*Strategic Management Journal*
*Strat. Mgmt. J.*, **23**: 171–179 (2002)
DOI: 10.1002/smj.221

## RESEARCH NOTES AND COMMENTARIES

# MAPPING TECHNOLOGICAL CAPABILITIES INTO PRODUCT MARKETS AND COMPETITIVE ADVANTAGE: THE CASE OF CHOLESTEROL DRUGS

ALLAN AFUAH*
*University of Michigan Business School, Ann Arbor, Michigan, U.S.A*

*While a lot of attention has been paid to those characteristics of capabilities that give firms a competitive advantage, a lot less attention has been given to supporting empirical evidence and to the deployment of these capabilities. This paper presents a model for mapping firm capabilities into customer value and competitive advantage in different markets. With empirical evidence from cholesterol drugs, I illustrate how the model can be used to estimate customer value and competitive advantage from technological capabilities.* Copyright © 2002 John Wiley & Sons, Ltd.

Attaining and sustaining a competitive advantage is fundamental to strategy. While research in the resource-based view of the firm has identified those characteristics of resources and capabilities that give firms a competitive advantage, very little progress has been made in providing empirical evidence. Moreover, we still know very little about the deployment of these capabilities. Yes, in the resource-based view of the firm, 'competitive advantage lies "upstream" of the product markets and rests on the firm's idiosyncratic and difficult-to-imitate resources' (Teece, Pisano, and Shuen, 1997: 513). Ultimately, however, resources must be converted to customer value since competitive advantage often comes from offering customers better value than competitors (Porter, 1991).

Key words: technological capabilities; competitive advantage; hedonics
*Correspondence to: Allan Afuah, University of Michigan Business School, 701 Tappan Street, Ann Arbor, MI 48109-1234, U.S.A.



*Received 8 February 1999*
*Final revision received 6 August 2001*

This paper presents a model and empirical evidence for valuation of firm capabilities. The model rests on the fact that customers' valuation of a product is a function of the characteristics of the product (Lancaster, 1971; Rosen, 1974). These characteristics are, in turn, a function of the capabilities that undergird them. By estimating how much customers value each characteristic, the competitive advantage that firms derive from different underpinning capabilities can be estimated. In the process, firm capabilities are mapped into different performance characteristics and, in turn, into customer valuation and competitive advantage.

In addition to shedding light on the important link between capabilities and customer value, the model is of potential interest to strategy research for three other reasons. First, although the concept of competitive advantage is central to strategy, many more tools have been developed for quantifying cost competitive advantage than for

quantifying a differentiation advantage (Besanko, Dranove, and Shanley, 2000). This model provides one method for estimating differentiation competitive advantage. Second, measurement is fundamental to research, and if we are to understand the role that capabilities play in building or eroding competitive advantage we need to explore different ways of measuring the advantage from capabilities. Finally, in estimating competitive advantage from capabilities, I am effectively measuring these capabilities. Thus, the paper is also a contribution to answering the call for more empirical research in the resource-based view of the firm.[1]

## MODEL

To give a firm an enduring competitive advantage, a resource must be heterogeneously distributed in the industry and be difficult or costly to imitate (e.g., Barney, 1986; Cool and Schendel, 1988; Miller and Shamsie, 1996; Helfat, 1997). Differences may arise from scarcity (Peteraf, 1993), irreversible commitments, or first-mover advantages such as customer-switching cost, experience, reputation, and property rights (Lieberman and Montgomery, 1998). Inimitability may come from the tacitness of the underpinning knowledge (Conner and Prahalad, 1996), or isolating mechanisms such as the historical or socially complex context in which they were created, or path-dependent nature of the creation process (Rumelt, 1984; Dierickx and Cool, 1989; Barney and Arikan, 2000). Ultimately, however, resources must be converted into customer value if their owners are going to profit from them. Below, I present a model for exploring the link between capabilities, customer value, and competitive advantage.

