concerning the structural explanation of those differences.

Rumelt (1991) respecifies Schmalensee's (1985) model to decompose line of business profitability variance over time into corporate,¹ business, industry, and other effects. By doing so, he can enter business units as a separate entity rather than using market share as a proxy for business unit effects. He uses variance components to estimate his model. Rumelt's results agree with Schmalensee in finding a very small corporate effect and modest industry effect. The difference is that Rumelt's additional business unit variables were quite influential and explained variance which in Schmalensee (1985) was part of the

error term. As a result, the relative size of the corporate effect and industry effect to this much larger business unit effect became very small. To understand his work, we will present a short digression on variance component techniques.

Variance component analysis of business unit and corporate effects

In econometrics, variance component techniques began with a concern that pooled time series cross-sectional analyses omitted important factors associated with the individual actor or firm (Wallace and Hussain, 1969). For example, assume we want to estimate the influence of variable X on firm performance using data that have multiple annual observations for each firm and multiple firms. If the model omits factors that influence firm performance, estimating the model without controls for such factors may result in inconsistent parameter estimates. An early solution was to enter a dummy variable for each firm. This dummy picks up the stable firm effect so that the relation between X and performance can be estimated based on how they vary over time for each corporation. But if the number of firms is large and the number of annual observations small, the large number of dummy variables results in a large loss of degrees of freedom. The variance components solution was to assume that each firm effect has a constant value $u(i)$ drawn randomly from some population. We can then estimate the mean and variance of the distribution of $u(i)$ s rather than each $u(i)$ individually. In much of the econometric literature, variance components were used to control for an unspecified set of firm or similar effects so as to give consistent estimates of other effects (Chang, 1979; Cashel-Cordo and Craig, 1990; Boehmer and Megginson, 1990; Baltagi, 1995; Dielman, 1989). The variance components are not interpreted themselves.

Geneticists who examine genetic effects on quantitative outcomes such as size of offspring have employed variance components. Rumelt (1991) cites Searle (1971: 380), who suggests incorporating an estimated variance component as part of a numerator, which when divided by the total variance is 'a ratio which is important for bringing about increased milk production through selective breeding.' Searle (1971) does not explain how quantitative geneticists derive for-

¹ Rumelt renames Schmalensee's firm effects as corporate effects because the norm in economics is to refer to an autonomous competitive unit within an industry as a firm. Rumelt chooses to say that industries and corporations are two different sets of business units. Accordingly, we adopt the terms corporate and business unit effects.

mulas to interpret the estimated variance components for selective breeding. In fact, quantitative geneticists use a variety of different calculations from the estimates depending on the exact situation being modeled. While Rumelt (1991) very creatively uses Searle (1971) in developing his model, his interpretation of results may be problematic because it does not use the logic and the formulas of any particular selective breeding example. These formulas differ, for example, if the progeny are half siblings or full siblings and also depend on the number of sires (male parent), the number of dams (female parent) per sire and the number of offspring per dam (Falconer, 1960: 173–175; Kempthorne, 1957: 245).

In selective breeding studies, geneticists seek to identify genetic effects which increase certain characteristics from one generation to the next in a model that also includes a variety of genetic and environmental factors (Falconer, 1960: 166). The genetic effects are unobservable but can be estimated from knowledge about the nature of the breeding experiment combined with estimates of the variance components. Unlike Rumelt (1991), who compares the size of estimated variance components, geneticists normally use the components to estimate how much of a given trait passes on to the next generation under conditions of controlled breeding (Falconer, 1960; Kempthorne, 1957).

In short, quantitative geneticists use variance components but in the context of carefully designed experiments. The specifics of the design (e.g., how many calves each bull fathers) influence the estimated components and geneticists use different formulae and interpretations depending on the design. Whereas Rumelt (1991) offers variance components as a way to avoid concern with model details, geneticists devote considerable attention to such details in variance components. Finally, the quantitative genetics literature addresses estimation of heritability but has not concerned itself greatly with comparing relative sizes of components.

