Resources, Adjustments, and Diversification: Evidence from Production Functions

Birger Wernerfelt

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Key words: Resources, Adjustments, Diversification, Theory of the Firm

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Abstract

The RBV posits as a necessary condition for diversification that a firm’s resources can be leveraged beyond its original business. To achieve sufficiency we need to know whether the resource is best leveraged inside the firm or through a market contract. We therefore couple the RBV with the Adjustment-cost Theory of the firm to make and test a set of predictions about when firms should extend their scope. The two strong points of the study are (1) Because we are specific about the theory of the firm invoked, we can make more precise predictions, and (2) we test the predictions in production functions as well as in estimates of actual firm scope.
INTRODUCTION

While the resource-based view of the firm (RBV) offers a framework for both business and corporate strategy, it has been extensively used in the study of corporate diversification. In this application, it is necessary to assess whether a firm’s resources should be leveraged inside the firm or through a market contract. That is, the RBV needs to be supplemented with a theory of the firm. While there are several competing theories of the firm, the diversification literature has generally not been very precise on this point, typically just asserting that the resources “cannot be leveraged in the market”. Since no one has claimed that the RBV is inconsistent with any theory of the firm, this is not a criticism of the literature. However, there is an opportunity to make sharper predictions by drawing on both the RBV and a specific theory of the firm.

In the present paper, we combine the RBV and the Adjustment-cost Theory of the firm (Simester and Knez, 2002; Wernerfelt, 1997; 2003). As its name implies, this theory is driven by attempts to economize on costs of adjusting trading relationships for services. If only a few alternative services are possible, the parties may agree on a price list up front, and if adjustments are rare, they can be negotiated on an as-needed basis. It suggests an employment relationship, a firm, in cases where the desired service changes widely and frequently. Because resources are assets, i.e. long-lived, the conditions under which their services are deployed can be mapped into the above categories. For some, it is possible to write a contract covering their possible uses, for some, only very occasional

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1 It has been suggested that the economic forces stressed by the RBV are similar to those driving the Property Rights Theory of the firm (Rajan and Zingales, 2001a, 2001b).
renegotiation is needed, and for others, neither of these types of contracts can be used in a practical way. The theory then predicts that the latter class of resources, many of which can be seen as improving management of specific processes, should be leveraged inside the firm. So the general proposition is that firms should diversify when their resources are such that effective deployment in other businesses requires frequent and diverse adjustments.

While it may be impossible to subject this to a comprehensive test, many individual implications are eminently testable. We look at firms competing in industries where new product development is more or less challenging or “fast paced”. The firms that survive in industries with fast paced new product development are probably good at managing such processes. That is, management of fast paced new product development is likely to be one of their resources. Since development processes typically involve lot of adjustments and iterations, we argue that it is hard to write a contract, or an algorithm, about how to manage them. So we hypothesize that a firm is more likely to diversify if it competes in industries with faster paced new product development.

Vertical integration differs from diversification because it may be undertaken even if the firm brings no resources to the new business. If a firm wants to compete at a particular stage of the value chain, it has no choice but to deal with the adjacent stages. For example, a firm with strong resources in assembly still needs to acquire parts. If the nature of a specific part needs to be adjusted frequently, it may be too costly to engage in negotiations at every turn. In such cases, the firm may bring parts manufacturing in-house even if it brings no special skills to that industry. So vertical integration can be seen as an indirect way to leverage resources at other stages of the value chain. However, just like
diversification, vertical integration is undertaken when it is important to make a lot of adjustments to trades between business units. Because diversification and vertical integration are concerned with different trades (horizontal versus vertical), this does not imply any general statement to the effect that they should co-vary. However, fast paced new product development is likely to impose a need for frequent adjustments on the supply chain. So we can predict that both diversification and vertical integration are more likely in firms that compete in industries with faster paced new product development.

We use the well-known PIMS database to test our two hypotheses. Specifically, we measure the extent to which an industry is characterized by fast paced new product development by the speed at which new products are developed, by the predictability of their launch times, and by how big a fraction of sales they account for. The evidence is unusual because we report on both production functions as well as data on the actual incidence of both diversification and vertical integration. The productivity regressions suggest that the marginal benefits of integration are positive in the fast paced industries, but near zero across all industries. The incidence results show that firms in fact do expend their scope in the predicted circumstances.