Consider a firm that uses its capabilities to offer products in one or more markets. Each of these products can be viewed as bundles of characteristics (Lancaster, 1971). The value that a customer attaches to the characteristics is a function of the extent to which they contribute to the customer's utility or pleasure (Lancaster, 1971; Rosen, 1974). Customers opt for one firm's product over another's if the product offers them better value than the other firms'. This customer value can be conceptualized as coming from three levels. Level 1 is the performance characteristics as perceived by customers. These are the characteristics that fit in the customer's own system of activities or value network (Christensen and Bower, 1996). For example, a digital animation studio's valuation of a computer is a function of how fast the computer processes images, how user friendly it is, how much information it can store, how the computer helps the firm 'bring images to life,' and so on.

Performance characteristics are, in turn, a function of physical characteristics (Level 2). In the computer example, the speed with which a computer performs tasks is a function of such physical characteristics as processor chip feature size, main memory capacity, disk capacity, and operating system. Physical and performance characteristics, in turn, rest on the product technology—the components and linkages between them, methods, processes and techniques, and core concepts that underpin them. Each firm has certain firm-specific technological resources (e.g., patents, skilled engineers, stock of knowledge in the form of databases, product or engineering designs, specialized plants and licenses, etc.) that it uses to offer products with desirable characteristics. A firm's technological capability, then, is its ability to use these resources to combine/recombine components, linkages between the components, methods, processes and techniques, and underpinning core concepts to offer products. According to the resource-based view of the firm, each firm's technological capabilities should be different. Some firms' capabilities are going to be superior to those of others, allowing them to offer products with superior characteristics for prolonged periods. If these characteristics are what customers value, the firm has a competitive advantage. Customer value often rests on more than technological capabilities; it also depends on complementary assets (Teece, 1986).

Thus, when customers pay for products they are paying for the different characteristics and indirectly for the underpinning capabilities of suppliers. Therefore one can use hedonics, traditionally used to estimate quality-adjusted price indexes (Griliches, 1971), to estimate competitive advantage from technological capabilities. To understand

[1] According to Schoenecker and Cooper (1998: 1140), 'Another limitation has to do with measurement of firm resources... Simply put, strategy researchers need better measures of firm resources.'

why, consider customers and suppliers in a market for a product with characteristics $Z(z_1, z_2, z_3)$. At a point say, $A$, where customers' indifference utility curves are tangential to suppliers' profit-characteristics indifference curves, buyers' marginal utility from an extra unit of product characteristic is equal to suppliers' marginal cost of providing the unit which is equal to the implicit or hedonic price, $p(z)$, of the product characteristic at that point (Rosen, 1974). Firms at a point such as $A$, face pure competition in product characteristics—that is, firms are price takers. An important question, and a critical one for this paper, is: Since firms do not have market power at equilibrium points such as $A$, and instead act as price takers, does it mean that a firm cannot have a competitive advantage at a point such as $A$? Of course, it can. A firm can make more profits than its competitors at point $A$ and therefore have a competitive advantage. How? The best explanation follows from Peteraf (1993). Consider a market with scarce resources that cannot satisfy demand, therefore offering an opportunity for Ricardian rents. Because the scarce resources cannot satisfy demand, inferior resources have to be brought into the market. Since firms are price takers, they produce at a point where price equals marginal cost. In equilibrium, industry demand equals supply and, while the equilibrium price is equal to the average cost for firms with inferior capabilities, it is higher than the average cost for firms with superior capabilities who make money (Peteraf, 1993: 180–181). If these superior capabilities stay scarce and inimitable, the firm will continue to have a competitive advantage.

According to Berndt (1991: 117), 'implicit marginal prices of the characteristics can be calculated as derivatives of the hedonic price equation with respect to levels of the characteristics.' Therefore a hedonic model can be constructed to determine the implicit prices of each product characteristic (Griliches, 1971; Rosen, 1974; Berndt, 1991), and the implicit value of the different underpinning capabilities. Accordingly, we have three simultaneous equations:

$$\mathbf{P}_t = f(\mathbf{Z}_t, \Phi_t, \mathrm{CA}_t) \quad (1a)$$

$$\mathbf{MS}_t = f(\mathbf{P}_t, \mathbf{Z}_t, \Phi_t, CA_t) \quad (1b)$$

$$\mathbf{Z}_t = f(\Phi_t, \mathrm{TC}_t) \quad (2)$$

$$\Phi_t = f(\mathrm{TC}_t) \quad (3)$$

where $\mathbf{P}_t$ is the price of the product, $\mathbf{Z}_t = (z_{1t} \ldots z_{nt})$ is the vector of performance characteristics at time $t$, $\Phi_t = (f_{1t} \ldots f_{nt})$ are the physical characteristics, TC are the underpinning technological capabilities, CA the complementary assets, and MS is the market share. By solving this system of simultaneous equations, the implicit price and market share of each product's characteristics and underpinning technological capabilities can be determined.