Rumelt presents a model with a number of different variance components reflecting different potential influences on business unit performance: business unit, corporation, year, industry, and year interacting with industry. He also allows for a corporation–industry association. He then estimates and interprets the size of the variance component as informing us on the relative impor-

tance of the different effects. If we define $\text{Performance}(i,k,t)$ as performance in year t of business-unit i,k , the part of corporation k in industry i , Rumelt's Model (1991) may be written as:

$$\begin{aligned} \text{Performance}(i,k,t) &= \text{Year}(t) + \text{Industry}(i) \\ &+ \text{Industry}(i) * \text{Year}(t) + \text{Corporation}(k) \\ &+ \text{Business unit}(i,k) + \epsilon(i,k,t) \end{aligned}$$

Each of the effects is assumed to be a constant value drawn from some population for which the variance can be estimated.

Rumelt finds that in two different samples, A and B, stable business unit effects are associated with between 46 percent (44%) of variance, while industry effects are 8 percent (4%) and corporate effects are 1 percent (2%). The stable industry effect is substantially less than the 19 percent reported by Schmalensee and roughly 1/6 of the size of the business unit effects. The corporate effects are small. Rumelt (1991: 182) interprets the small variance component on corporate effects as indicating that 'if one business-unit within a corporation is very profitable, there is little reason to expect that any of the corporation's other business-units will be performing at other than the norms set by industry, year, and industry-year effects.'

Questions

We see two very different potential problems with Rumelt's interpretation of variance components. First, the magnitude of the variance component may not relate in some readily interpretable manner to what we might see as the importance of the factor. Secondly, some theories in strategy may question whether this is the correct model for a corporate effect. Let us consider each in turn.

The problem with descriptively interpreting the size of the variance component is that while the theory of estimating variance components in order to interpret the effect of other variables has been well developed in econometrics, this literature has less to say on actually interpreting the relative importance of variance component estimates. Much of the literature assumes that one estimates the component to get better estimates of some other (nonerror component) effect. The size of an unobserved variance relative to total variance

is an important theoretical construct in the genetics literature. Estimated variance components are used to derive the unobserved variances. Comparisons of different effects which are meant to interpret relationships between underlying values such as that between breeding values and phenotypic values are interpreted through particular Response to Selection formulas which include either heritability, which is a ratio of a derived variance to total variance, or through its square root (Falconer, 1960: 193).

Rumelt (1991) makes statements of *importance* based on explained variance rather than an estimated parameter (Freedman, Pisani, and Purves, 1978: ch. 29). A conventional regression analysis with continuous variables uses the estimated parameter plus the variable's variance to gauge importance. Importance is the expected change in the dependent variable for a given change in the independent variable, often the change in dependent variable for a one standard deviation change in the explanatory variable (standardized β). Rumelt (1991) basically measures importance by the variance explained by a group of dummy variables rather than using the actual size of the parameters.

In our opinion, if the explanatory variables are a group of dummy variables representing a given factor (for example, a set of corporate dummy variables with one dummy variable for each corporation), then importance would be how much the expected value of the dependent variable differs across the dummy variables. Thus we would have a larger corporate effect if the coefficients on the corporate dummies had a large range than if they had a narrow range. In the extreme, if all the corporate dummy variables, including the excluded category, had the same value, we would conclude that there is no corporate effect.

Unlike variance component estimates on field data, our data are constructed by simulation. The data are constructed by random draws on a population of corporate or business unit values in which we have set the population characteristics. Since we construct the data from actual values for each corporation and business unit, we can directly examine the corporate and business unit values. Thus we can ask, how different is performance for high vs. low corporate values and high vs. low business unit values? These values are directly measured and are not estimated by variance components.