We start the argument with a brief review of the Adjustment-cost Theory of the firm. After a micro-level discussion of the ways in which some specific resources are leveraged, we formulate our hypotheses and present data and results.
THE ADJUSTMENT-COST THEORY OF THE FIRM

In this Section, we will present a very simple version of the theory, based solely on “direct adjustment-cost” incurred in bargaining and negotiation processes. Other versions are based on “indirect adjustment-costs”, i. e. incentive effects. The exposition is based on Wernerfelt (1997, 2003)\(^2\).

To keep things simple, we assume that all adjustments are implemented perfectly, such that governance mechanisms can be compared in terms of the direct adjustment costs of implementation. In each period, a buyer may receive a service from a seller. The service is costly to the seller, but creates value for the buyer. Part of this value can be transferred to the seller through a payment \(w\). There is a set \(A\) of feasible services and the “ideal” service is that which generates most gross surplus (buyer value minus seller costs gross of adjustment-costs). Between any two periods, costs and values of all services change, such that the identity of the ideal service changes with probability \(\lambda\). We assume that the buyer always knows the identity of the ideal and that the players always implement it.

Given these assumptions, we can compare how alternative game forms govern adjustments. We focus on just three:

- *Negotiation-as-needed*, in which the players negotiate a new \(w\) whenever they switch to another service,

\(^2\) Empirical evidence is found in Simester and Knez, 2002.
- *Price list*, in which the players negotiate a set of prices ex ante, after which the buyer picks from the menu at each opportunity to switch, and

- *Employment relationship*, in which the players first negotiate a constant $w$, and then enter an implicit contract in which the buyer dictates adjustments to the seller, and either player may terminate the relationship at any time.

Negotiation-as-needed and the Price list represent the market. We could look at other market game forms as well, but it is clear that we cannot produce a complete list. On the other hand, the Employment relationship, a.k.a. the Firm, is not an arbitrary choice. Among all game forms, none require the players to negotiate fewer prices and none have lower variable costs per adjustment.

The costs of negotiating a wage contract are $C_f$, and the costs of negotiating a price list of length $|A|$ is $C(|A|)$, and the costs of bargaining over a single price are $C_b$. Since we assume that all adjustments are implemented, the Price list has to cover all elements of $A$ and average per-period net surpluses from the three game forms differ only in terms of these direct adjustment-costs. If $\rho$ is the rate of interest, these are $\lambda C_b$ for Negotiation-as-needed, $\rho C(|A|)$ for the Price list, and $\rho C_f$ for the Employment relationship. *The Employment relationship is more efficient than Negotiation-as-needed when the frequency of adjustment is high, and more efficient than a Price list when the set of possible adjustments is very diverse.*

This is illustrated in Figure 1 below.
HOW ARE RESOURCES LEVERAGED?

In this Section, we will look at three specific resources and ask what actually happens if the resource is put to use in a business unit different from that in which it originated. The purpose of the discussion is to support the claim that many resources are deployed under conditions that make it impractical to contract for their use. We will go from simpler to more complex examples.

*Patents.* It is not unusual to see patents applied in several markets, and the application is often governed by a contract giving the licensee the, perhaps exclusive, right to use the patent to make a particular class of products and sell them in a specific geographical area. The agreement covers all uses within these bounds, and adjustments are rarely needed.

*Brand names.* In contrast to patents, brand names are typically leveraged inside the firm. A plausible explanation is that the value of a brand is affected by all its uses. For
example, while Disney might approve of a single specific use of one of its characters, it would want to approve even minor variations. To manage this across firm boundaries may entail prohibitively large adjustment-costs.