When product prices are regressed on product attributes, the coefficient of each attribute represents the average marginal implicit price for the attribute. As with any regression, the residues include any omitted variables. However, since the hedonic function traces the points where marginal cost equals marginal utility, the residues from the regression have several other important interpretations. They can also mean overpricing by sellers (from firm inefficiencies and higher costs), or additional consumer value not captured by product attributes (Stavins, 1991; Hartman and Teece, 1990). High residues can also be indicative of market power by firms. Finally the residues may reflect firm strategies (Hartman and Teece, 1990). For example, a firm may decide to price low in order to penetrate a market. Which of these situations prevails is better sorted out with the help of the theory that underpins the study.

I have made three assumptions here that are worth explicitly stating: First, that firms with distinctive capabilities are the ones that offer unique customer value or higher levels of it (Prahalad and Hamel, 1990) and the premium customers pay for it is a reflection of the distinctive value. Second, that one can divide capabilities into technological and complementary (Teece, 1986). The rationale here is that while complementary assets such as reputation, marketing, and distribution channels, can enhance customer perception of performance and physical characteristics, these characteristics are still largely determined by the firm's technological capabilities. That is, a computer's speed is influenced by the microprocessor in it and how the PC maker links the different components of the system, not by the reputation of the PC maker. Finally, I assume that a firm's technological capabilities can be divided into different segments. For example, Intel can be seen as being made up of different

groups each of which has different technological capabilities that deliver value to different customers: microprocessor, flash memory, computer systems, and so on. The microprocessor group, for example, has patents and copyrights associated with it, employees skilled in the Intel architecture, and a strategy of pushing the edge in microprocessor performance.

To summarize, the model has two major steps. In the first, customer valuation of performance and physical characteristics is determined using Equation 1. This valuation is in the form of the implicit prices that customers pay for the characteristics, and in the market share that the firm captures. In the second step, the performance and physical characteristics whose value is now known are mapped into the technological capabilities that underpin them (Equations 2 and 3). The extent to which the firm's capabilities enable it to provide products with characteristics that customers value is determined. The firm's competitive advantage is also determined.

## THE CASE OF CHOLESTEROL ETHICAL DRUGS

### Customer value and capabilities

The primary goal of pharmaceutical drug companies engaged in cholesterol drug development is to produce drugs that reduce the level of total plasma cholesterol, especially the level of so-called bad cholesterol or low-density lipoprotein (LDL) cholesterol, while also increasing the level of good cholesterol or high-density lipoprotein (HDL) cholesterol. These firms also want to offer drugs that are safe, with very few side effects. To meet these goals, pharmaceutical companies have pursued different cholesterol drug technologies over the years.

### Data

The data are for cholesterol drugs in the market from 1988 to 1994. The primary sources of drug characteristics were the National Library of Medicine MEDLINE database and medical journals. Retail drug prices and market share came from Pharmaceutical Data Services data that were published in *Drug Topics* from 1988 to 1994. The data were for 7 years with a total of 78 observations.

### Model operationalization

The dependent variable for Equation 1a is *Price*, the price paid for one day's worth of cholesterol drugs, deflated to 1992 dollars using a GDP deflator. In Equation 1b, the dependent variable is market share, measured both as a drug's share of number of prescriptions for the year in question and as the hedonic price times share of the number of prescriptions. A drug's performance is usually measured by two parameters: efficacy and safety. Efficacy is the ability to cure or prevent an illness, or alleviate a condition or symptom that the drug is designed to attack. For this study, efficacy was measured by: *Reduction in total cholesterol* and *Increase in HDL cholesterol* (high-density lipoprotein cholesterol, so-called good cholesterol). In the United States, the safety requirement is usually enforced well before the Food and Drug Administration (FDA) approves a drug for marketing. Even then, drugs often have side effects that can be unpleasant to some patients. Safety was measured by the number of *Adverse effects* of the drug in question.