Our primary measure of importance of a given factor will be the difference in average performance between top and bottom quartile corporate or business unit values. When someone says *X* matters a lot for success in school, they mean that students who are higher in *X* do well and students who are lower in *X* do poorly. When someone says *Y* is more important than *X*, they mean that high vs. low in *X* makes a smaller change in the criterion variable than high vs. low in *Y*. Our metric of importance will be the difference in average performance between those in the top quartile and those in the bottom quartile of the factor. For example, if firms with top quartile corporate values have performance of 0.1 and bottom quartile of 0, we would have a measure of importance which is the difference between these values, i.e. 0.1. Since this metric is linear, we can say that a factor with a difference of 0.1 is half as important as a factor with a difference of 0.2.

The quantitative genetics literature suggests that the interpretation of the magnitude of an estimated variance component is somewhat complicated. Given Rumelt's (1991) surprising findings, and that variance is associated with squares of values, we think the relation between variance component magnitudes and other indicators of performance deserves attention. This leads to our first question:

Question 1: How does the relative magnitude of a variance component estimate relate to other indicators of relative importance of that particular effect?

Schmalensee (1985) described his firm (corporate) effect in terms of Peters and Waterman (1982) effects because the Excellent Companies discussed in *In Search of Excellence* presumably had a corporate culture that improved the performance of all the firm's business units. For this type of construct, the firm effect, which is essentially a dummy variable for each firm, is appropriate. Likewise, Rumelt's (1991) corporate effect assumes the corporation adds a given amount to the returns of all divisions beyond their industry and other effects. Rumelt suggests his model tests for differences between corporations including 'differences in the quality of monitoring and control, differences in resource sharing and other types of synergy, and differences in accounting policy' (Rumelt, 1991: 173).

Schmalensee's (1985) and Rumelt's (1991)

approaches correspond most closely to a managerial skill model of corporate strategy. That is, corporate managers differ in skill and that skill is reflected in general improvement or degradation of performance in the business units—truly a Peters and Waterman model of the corporation. However, the literature on corporate strategy including that on the effects of synergy, portfolio analysis, and even related diversification does not generally make the restrictive assumption that corporate management must make a uniform contribution to the performance of its business units. The specification may be overly restrictive and hence underestimate corporate effects, if by corporate effects one means the effects of corporate strategy on performance of business units.

Corporate strategies could have large impacts on profitability but not equally influence reported profits for all divisions of the firm—beyond the contribution of industry and other effects. Even a corporation following a BCG or GE matrix analysis would consciously choose to have some divisions with high reported profits and others with lower reported profits, and some would be in strong competitive positions relative to their industry and others would not (Bettis and Hall, 1981). It would be surprising if Cash Cows which are supposed to have high positive cash flow had the same return on assets as stars or question marks which have lower and potentially negative cash flows. Likewise, a corporation with synergies would have differential influences on business unit returns if the synergies do not assist all businesses in the corporation equally. For example, in related diversification, the combination of businesses may help performance in one business or a group of businesses but not give any advantage to the other businesses of the corporation. Rumelt (1974) considered this possibility that there are different types of relatedness within groups of business units and called it the related-linked category (see also Palepu, 1985). General Electric is a good example of a company which has pursued related-linked diversification. Turbine technology links power generation equipment and jet engines and a different strength or skill, distribution channels, link x-ray equipment with CAT Scanning medical diagnostic equipment.

To allow for diversification based on different strengths or skills for different business units in the corporation, some researchers measure

relatedness for each business unit separately (Wells, 1984; Mahajan and Wind, 1988; Lemelin, 1982). Others argue for a distinct construct of business unit relatedness (Davis *et al.*, 1992), or an interbusiness perspective on related diversification (Brush and Hendrickx, 1996). Indeed, a related-diversified corporation might plan to have normal or even low returns in some divisions in order to make extraordinary profits in another division. Consider, for example, the current rush to create corporations that contain both movie and television show production along with the distribution channels to generate market power. For example, Time-Warner Inc. in cable systems recently purchased Turner Broadcasting System Inc., which produces movies and content for cable systems. Even if successful in increasing overall corporate profits, there is absolutely no reason to suppose that this strategy will equally benefit, or harm, both divisions. Indeed, some argue that vertically integrated corporations exist in order to maximize corporate profits by joint profit maximization (Schmalensee, 1973; Waterson, 1980; Perry, 1978). Due to transfer pricing this could mean high profits in some divisions, and low profits in others.