*New product development skills.* These are almost always leveraged inside the firm. To see why, we will for a moment not worry about governance, but instead engage in a thought-experiment. Let us think about how Proctor and Gamble best could help another, client, firm with new product development. The process could start with advice about collecting certain kinds of information and using a particular organizational structure. However, this is not likely to contain a lot of news for the client. Because it is unconditional, this type of advice can be codified and sold, so the client probably knows it already. P&G might add more value after the start of the process, when the client has to react to information as it is revealed. At this point, codification is impossible, and judgment is required. To transfer this, P&G would likely move groups of its own experienced people into “shadow positions” where they can give ongoing advice to key members of the client’s organization. Others in P&G could be consulted on an occasional basis. In the end, the client will have received a very, very large number of small services, mostly in the form: “in this situation, we will try such-and-such”.

The above thought-experiment suggests that it is impractical to leverage skills in new product development outside the boundary of the firm in which they originate. Process management consists of a lot of little things and the skills are therefore hard to transfer outside the firm (and hard to imitate as well). One could tell a similar story about skills in other business processes.
HYPOTHESES

Both the strategy and the economics literatures contain several empirical studies of the scope of the firm. However, they have approached the topic in very different ways. In strategy, we have a long research tradition focussed on diversification and its effect on firm performance. These studies often test a theory by showing that firms which follow it “more closely”, perform better than others. In economics, most empirical studies are concerned with vertical integration and look at the incidence of integration as a function of various measures associated with the theory being tested (Masten, 2002). The premise being that surviving firms “do the right thing”.

The PIMS database used in the present paper allows us combine these two approaches. We study both diversification and vertical integration, and we look at both performance and incidence. So we will, among other things, see if firms perform better by following the Adjustment-cost Theory of vertical integration, and check that firms on the average do diversify when the theory says that they should.

Our tests for performance effects are based on production functions (as in Shoar, 2002). We estimate SBU-level production functions and look at the productivity effects of diversification and vertical integration as functions of exogenous indicators of the need for adjustments. By using interaction variables, we can isolate circumstances in which changes in scope helps and hurts labor productivity. By comparison, the incidence tests are relatively straightforward: we look at measures of diversification and vertical integration as functions of the same exogenous indicators of the need for adjustments.

We admit that there is some tension between the two testing strategies. The incidence tests rely on the assumption that firms, on the average, do not make mistakes,
while the performance equations cannot be estimated unless we have some more or less serious mistakes among the observations. While it clearly is possible that most, but not all, firms are correct, this does not allow us to escape the problem entirely. The logical issue is that we treat scope decisions as endogenous in one test and exogenous in another. However, one can reasonably appeal to a distinction between long and short-term endogeneity by asserting that firm scope changes “more slowly” than performance. More pragmatically, our equations are likely to suffer from omitted variables and variance in these could generate the apparent mistakes necessary to estimate the interaction variables in the production functions.

To test the Adjustment-cost Theory, we need indicators of the need for diverse and frequent adjustments. Quantity adjustments, the need for which could be captured in measures of demand instability, are unlikely to satisfy the diversity requirement. In industries where quantity adjustments are frequent, one must expect them to be anticipated in procurement contracts. Conversely, we conjecture that adjustments brought about by technological change are too infrequent to justify firm governance. New product development is a more promising area. The nature of adjustments is harder to anticipate, and they may be needed quite frequently. Accordingly, we look for indicators of needs for frequent and diverse adjustments in the area of new product development, trying to capture the degree to which industries are “fast paced”. With less indirect indicators of the need for frequent and diverse adjustments, we might be able to pose different hypotheses about diversification and vertical integration. However, since this does not seem possible, we will use the same explanatory variables to predict both aspects of firm scope.
In selecting independent variables, we try to steer clear of endogeneity problems to the extent possible. When looking for indicators of the need for frequent and diverse adjustments, we cannot use any measures that are directly controlled by the firm. For example, it would not be possible to interpret a single regression which included things such as product quality, firm advertising, or firm R&D. We succeeded in finding measures that are reasonably exogenous: Two of them are at the industry-level and one is an outcome measure. The industry measures capture the time typically needed to develop a new product, and the extent to which it is hard to predict when new products will be launched. The outcome measure is the percentage of firm sales accounted for by new products. Since this is indirectly controlled, though price and other marketing variables, it is “less exogenous” than the industry measures. On the other hand, it is certainly better than advertising or quality.