Two popular physical characteristics for pharmaceuticals—half-life and absorption rate—were omitted because their effect was considered irrelevant in this study. Half-life is the time required for blood drug concentration to drop by half and an indicator of how long a drug remains in the bloodstream. The doctors I interviewed indicated that this was not a primary consideration in their choice of cholesterol drugs. Absorption rate measures how quickly a drug enters the bloodstream, and while it may be critical for, say, heart attack drugs, it is not important in lowering cholesterol levels. Moreover, some cholesterol drugs such as bile acid-binding resins work inside the stomach without being absorbed into the bloodstream.

I proxied a firm's technological capabilities with the interaction of a technology variable and firm dummy. For example, Merck's technological capabilities in statins is proxied by STATIN∗MERCK. Recall that in developing drugs using one of the technologies, each firm has its own patents, knowledge base, organizational structure, integration of know-how, and people. It has its own capabilities. The dummy variables for each of the different technologies are NICOTINIC, FIBRATES, BILEACID, PROBUCOL, and STATINS. Firm dummies such as MERCK for the firm Merck are also used.

### Model specification and estimation

Since there are no physical characteristics of significance in cholesterol drugs, Φ in Equations 2 and 3 drops out, leaving Equations 1 and 2, which are estimated as:

$$\begin{aligned}\text{Log}P = {} & \beta_0 \\ & + \beta_1 * (\text{Reduction in total cholesterol}) \\ & + \beta_2 * (\text{Reduction in total cholesterol})^2 \\ & + \beta_3 * (\text{Increase in HDL cholesterol}) \\ & + \beta_4(\text{Adverse effects}) + \beta_5\text{Competitiors} \\ & + \beta_6\text{FirmDummies} + \varepsilon \end{aligned} \quad (4)$$

$$\begin{aligned}\text{Log(Market share)} = {} & \beta_0 \\ & + \beta_1 * (\text{Reduction in total cholesterol}) \\ & + \beta_2 * (\text{Reduction in total cholesterol})^2 \\ & + \beta_3(\text{Increase in HDL cholesterol}) \\ & + \beta_4(\text{Adverse effects}) + \beta_5\text{Competitiors} \\ & + \beta_6\text{FirmDummies} + \beta_7\text{Price} + \varepsilon \end{aligned} \quad (5)$$

$$\begin{aligned}\text{Reduction in total cholesterol} = {} & \beta_0 \\ & + \beta_1\text{Technology} \\ & + \beta_2\text{FirmDummies} * \text{TechnologyDummies} + \varepsilon \end{aligned} \quad (6)$$

where FirmDummies are the firm dummy variables, $\varepsilon$ is the error term, and the other variables are as defined earlier.

Since using ordinary least squares (OLS) to estimate panel data can result in biased estimates because of unobserved heterogeneity, I performed a Hausman (1978) specification test of the null hypothesis of a random-effects model in comparison to the alternative hypothesis of a fixed-effects model to determine which model was better for the analysis: random effects or fixed effects. The resulting chi-square statistic of 1.32 is not significant even at the 10 percent level. This supports the conclusion that the random-effects model adequately characterizes the relationships in Equations 4 and 5. To estimate these equations, I used the STATA function **xtreg**, which estimates cross-sectional time-series regression models and, with the **re** option, estimates random-effects models using a generalized least squares (GLS) estimator that produces a matrix-weighted average of the between and within effects (Stata, 1999).

## RESULTS AND ANALYSIS

### Illustrating the model

Recall that the model determines the implicit price and market share premiums of superior product characteristics as valued by customers and, from them, the advantage from the underpinning capabilities.