Finally, the corporate influence on division profitability may vary inadvertently. Few corporations find their efforts to implement policies equally successful in all divisions. In the communications example above, it would be surprising if the corporate management were equally successful in handling the diverse businesses under their control (again, even if overall the structure led to high corporate profits).

In short, Rumelt's Model where corporate effects influence all divisions equally merits debate and the sensitivity of his results to this assumption merits exploration. This raises our second question:

Question 2: How does changing the number of business units influenced by the corporate effect influence the estimated magnitude of the variance component associated with corporate effect?

METHOD

We investigated the two questions above by estimating variance component models on simulated data. The simulation creates a data set of known

characteristics; the estimation sees whether the variance component technique finds these characteristics. Thus we vary, for example, the number of business units influenced by the corporate effect and can see how this influences the estimated variance component. Throughout, we use a model where performance is determined strictly by corporate and business unit effects along with an error term. Adding more effects would unduly complicate the analysis without capturing more of the problem we wish to examine.² The simulation and estimation were written within the SAS package and used the SAS procedure Proc Varcomp for the variance component estimates.

We constructed data using the following general model:

$$\text{Performance}(i,k,t) = \text{scale Corporation}(i) + \text{business unit}(i,k) + \epsilon(i,k,t)$$

where i indexes the corporation, i,k the business unit and t the year. *Scale* is a scalar parameter which we will use to vary the influence of the corporate effect on performance to investigate the sensitivity of the estimation technique to different true levels of the underlying effect. That is, we can examine the effect of truly different corporate effects by multiplying the corporate random variates by a scale factor. In our data, the largest corporate effect is when *scale* equals 1 and the smallest is when *scale* is 0.2.

The simulation proceeded by generating a value for the effect of Corporation 1 and then values for each of the four business units within the corporation. Then, for each business unit we generated four random error terms, one for each annual 'observation.' Thus each corporation would have 16 observations: 4 years for each of four business units. Four business units per corporation were chosen to approximate Rumelt's Sample B (4.56 business units per corporation). Each simulation run included data for 200 corporations. All simulations were run 10 times with the same parameters. The mean, maximum, and minimum variance components are reported.

We develop three models to simulate the relative importance of corporate and business unit effects. The three models correspond to different

assumptions about the form of the corporate and business variants, which are designed to answer the questions posed in the prior section. In Models 1 and 2, both the corporate and business variates are standard, normal variables with mean zero and variance equal to one. In Model 1, the corporate effect influences all business units. In Model 2, the corporate effect only influences half of the business units. One could think of this as *scale* in Equation 2 equaling zero for half of the business units within the corporation. Model 2 reflects the possibility, as described in Question 2, that not all businesses benefit equally from the corporate strategy.

We varied the importance of corporate effects relative to business unit effects by changing the value of *scale* while leaving the size of business unit and error effects constant. In each model we try five levels of the corporate scale parameter (*scale*), 0.2, 0.4, 0.6, 0.8, and 1. With *scale* equal to 1, the corporate effect contributes just as much to the business unit's performance as the business unit does. Examining the change in variance component for a change in *scale* lets us address Question 1—how the variance component estimate changes with importance of the variate.

Changing *scale* in Models 1 and 2 changes the importance of the corporate effect, but we are still not certain that *scale* provides a linear measure of the importance of the corporate effect. Model 3 handles relative importance by having the corporation and business unit variates 0,1. That is, half the corporations and half the business units have a value of 0 and half have 1. The corporate value is then modified by the scale factor. This means we then have a clearer idea of what a particular scale means—*scale* of 0.5 means the corporate value is 0 or 0.5 and the business unit effect is 0 or 1—the corporate effect is half of the business unit effect. A small amount of noise (a random variable uniformly distributed between 0 and 0.05) is added to the corporate effect to prevent identification problems.