As discussed above, we estimate the production function under the implicit assumption that diversification and vertical integration are exogenous (because of omitted variables and mistakes), or at least fixed in the short run. While this seems defensible, we need to make the same assumptions about labor and capital, and in the case of labor it is less compelling. To mitigate these problems, we estimate the log of performance on a per employee basis.

We postulate a constant-returns-to-scale production function in which value added ($V$) depends on labor ($L$), capital ($K$), integration ($I$), and indicators of the need for adjustments ($A$). \[^3\] Specifically, we estimate

$$V = a(I,A)K^\beta L^{1-\beta},$$

(1)
in the form
\[
\log (V/L) = \gamma_0 + \gamma_1 I + \gamma_2 A + \gamma_3 IA + \beta \log (K/L).
\] (2)

If we take the functional form of (2) seriously, \( \alpha(I, A) = \exp(\gamma_0 + \gamma_1 I + \gamma_2 A + \gamma_3 IA) \). We therefore want to test the hypothesis that \( \gamma_3 + (\gamma_1 + \gamma_3 EA)(\gamma_2 + \gamma_3 EI) \) is positive, where \( E \) is the expectation operator. A more general hypothesis is that \( \gamma_3 \) is positive.

The incidence tests will be of the form
\[
I = \delta_0 + \delta_1 A,
\] (3)
where the hypothesis is that \( \delta_1 \) is positive.

**DATA AND MEASURES**

As mentioned above, the study was conducted on the PIMS database. The database, which is described in Buzzell and Gale (1987), is unique because it contains both financial information and a number of more qualitative items. It has been used in more than one hundred academic papers, although much more so in the 1970’s and 80’s than in the recent past. Nevertheless, it is still being updated and maintained by the PIMS Europe consulting company in London, England.

Compared to a customized data collection effort, the size of PIMS is a major advantage: It spans several thousand businesses. Since most large firms are very diversified, it is a major advantage that the unit of observation is a “business-unit”, rather than a firm. By avoiding averaging, this gives us much more precise picture of the individual relationships, even if the data are subject to some measurement error from

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3 Because the data is disguised by scaling, it is not possible to allow flexible returns to scale. Exploratory manipulations lead us to believe that the true model has moderate returns to scale. Perhaps to a power of 1.1.
allocation rules. An obvious disadvantage of using this database is that we cannot ask new questions with “new” variables, but are limited to a fixed set of preexisting items.

We use the most recent observation for each business of the variables discussed below.

-Diversification (DI) is measured by management responses to a question about the “extent to which your business unit shares facilities” with other units in the firm? Since this is reported on a three-point scale, as “less than 10%”, “between 10% and 80%”, and “over 80%”, it is a very coarse measure. However, since we have so many observations, this is not likely to be a serious problem. Another concern is that it is likely to underreport diversification because many diversified firms may have divisions that do not share plant and equipment with any other division of the firm. However, it is hard to tell a natural story in which this creates a bias in favor of our hypotheses. Suppose that the Adjustment-cost Theory is wrong and that firms diversify for other reasons. In this case one should think that it is harder to share assets in fast paced industries, resulting in a negative relationship between the measured incidence of diversification and the extent to which the business operates in a fast paced industry. The same argument would seem to defend against misinterpretations of our performance model.

-Vertical integration (VI) is measured by value added as a percentage of sales on the business unit level. We omit about twenty percent of the business units because they report internal sales or purchases. In such cases, we cannot track the internal flows and are thus unable to measure corporate integration. For the observations we use, VI is equal to both business and corporate level integration, for the product line in question.
-Development time for new products (DT) is measured by management responses to the question: “For this business and its major competitors, what is the typical time lag between the beginning of development effort for a new product and market introduction?” The possible answers are “less than one year”, “1-2 years”, “2-5 years”, “more than 5 years”, and “little or no product development occurs in this business”. These are coded as 1, 2, 3, 4 and 5, respectively.

-Random product changes (PC) are measured by management responses to the question: “Is it typical practice for this business and its major competitors to change all or part of the line of products or services offered annually?” “Seasonally?”, “Periodically, but at intervals longer than one year?”, or “No regular, periodic pattern of change?” Since this question confounds frequency and randomness, we use only observations with the last two responses, coded as 3 and 4 respectively. (Only about 5% of the data are lost by this procedure.) So this is another variable that is measured very coarsely.