Table 1 presents the estimates of Equations 4 and 5. In Model M1, the coefficient of *Reduction in total cholesterol* is highly significant, suggesting that the more a drug reduces total cholesterol levels, the higher the price that it can command—that

Table 1. Results of panel random-effects model

| | Dependent variable: Log(PRICE) $n = 78$ M1 | Dependent variable: Log(Share of number of prescriptions) $n = 78$ M2 |
|---|---|---|
| CONSTANT | −37.12** | −60.98 |
| | (−2.30) | (−1.42) |
| Reduction in total cholesterol (%) | 4.72** | 7.41 |
| | (2.34) | (1.39) |
| (Reduction in total cholesterol)$^2$ | −0.14** | −0.23 |
| | (−2.31) | (−1.45) |
| Increase in HDL cholesterol | 0.33* | 0.58 |
| | (1.96) | (1.31) |
| Adverse effects | −0.08** | −0.09 |
| | (−2.20) | (−0.94) |
| Number of products in market | 0.01 | −0.05*** |
| | (0.94) | (−2.96) |
| Price | | −0.16** |
| | | (−2.26) |
| Bristol Meyers | −0.32 | 3.6*** |
| | (−1.08) | (4.66) |
| Merck | 9.4** | 22.24** |
| | (2.29) | (2.02) |
| Merrell | 10.79* | 19.8 |
| | (1.86) | (1.30) |
| Parke Davis | −0.25 | 0.97** |
| | (−1.36) | (2.06) |
| Upjohn | −0.96*** | 2.25** |
| | (−2.80) | (2.48) |
| Wyeth Ayest | 0.06 | 0.04 |
| | (0.23) | (0.05) |
| $\chi^2$ | 192.29** | 98.16** |

Rugby is the firm dummy
*** Significant to less than 1% level
** Significant to less than 5% level
* Significant to less than 10% level

is, the more customers value it.[2] The doctors I interviewed in this research expected this result. A one-percentage point increase in a drug's ability to reduce total cholesterol levels results in an increase of 0.6% in the price that the firm can charge.[3] I will call this percentage change in price that results from a 1 percentage change in reduction in total cholesterol levels the total cholesterol *price elasticity of value.* Price elasticity of value measures the extent to which a firm can command a price premium when it improves a product attribute that customers value. It is the percentage change in price, given a percentage improvement in product attribute. This is not to be confused with the traditional price elasticity of demand which measures the percentage change in demand given a percentage change in price. Price elasticities of value for *Increase in HDL cholesterol* and *Adverse effects* can be similarly determined to be 0.33 percent and 0.08 percent.

Having determined the implicit price for *Reduction in total cholesterol*, I can now determine the implicit prices of the underpinning technological capabilities. I do so by regressing each of the performance characteristics, whose implicit prices are now known, against technology dummies. Table 2 presents the results for *Reduction in total cholesterol*. Nicotinic acid is the reference technology dummy and since all the independent variables are dummy variables, each coefficient tells us the extent to which each technology can reduce total cholesterol levels better than nicotinic acid. Model M1 of the table is interpreted as follows. The average mean reduction in total cholesterol by nicotinic acid technology is 12.5 percent since the constant term has a coefficient of $-12.5$ and nicotinic acid is the reference technology dummy. Bile acids reduce total cholesterol levels by 6.4 percent more than nicotinic acids (the coefficient of BILEACIDS is $-6.4$). That is, the average reduction by bile acids is 18.9 percent (6.4% + 12.5%). The average percentage reduction in total cholesterol for probucol and statins is 13.9 percent and 25.5 percent, respectively. Since the average reduction in total cholesterol for all drugs is 19 percent, statins have an advantage of 6.5 percent over the average cholesterol drug. Given a cholesterol *price elasticity of value* of 0.60 percent and that the average price of a daily dose is \$1.89, this advantage fetches a price premium of \$0.07 per daily dose.[4]