In addition to the scale factor, we developed one additional indicator of importance. We selected the top and bottom quartiles for corporate and business unit effects and then calculated the means ROA for these quartiles. The difference in means between the top and bottom quartiles provides an alternative measure of the size of effect for the corporation or business unit. Inter-quartile range estimates use data pooled from the 10 replications of the simulation.

² We explored a simulation with two additional components designed to mimic Rumelt's industry and year variance components. The results agreed with those presented here.

EMPIRICAL RESULTS

In Model 1 (normal corporate and business unit variates, corporate variates influence all business units), the variance component for the corporation, or corporate effect, drops rapidly as *scale* decreases (see Table 1, Model 1). When *scale* is 1 (corporate and business unit effects of identical magnitude) we obtain very similar variance component estimates 0.97 for corporation and 1.0 for business unit). But with *scale* at 0.6, the corporate component drops to 0.38 compared to the business unit effect at 0.98. With *scale* 0.2, the corporate effect is essentially zero (0.03). We will discuss *scale* of 0.2 since the 1.5 percent corporate effect is very similar to what Rumelt (1991) found.

When *scale* is at 0.2 and the component negli-

gible (0.03), we still find a substantial difference in performance between corporations with high and low values for the corporate effect. Top quartile corporations have average performance of 0.21 and bottom quartile corporations have average performance of -0.28, a difference of 0.49. Top and bottom quartile business units differ by 2.5 (1.27 + 1.28). This indicates that at this *scale* the relative importance of the corporation is approximately 0.5/2.5, or about 20 percent as important as business unit for explaining performance. But the variance component suggests that it is about 3 percent as important!

The answer to Question 1 is clear: variance component magnitudes do not reflect importance in a linear manner. The data appear to suggest a squared relation much like the relation between

Table 1. Simulation results of corporate and business unit effects

Scale	Corporate effects			Business unit effects			Error	Corporate quartile effects		Business unit quartile	
	Mean ^a	Min. ^b	Max. ^c	Mean ^a	Min. ^e	Max. ^f		Mean ^g	Q1 ^h	Q4 ⁱ	Q1 ^j
Model 1: Normal effects, all business units influenced by corporation											
0.2	0.029	-0.025	0.096	1.011	0.943	1.069	1.009	-0.283	0.207	-1.281	1.270
0.4	0.124	0.066	0.193	1.027	0.928	1.131	1.004	-0.502	0.503	-1.280	1.258
0.6	0.379	0.196	0.498	0.976	0.869	1.053	1.013	-0.819	0.779	-1.296	1.265
0.8	0.635	0.511	0.864	0.995	0.914	1.060	0.994	-0.979	1.000	-1.253	1.281
1.0	0.970	0.821	1.174	1.019	0.888	1.161	0.992	-1.261	1.296	-1.290	1.248
Model 2: Normal effects, half of business units influenced by corporation											
0.2	0.010	-0.066	0.054	0.995	0.857	1.042	1.005	-0.173	0.120	-1.251	1.259
0.4	0.032	-0.010	0.080	1.048	0.974	1.155	1.011	-0.255	0.249	-1.287	1.273
0.6	0.062	0.023	0.127	1.150	1.013	1.288	1.003	-0.381	0.383	-1.263	1.310
0.8	0.095	0.032	0.153	1.225	1.115	1.367	0.993	-0.472	0.501	-1.282	1.265
1.0	0.168	0.069	0.274	1.364	1.252	1.472	1.010	-0.590	0.650	-1.219	1.311
Model 3: 0/1 effects, all business units influenced by corporation											
0.2	0.069	-0.091	-0.055	0.333	0.261	0.363	1.005	0.499	0.744	0.105	1.138
0.4	0.044	-0.061	-0.020	0.334	0.263	0.374	1.000	0.527	0.932	0.213	1.242
0.6	0.006	0.040	0.039	0.340	0.289	0.395	1.000	0.525	1.150	0.339	1.353
0.8	0.073	0.054	0.086	0.329	0.277	0.366	1.012	0.534	1.360	0.419	1.464
1.0	0.164	0.141	0.194	0.336	0.288	0.400	0.995	0.535	1.573	0.521	1.559

All results come from 10 runs.