-Percentage of sales from new products (NP) refers to products introduced in the last three years and is measured at the business, rather than the industry, level.

-Labor productivity (VA/L) is measured in constant dollars as value added per employee.

-Capital per employee (K/L) is measured in constant dollars as total assets per employee.
Table 1 below contains the descriptive statistics.

Table 1

Descriptive Statisticsa

<table>
<thead>
<tr>
<th></th>
<th>Mean (sd)</th>
<th>VI</th>
<th>DT</th>
<th>PC</th>
<th>NP</th>
<th>VA/L</th>
<th>K/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI</td>
<td>1.70 (.77)</td>
<td>.038</td>
<td>-.053***</td>
<td>.014</td>
<td>.051***</td>
<td>.252</td>
<td>.120</td>
</tr>
<tr>
<td>VI</td>
<td>54.8 (16.8)</td>
<td>-.049***</td>
<td>.061***</td>
<td>.063***</td>
<td>-.006</td>
<td>-.217</td>
<td></td>
</tr>
<tr>
<td>DT</td>
<td>2.98 (1.30)</td>
<td>.156</td>
<td>-.262</td>
<td>-.041</td>
<td>.086</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC</td>
<td>3.74 (.59)</td>
<td>-.184</td>
<td>.050</td>
<td>.024</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NP</td>
<td>8.15 (14.9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VA/L</td>
<td>57.7 (50.4)</td>
<td>.014</td>
<td></td>
<td></td>
<td>.718</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K/L</td>
<td>50.5 (66.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

aN ranges from 3469-3526, *** Significant at 1%

RESULTS

Looking first at the correlations in Table 1, we see the pattern predicted by the theory. Both diversification and vertical integration are negatively correlated with product development time (DT), and positively correlated with the extent to which new product introductions occur at random times (PC) as well as the importance of new products (NP). Five of these six correlations are significant at the 1% level.

Estimates of the two production functions are reported in Table 2.
### Table 2

**Estimates of Log Labor Productivity\(^a\)**

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Productivity of Vertical Integration</th>
<th>Productivity of Diversification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log K/L</td>
<td>.6004 (79.23)</td>
<td>.5621 (72.13)</td>
</tr>
<tr>
<td>Vertical Integration(VI)</td>
<td>.0082 (2.75)</td>
<td></td>
</tr>
<tr>
<td>Diversification(DI)</td>
<td>- .1067 (-1.06)</td>
<td></td>
</tr>
<tr>
<td>Development Time(DT)</td>
<td>.0262 (1.54)</td>
<td>.0279 (2.06)</td>
</tr>
<tr>
<td>Random Prod Change(PC)</td>
<td>.0241 (.59)</td>
<td>-.0750 (-1.57)</td>
</tr>
<tr>
<td>%Rev from New Prods(NP)</td>
<td>-.0030 (-1.70)</td>
<td>.0006 (.52)</td>
</tr>
<tr>
<td>VIxDT (Hyp&lt;0)</td>
<td>-.0013*** (-4.30)</td>
<td></td>
</tr>
<tr>
<td>DIxDT (Hyp&lt;0)</td>
<td>- .0419*** (-5.76)</td>
<td></td>
</tr>
<tr>
<td>VIxPC (Hyp&gt;0)</td>
<td>.0006 (.75)</td>
<td></td>
</tr>
<tr>
<td>DIxPC (Hyp&gt;0)</td>
<td>.0835*** (3.28)</td>
<td></td>
</tr>
<tr>
<td>VIxNP (Hyp&gt;0)</td>
<td>.0001** (2.32)</td>
<td></td>
</tr>
<tr>
<td>DIxNP (Hyp&gt;0)</td>
<td>.0005 (.85)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>3412</td>
<td>3244</td>
</tr>
<tr>
<td>R(^2)</td>
<td>.6586***</td>
<td>.6449***</td>
</tr>
</tbody>
</table>

\(^a\) t-statistics in parenthesis, ***Significant at 1%, **Significant at 5%.