Merck's cholesterol-lowering capability in statins is shown in Model M2 of Table 2 as the coefficient of MERCK * STATINS. Its competitors' statins reduce cholesterol by an average of 21.2 percent (the coefficient of statins in M2 plus that of the constant term). Merck has an advantage of 5.33 percent (coefficient of MERCK * STATINS) compared to the industry average statin and an average advantage of 7.53 percent over the average drug.[5] This tells us that there is something about Merck's capabilities in statins that allows it to offer customers drugs that, on the average, reduce total cholesterol levels by 5.33 percent better than other statins and 7.33 percent better than the average drug. This Merck advantage has been attributed to its early commitment to invest in pursuing therapies for cholesterol drugs when most pharmaceutical firms focused on building capabilities to develop therapies for more 'serious' diseases at a time when cholesterol was not seen as much of a threat to health as other ailments (Vagelos, 1991). Since, from stage one of the model, the cholesterol *price elasticity of value* is 0.60, Merck's 7.53 percent advantage over the average drug gives it a price advantage of \$0.08 per daily prescription over the average cholesterol drug,[6] while its 5.33 percent advantage over statins gives it an advantage of \$0.06 over the average industry statin.

Parke Davis's cholesterol-lowering capabilities in bile acids and fibrates are shown in Model M3 as the coefficients of PARKE * BILEACIDS, and PARKE * FIBRATES respectively. Parke Davis's competitors' fibrates reduce cholesterol by an average of 15.4 percent (the coefficient of fibrates plus that of the constant term). However, Parke Davis's

[2] To insure that the results of estimating Equations 4 and 5 are not an artifact of the logarithm transformation, I ran the models with both Price and Log(Price) as dependent variables. The quadratic effect was significant in both cases, assuring me that the results of estimating these equations are not an artifact of the logarithm transformation. My thanks to an anonymous referee for this suggestion and many other suggestions.

[3] Taking the derivative of Equation 4 with respect to $C$, the total decrease in cholesterol level, $\frac{dp}{p} = dC(\beta_1 + \beta_2 * C)$. Since the average reduction in cholesterol is 19 percent, a 1 percent reduction in total cholesterol level results in a percentage price change of $-1(4.72 - 2 * 0.14 * 19) = 0.6$ percent.

[4] $\frac{dp}{p} = dC(0.60\%) = 6.5 * 0.0060$. Hence $dp = \$1.89 * 6.5 * 0.0060 = 0.07$.

[5] $5.33 + (21.2 - 19) = 7.53$, since the average drug reduces total cholesterol levels by 19 percent.

[6] $\frac{dp}{p} = dC\ (0.60\%) = 7.33 * 0.0060$. Hence $\mathrm{d}p = \$1.89 * 7.33 * 0.0060 = 0.08$.

Table 2. Underpinnings of performance characteristics. Dependent variable = Reduction in total cholesterol ($n = 78$)

| | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 |
|---|---|---|---|---|---|---|---|---|
| CONSTANT | −12.50*** | −12.50*** | −12.50*** | −12.50*** | −12.50*** | −12.50*** | −12.50*** | −12.50*** |
| | (−9.34) | (−14.97) | (−10.17) | (−14.87) | (−9.34) | (−10.65) | (−9.39) | (−19.78) |
| BILEACID | −6.40*** | −6.40*** | −6.38*** | −6.35*** | −6.45*** | −6.40*** | −6.40*** | −6.24*** |
| | (−4.30) | (−6.86) | (−4.50) | (−6.17) | (−4.17) | (−4.87) | (−4.30) | (−6.98) |
| FIBRATES | −1.47 | −1.47 | −2.85** | −1.48* | −1.48 | −0.53 | −1.30 | −3.21*** |
| | (−1.06) | (−1.69) | (−2.13) | (−1.68) | (−1.06) | (−0.43) | (−0.92) | (−4.47) |
| PROBUCOL | −1.40 | −1.40 | −1.40 | −1.40 | −1.40 | −1.40 | −1.40 | −1.40** |
| | (−0.98) | (−1.56) | (−1.06) | (−1.55) | (−0.97) | (−1.11) | (−0.98) | (−2.06) |
| STATIN | −12.95*** | −8.7*** | −12.95*** | −14.05*** | −12.95*** | −12.95*** | −12.95*** | −8.72*** |
| | (−9.46) | (−9.2) | (−10.24 | (−16.13) | (−9.40) | (−10.73) | (−9.45) | (−9.45) |
| MERCK * STATINS | | | | | | | | −5.33*** |
| (Merck's competitive advantage in statins) | | −5.33*** (−10.64) | | | | | | −5.33*** (−14.06) |
| PARKE * BILEACIDS | | | −0.07 | | | | | −0.21 |
| | | | (−0.05) | | | | | (−0.23) |
| PARKE * FIBRATES | | | 2.88*** | | | | | 3.24*** |
| | | | (3.80) | | | | | (7.35) |
| BRISTOL * BILEACIDS | | | | −0.10 | | | | −0.21 |
| | | | | (−0.12) | | | | (−0.27) |
| BRISTOL * STATINS | | | | 5.33*** | | | | |
| | | | | (10.57) | | | | |
| UPJOHN * BILEACIDS | | | | | 0.21 | | | |
| | | | | | (0.13) | | | |
| WYETH AYEST* BILEACIDS | | | | | | −3.97*** | | |
| | | | | | | (−4.67) | | |
| RUGBY * FIBRATES | | | | | | | −0.93 | 0.97* |
| | | | | | | | (−0.89) | (1.73) |
| Adjusted $R^2$ | 0.896 | 0.959 | 0.911 | 0.958 | 0.894 | 0.919 | 0.895 | 0.976 |