^aCorporate mean: mean variance component for corporation.

^bCorporate min.: minimum variance component for corporation.

^cCorporate max.: maximum variance component for corporation.

^dBusiness unit mean: mean variance component for business unit.

^eBusiness unit min.: minimum variance component for business unit.

^fBusiness unit max.: maximum variance component for business unit.

^gError mean: mean error component.

^hQ1: mean returns for bottom quartile of corporate effect.

ⁱQ4: mean returns for top quartile of corporate effect.

^jBusiness unit Q1: mean returns for bottom quartile of business unit effect.

^kBusiness unit Q4: mean returns for top quartile of business unit effect.

correlation and R^2 .³ If X is a random variable and $scale$ is a constant, then it can be shown that the variance of $(scale * X) = (scale)^2 * \text{variance of } X$ (Kmenta, 1971: 62). Thus when the corporate variate is multiplied by a scalar multiple of $scale$, this should result in a $scale^2$ change in the variance of the corporate variate. In terms of variances, for a multiple of 0.8, this would result in a variance of 0.64, for 0.6 a variance of 0.36, for 0.4 a variance of 0.16, and for 0.2 a variance of 0.04. In fact, corporate variance components of 0.97, 0.64, 0.38, 0.12 and 0.03 are estimated respectively for the five values of $scale$.⁴ Variance components appear to be approximately the square of importance.

This nonlinearity will also apply to the interpretation of the importance of industry effects relative to business unit effects in Rumelt (1991). Many authors have concluded that the industry level of analysis is roughly one-sixth as important as the business unit level of analysis because the size of the industry variance components is roughly 1/6 the size of the business unit variance component (McGrath, MacMillan, and Venkatraman, 1995; Black and Boal, 1994; Powell, 1992; Hitt and Tyler, 1991; Levinthal and Myatt, 1994). Our results show that having the industry variance component 1/6 the size of the business unit component does not mean that the relative importance is 1/6. It simply implies that the importance is such that the ratio of variance components is 1/6. If the ratio of industry to business unit effects is 1/6, this implies that industry is about 40 percent as important as business unit.⁵

³ In fact, the ratio of the sum of the explained variances to the total variance equals the adjusted R^2 . We thank the comments of a referee for suggesting we examine this issue.

⁴ We also examined whether changing the scale of the business unit effect would demonstrably change the results. The model was run with the business unit effect scaled at 0.5 and the corporate effect scaled at 0.1, 0.2, 0.3, 0.4 and 0.5. The estimated variance components remain approximately the square of the scale factor (e.g., for the business unit effect the component estimates were approximately 0.25). When scale was 0.1, the corporate variance component was 0.008, that is 3 percent the size of the business unit effect even though the corporate effect was 20 percent of the size of the business unit effect.

⁵ Let importance of business unit be B and the importance of the industry be I . Their variance components are then approximately B^2 and I^2 . Therefore if the ratio of their variance components is 1/6, then I^2/B^2 equals 1/6. For any given B , we can solve for I and calculate the ratio of I/B . I/B , relative importance of industry to business unit, will equal 0.4 if the ratio of the variance components is 1/6. While these figures are approximate, we believe they are generally

The results vary substantially from one simulation run to another, despite the fact that this simulation uses data that conform precisely to the theoretical specification for variance components analysis. For example, with $scale$ equal to 1, we obtain estimates of the corporate effect that range from 0.82 to 1.17. This range of 0.35 is approximately 36 percent as large as the mean result of 0.97. With $scale$ equal to 0.2, we obtain a range on firm effects from -0.025 to 0.096 for a range of 0.12, which is four times the average effect of 0.029. If one runs this procedure on one set of real data, one's conclusions concerning the corporate effect have very little reliability. With the same real underlying distributions, one can get everything from -0.025 (i.e., no effect) to 0.096 (a real effect).