The six test statistics of the form \(\gamma_3 + (\gamma_1 + \gamma_3 \cdot EA)(\gamma_2 + \gamma_3 \cdot EI)\) all have the predicted sign, and five of the six interaction variables \(\gamma_3\) are significant. Both vertical integration and diversification helps productivity when product development times are short, when product designs change at random times, and when new products are
important. While there can be many reasons for insignificance, the results are also consistent with the appealing claim that integration, on the average, neither helps nor hurts productivity. (The net coefficients on VI and DI are .0073 and .0848, respectively. Both have t-values below one.) Consistent with the premise that it takes skills/resources to survive in industries with faster paced new product development, the evidence suggests that these firms perform better.

As a further check on the argument we report the incidence estimates in Table 3 below.

Table 3
Extent of Vertical Integration and Diversificationa

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Vertical Integration</th>
<th>Diversification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Time(DT)</td>
<td>-.5530*** (-2.42)</td>
<td>-.0291*** (-2.68)</td>
</tr>
<tr>
<td>Random Prod Change(PC)</td>
<td>2.3487*** (4.74)</td>
<td>.0104 (.28)</td>
</tr>
<tr>
<td>%Rev from New Prods(NP)</td>
<td>.0742*** (3.71)</td>
<td>.0022** (2.32)</td>
</tr>
<tr>
<td>N</td>
<td>3413</td>
<td>3245</td>
</tr>
<tr>
<td>R²</td>
<td>.0114***</td>
<td>.0051***</td>
</tr>
</tbody>
</table>

*a-t-statistics in parenthesis, ***Significant at 1%, **Significant at 5%.

Once again, all the signs are as predicted, and five of the six coefficients are significant. While the pattern of significance is different, the results are remarkably consistent with those in Table 2. As suggested by the production functions, firms integrate more when product development times are short, when product designs change at random times, and when new products are important.
DISCUSSION

We have coupled the RBV with a specific theory of the firm to make and test a set of predictions about when firms should extend their scope. The two strong points of the study are: (1) Because we are specific about the theory of the firm invoked, we can make more precise predictions, and (2) we test the predictions in production functions as well as in estimates of actual firm scope. The production function estimates are based on largely exogenous measures and are consistent with the belief that the average firm could not improve its performance by focusing or diversifying.

In the context of the RBV-inspired literature on diversification (Montgomery, 1994), the paper is unusually explicit about the jointly invoked theory of the firm. We used the two theories, plus several reasonable assumptions, to make a set of predictions that by and large could not be rejected. However, we admit that this only constitutes a very weak joint test of the two theories. Limitations of the data, resulting in a lack of control variables, open the door for a host of alternative explanations. However, most alternative theories do not speak to the variables used to indicate that an industry is characterized by fast paced new product development, and the fact that the same three variables predict increased scope in four different cases raises the bar for alternative explanations.

As mentioned in the Introduction, we do not mean to imply that diversification and vertical integration in general go hand-in-hand. The extent to which an industry is characterized by fast paced new product development may be one of the only variables
that correlate positively with both types of integration. In both cases it increases the need for frequent and diverse adjustments, but the mechanisms underlying the two correlations are quite different. Fast paced new product development correlates with diversification because it indicates that the firm has a resource, skills in management of development processes, the application of which generates lots of adjustments. It correlates with vertical integration because it causes demands for adjustments in the supply chain.

We also do not claim that fast paced new product development always imply that firms should increase their scope. It is not the fast pace itself, but the adjustments we believe it correlates with, that dictate the need for increased scope. As should be clear from the theoretical part of the paper, we also do not believe that fast paced new product development is the only circumstance calling for increased scope. It is just the only such circumstance we could proxy with the PIMS data.

Different databases will allow us to test other predictions about diversification and vertical integration, based on the Adjustment-cost Theory or other theories of the firm. Over time, work along these lines can help us move beyond high-level predictions such as “firms diversify based on advertising and R&D capital”, through mid-level predictions of the type tested here, and ultimately become really precise about when firms should diversify.
REFERENCES