Nicotinic acid is the reference technology
*t*-statistics in parentheses
*** Significant to less than 1% level
** significant to less than 5% level
* significant to less than 10% level

fibrates have a disadvantage of 2.9 percent (coefficient of PARKE * FIBRATES) compared to the average fibrate and a disadvantage of 6.35 percent compared to the average cholesterol drug. Since the cholesterol *elasticity of value* is 0.6 percent, Parke Davis's 6.35 percent disadvantage gives it a $0.07 price disadvantage per daily dose. That is, its prices are $.07 below the average price of $1.89.[7] Bristol Myers' cholesterol-lowering capabilities are shown in Model M4. Its statins have a cholesterol-lowering disadvantage of 5.33 percent compared to the average statin. One plausible explanation for the disadvantage that both Parke Davis and Brystol Myers have is the fact that they were latecomers in using their respective technologies to enter the cholesterol market, and in pharmaceuticals moving early can be critical (Henderson, 1994). Competitive advantage from superior capabilities in increasing *HDL cholesterol* or decreasing *adverse effects* can also be similarly determined. Similarly, market share competitive advantage can be estimated.

## CONCLUSIONS

In this paper, I presented a model for estimating the value of distinctive technological capabilities. In addition to being a tool for analyzing how much of a competitive advantage a firm can derive in a particular market using its scarce resources, the model has other potential applications. For example, several researchers have

[7] $\frac{dp}{p} = dC(0.60\%) = 6.4 * 0.0060$. Hence $dp = \$1.89 * 6.4 * 0.0060 = 0.07$.

argued that it is just as important to determine what capabilities to build as it is to determine how to deploy existing ones (e.g., Wernerfelt, 1984; Teece *et al*., 1997). One logical first step in building such capabilities is to determine which ones are valued in a market, their elasticities of value and then the capabilities that the firm must build to have a competitive advantage in each market. Also, one property of core competences is that they can be deployed in more than one market. On the other hand, the product–market position suggests that a lack of focus—for example, positioning oneself in too many market positions—can result in poor performance (Porter, 1991). An important question, then, is: How much extension to different markets is too much? This model provides some guidelines in exploring this important question.

Although using hedonics allows one to estimate competitive advantage from differentiation and the value of technological capabilities, it has several limitations. It is of little use for estimating the value of cost-saving technological capabilities. While it allows one to estimate the value from differentiation, it does not allow one to incorporate the cost of the differentiation. Finally, it does not account for the value that comes from intangible product features.

Research in the resource-based view of the firm has enriched our theoretical understanding of what types of capabilities are likely to give a firm a competitive advantage. Very little of that research is empirical. Moreover, we know very little about how capabilities translate into competitive advantage in different markets and how much. This paper's model offers some guidance for future research into this important link between capabilities and competitive advantage. If we are to understand important links such as the relationship between the product–market position and the resource-based view of the firm, we need more research in mapping capabilities into customer value and competitive advantage.