Given these results, we examined the distribution of estimates more closely. For this set of runs we simulated 450 corporations, which is very similar to Rumelt's (1991) 456 in sample A and 452 in sample B. We ran 500 iterations of Model 1 (normal corporate effect that influences all business units) with $scale$ equal to 0.2. The corporate effect averaged 0.0403 with a standard deviation of 0.0269. With a standard deviation 2/3 the size of the parameter, obviously one should put little faith in the magnitude of the estimate. For example, if we look at the bottom and top of the one standard deviation confidence interval (0.0134, 0.0672), this corresponds to a range of importance from 0.1158 to 0.2592. In other words, when one finds a 0.03 variance component, there is a 33 percent chance that the real value of importance will lie outside the range 0.1158–0.2392. Given a true value of 0.2, these estimates are extremely unreliable. This lack of reliability, as indicated by the variance component procedure, would be called low statistical power in a regression model (Cohen, 1988).

The random effects model assumes that the data are randomly drawn from the population, just like one iteration of the simulation. By construction, our model is correctly specified, which would be uncertain in any application to naturally occurring data. The lack of reliability suggests that any interpretation of one run of a random

consistent with Rumelt's estimates (Rumelt, 1991). In other words, Rumelt's findings should be interpreted as industry is 40 percent as important as business unit.

effects model must be done with extreme caution since the results are subject to high relative levels of random variation.

Rumelt (1991: 177–178) estimated a similar simulation in order to assess whether the estimated effects should be interpreted as reflecting nonzero population parameters. Just as we found for the small corporate variance component ($scale = 0.2$), Rumelt found the standard errors are so large that one cannot conclude that there is a nonzero corporate effect. The difference is that we know by construction that the corporate factor is 1/5 as important as the business unit. Whereas Rumelt interprets his finding to mean that the corporate effect is quite likely to be zero, we conclude that the technique does not find corporate effects when they definitely exist.

In Model 2, corporate and business unit effects are normal variates but the corporate effect only influences half the business units. This reflects Question 2, which asks how estimated variance components vary if the corporate effect influences only some business units. The results are similar to Model 1 of Table 1, but with even more extreme values (see Table 1, Model 2). If the *scale* is 1, meaning the size of the effect is the same for corporate and business unit effects but the corporate influences only half the business units, we get a corporate component of 0.17 compared to the business unit effect of 1.36; the corporate effect is only 12 percent of the size of the business unit effect. We would argue that a normal intuitive interpretation of this model (corporate and business unit effects of same magnitude but corporate effects only influencing half the business units) would be that corporate effects should be half the size of the business unit effect. Examination of the interquartile differences tells a similar story; corporate interquartile difference is 1.24 (0.59 + 0.65) and business unit interquartile difference is 2.52 (1.22 + 1.31). That is, both a direct examination of the construction and the interquartile difference indicate that the corporate effect is 50 percent of the business unit effect, while the variance component estimate places it at 12 percent.

Comparing the values in Model 2 of Table 1 to those in Model 1, we find that the estimated variance component in Model 2 is much less than half the size of the component in Model 1. The answer to Question 2 is clear: if the corporate effect only influences some business units, then

the estimated variance component will give an impression of a corporate effect well below the actual corporate effect.

Finally, we consider the case in which variates are assigned as 0 or 1. This helps to interpret the effects of scaling. If variates are 0,1 then it is clearer how one would interpret the scaling. For example, in the case of a 0.6 *scale*, the low performance half of the corporations have a 0 for the corporate effect and the high half have a 0.6 for the corporate effect. The business unit effect is always 0,1 with half the business units at 0 and half at 1. So with *scale* at 0.6, the corporate effect should be roughly 60 percent of the business unit effect. Yet in this case, we have a corporate variance component of essentially 0 (0.006) with *scale* of 0.6 while the business unit variance component is 0.34 (see Table 1, Model 3). Below 0.6, we get negative variance component estimates for the corporate effect which are normally equated to zero effect. For *scale* equal to 0.6, the interquartile difference for the corporate effect is 0.63 compared to 1.01 for the business unit. That is, the corporation is 60 percent as important as business unit (as one would expect, since they are all 0/1 variables and the corporate effect is scaled to be 0/0.6 compared to the business unit effect of 0/1). But the variance component shows the corporation to be 2 percent as important as the business unit (0.006/0.340).