## ACKNOWLEDGEMENTS

I would like to thank Jane Dutton, Michael Cohen, Rebecca Henderson, Will Mitchell, Joanne Oxley, and two anonymous referees for valuable comments and suggestions. Any errors, however, are mine. Funding from the MIT Program on the Pharmaceuticals Industries is gratefully acknowledged.

## REFERENCES

Barney J. 1986. Organizational culture: can it be a source of sustained competitive advantage? *Academy of Management Review* **11**: 656–665.

Barney JB, Arikan AM. 2000. The resource-based view: origins and implications. Working paper, Fisher College of Business, Ohio State University.

Berndt ER. 1991. *The Practice of Econometrics: Classic and Contemporary*. Wiley: New York.

Besanko D, Dranove D, Shanley M. 2000. *The Economics of Strategy*. Wiley: New York.

Christensen CM, Bower JL. 1996. Customer power, strategic investment and failure of leading firms. *Strategic Management Journal* **17**(3): 197–218.

Conner K, Prahalad CK. 1996. A resource-based theory of the firm: knowledge versus opportunism. *Organization Science* **7**(5): 477–492.

Cool K, Schendel D. 1988. Performance differences among strategic group members. *Strategic Management Journal* **9**(3): 207–223.

Dierickx I, Cool K. 1989. Asset stock accumulation and sustainability of competitive advantage. *Management Science* **35**(12): 1504–1513.

Griliches Z. 1971. *Price Indexes and Quality Change: Studies in New Methods and Measurement*. Harvard University Press: Cambridge, MA.

Hartman R, Teece DJ. 1990. Product emulation strategies in the presence of reputation effects and network externalities: some evidence from the microcomputer industry. *Economics of Innovation and New Technology* **1**: 157–182.

Hausman J. 1978. Specification tests in econometrics. *Econometrica* **46**: 69–85.

Helfat C. 1997. Know-how and asset complementarity and dynamic capability accumulation: the case of R&D. *Strategic Management Journal* **18**(5): 339–360.

Henderson RM. 1994. The evolution of integrative capability: innovation in cardiovascular drug discovery. *Industrial and Corporate Change* **3**: 601–630.

Lancaster KJ. 1971. *Consumer Demand: A New Approach*. Columbia University Press: New York.

Lieberman MB, Montgomery DB. 1998. First-mover (dis)advantages: retrospective and link with the resource-based view. *Strategic Management Journal* **19**(12): 1111–1125.

Miller D, Shamsie J. 1996. The resource-based view of the firm in two environments: the Hollywood film studio from 1936 to 1965. *Academy of Management Journal* **39**: 519–543.

Peteraf MA. 1993. The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal* **14**(3): 179–191.

Porter ME. 1991. Towards a dynamic theory of strategy. *Strategic Management Journal*, Winter Special Issue 12: 95–117.

Prahalad CK, Hamel G. 1990. The core competences of the corporation. *Harvard Business Review* **68**(3): 79–91.

Rosen SM. 1974. Hedonic prices and implicit markets: product differentiation in pure competition. *Journal of Political Economy* **82**(1): 34–55.

 

Rumelt RP. 1984. Towards a strategic theory of the firm. In *Competitive Strategic Management*, Lamb RB (ed.). Prentice-Hall: Englewood Cliffs, NJ; 556–570.

Schoenecker TS, Cooper AC. 1998. The role of firm resources and organizational attributes in determining entry timing: a cross industry study. *Strategic Management Journal* **19**(12): 1127–1143.

Stata. 1999. *Stata Reference Manuals, H–O and Su–Z*. Stata Press: College Station, TX.

Stavins J. 1991. Model entry and exit in a differentiated-product industry: the case of the personal computer market. Working paper, National Bureau of Economic Researchers: Boston, MA.

Teece DJ. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy* **15**: 285–306.

Teece DJ, Pisano G, Shuen A. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal* **18**(7): 509–533.

Vagelos PR. 1991. Are prescription drug prices higher? *Science* **24**(252): 1080–1084.

Wernerfelt B. 1984. A resource-based view of the firm. *Strategic Management Journal* **5**: 171–180.