CONCLUSIONS

The results provide strong evidence that variance components estimates cannot be used as if they were (implicitly) linear indicators of the importance of differing factors. In our simulated data, we consistently get variance component estimates near zero, well into the realm where we would ask why these are of any interest, when we also have strong indications of a substantial corporate effect. The conclusion from Rumelt (1991) concerning corporate effects appears to be premature:

But the results indicate that the dispersion among corporate returns can be fully explained by the dispersions of industry and business-unit effects; there is no evidence of 'synergy'.

Our conclusions with regard to Rumelt's findings also derive from three other points: (1) the importance of an effect is approximately the

square root of the variance component. Since the effects are less than one this results in an extremely small estimated variance component having a medium-sized importance; (2) variance component estimates can be extremely unreliable indicators of the underlying distributions in models that are structurally similar to Rumelt's (1991). That is, for effects of medium importance, variance components analysis provides a very wide range of component values such that interpretation of any specific value is extremely questionable; and (3) Rumelt's model conforms to a narrow conception of the influence of corporate strategy on business unit performance where corporate strategy has an equal impact (in a return on investment metric) on the returns for each business unit in the corporation. In terms of theories of corporate strategy, this really conforms only to the most extreme of the managerial approaches where corporate strategy is the transmission of managerial ability or inspiration to the business units.

The third point raises a number of complex issues regarding how to specify and estimate this kind of model. If portfolio, diversification, core competence, or any other strategic approach results in differential benefits in terms of measured ROA across business units, Rumelt's variance components model will underestimate their importance. Furthermore, *Rumelt's variance component analysis imposes as a constraint on the estimation that there is no correlation between business unit and corporation effects.* Whereas Rumelt (1991) explicitly assumes that corporations do not have an impact on the selection of individual business units, except insofar as they select which industries to be in, much of corporate strategy is about selection of business units.

Wernerfelt and Montgomery (1988) found that related diversification adds modest explanatory power to the estimation of firm, industry, and business effects for *firm* performance. Their model found that diversification, or firm focus, explained 2.5 percent of variance in Tobin's Q —compared to 19.5 percent for industry and 0.94 percent for firm average market share. The focus effect is roughly in accord with Rumelt's findings for a corporate effect. The interpretation of these estimated variance decompositions may also differ from a linear measure of importance.

How should the Rumelt (1991) results be inter-

preted? First, they suggest that corporate-managerial influences on business unit performance are not overwhelming, but they do not demonstrate that such influence is unimportant. Our results show many ways in which a reasonable corporate effect would be consistent with Rumelt's results. In his final results he finds a corporate effect of 0.8–1.6 percent of the total variance (Rumelt, 1991, Table 3). In our estimates, we found similar percent explained variance with a corporate effect of one-fifth the size of the business unit effect. Furthermore, the estimates are so unreliable that little faith can be put in the actual values. Rumelt has shown that the corporate effect is significantly smaller than the business unit effect but not that it is trivial. Second, they do not imply whatsoever that traditional corporate strategy issues such as diversification lack importance.

We have shown that Rumelt's results concerning the relative importance of corporate and business unit effects cannot be interpreted simply. If studies are to be compared, then following Falconer (1960) and work in quantitative genetics, interpretation of such results requires careful adjustments for the number of industries, number of corporations per industry, and the number of business units per corporation (Falconer, 1960: 173). Further, the results depend critically on several assumptions that may be inappropriate in this case—assumptions which when violated result in even lower estimates of the corporate effect. Our purpose in this paper has been to explore the properties of Rumelt's estimates. It is important to understand the limitation of current findings even if a better research approach is not obvious. Far from answering the question of what level of analysis researchers should emphasize, Rumelt provides a challenging introduction, but one that needs substantial further theoretical and empirical exploration.

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