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# MANAGING PRODUCT VARIETY: A STUDY OF THE BICYCLE INDUSTRY

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## Abstract

Cannondale, a producer of premium mountain bikes, offers 22 models ranging in price from $500 to $3000. VooDoo, a competitor, offers 672. Each mountain bike from National is offered in 104 different colors. A bike from Specialized is offered in only one. Why are the variety practices of these four companies so different? Given differences in their product lines, are the companies' operations also dramatically different? Can such diverse strategies coexist in the marketplace? In this paper, we use field data from four companies in the mountain bicycle industry— Cannondale, Specialized, VooDoo, and National— to identify and analyze managerial decisions relating to product variety. We assert that successful firms must make coherent decisions in six strategic areas: (1) the dimensions of variety offered to the market, (2) the nature of the customer interface and distribution channel, (3) the degree of vertical integration, (4) the process technology, (5) the location of the decouple point, and (6) the product architecture. Many of the differences among these companies arise from different sets of decisions, perhaps equally coherent, in these six areas.

**Key words:** product variety, product strategy, bicycle industry.

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## 1. Introduction

Cannondale, a producer of premium mountain bikes, offers 22 models[1] ranging in price from $500 to $3000. VooDoo, a competitor, offers 672. Each mountain bike from National is offered in 104 different colors. A bike from Specialized is offered in only one. Why are the variety practices of these four companies so different? Given differences in their product lines, are the companies' operations also dramatically different? Can such diverse strategies coexist in the marketplace?

In this paper, we use field data from four companies in the mountain bicycle industry— Cannondale, Specialized, VooDoo, and National— to identify and analyze managerial decisions relating to product variety. We assert that successful firms must make coherent decisions in six strategic areas: (1) the dimensions of variety offered to the market, (2) the nature of the customer interface and distribution channel, (3) the degree of vertical integration, (4) the process technology, (5) the location of the push/pull boundary, and (6) the product architecture. Many of the differences among these companies arise from different sets of decisions, perhaps equally coherent, in these six areas.

We focus our analysis on the bicycle industry, but we believe our insights are applicable in many industries. By focusing on one industry, we are able to describe managerial practices in detail. In the final section of the paper, we discuss how the insights from the bicycle industry may apply more generally. We believe that this case analysis is useful for managers crafting a variety strategy and for students of operations management, marketing, or product design as an example of the interdisciplinary nature of variety decision making.

The remainder of the paper is organized as follows. Section 2 provides a brief description of the bicycle industry. In section 3, we describe a generic bicycle supply chain and enumerate the strategic decisions each firm makes to uniquely configure its system. In section 4, we describe the four companies and the strategic decisions each has made. Section 5 proposes a set of criteria by which a firm should choose a variety strategy. We conclude by summarizing the key ideas of the case studies, considering how the insights may be generalized, and identifying future challenges.

[1] For this example, we define a *model* as a unique combination of a frame geometry and a component group.

## 2. The Bicycle Industry

The United States bicycle market constitutes approximately 10% of the 100 to 130 million unit world bicycle market. Approximately 75% of all bicycles in the U.S. are sold through the mass merchandising channel in stores such as Toys ëR Us, Walmart, and Kmart. Bicycles sold through this channel are typically childrenís bicycles and adult bicycles priced below $200. The remaining 25% of U.S. bicycle sales occur through independent bicycle dealers (IBDs). Ninety-five percent of all bicycles priced above $200 are sold through IBDs. As of 1995, there were approximately 6,000 IBDs in the U.S. with 1,500 dealers accounting for 60% of all unit sales. Total unit sales have been fairly constant over the past decade, but the proportion of "mountain bikes" has increased from 12% in 1985 to 66% in 1995.

Our analysis focuses on four companies in the ìover-$200" portion of the mountain bicycle market, which accounts for about 2 million units per year in the United States. Over 75 firms compete in the over-$200 category, allowing for substantial natural variation in strategies. We focus on Specialized, Cannondale, VooDoo, and National because each exemplifies a distinct variety strategy. Specialized, Cannondale, and VooDoo sell internationally, but are primarily focused on the U.S. market. National has made forays into the U.S. market, but remains primarily a competitor in the Japanese market. These firms are all successful. Cannondale and Specialized are two of the top three brands in the United States (Trek is the top-selling brand). National is the leading brand in Japan. VooDoo is the leading "make-to-order" brand in the United States and has been gaining market share rapidly.

For our study, we obtained detailed product information from *Bicycling Magazine*, whose technical editor gathered these data from the manufacturers for inclusion in the magazineís annual buying guide. The descriptions of each model include the full list of components (spokes, rims, pedals, brakes, hubs, etc.), the weight, the suggested retail price, and the sizes and colors in which the bicycle is offered. We supplemented the database with information from trade and consumer publications; company web sites and catalogs; visits to the company sites; and interviews of manufacturers and retailers in the industry. We base much of our analysis of National on several site visits associated with the development of a teaching case (Fisher 1993).

## 3. Managing the Variety Delivery System

Exhibit 1 illustrates a generic "variety delivery system" including the physical supply chain from raw materials and components to the end user. The ordering in Exhibit 1 is relatively standard for the industry, but may vary in some essential details from firm to firm. Most bicycle frames

are constructed by cutting and welding tubes together according to a pre-specified frame design commonly referred to as the *frame geometry*. The frame geometry is defined by the geometric pattern of the frame tubes and the angles between them. A single frame geometry may be available in several sizes, resulting from extension of some tube lengths. After welding, a frame is painted and decals are applied. Bicycle components including derailleurs, forks, rims, hubs, and wheels are joined with the frame in an assembly operation resulting in a finished product. Bicycles are then transported and delivered to the end customer. In addition to the physical supply chain operations, selling a bicycle requires a *customer interface* which includes the tasks of *promotion* to gain customer consideration for a bicycle, *display* to allow the customer to evaluate the bicycle attributes, and *fit* to determine which of the many end-products a firm may offer maximizes utility for a given customer.

Each firm makes decisions to uniquely configure its variety delivery system. We categorize the decisions as either *strategic* or *tactical*. Strategic decisions deal with the fundamental structure of the variety delivery system. In the bicycle industry strategic decisions are made every 5 to 10 product cycles and include: (1) the dimensions of variety offered to the market, (2) the nature of the customer interface and distribution channel, (3) the degree of vertical integration, (4) the process technology, (5) the location of the push/pull boundary, and (6) the product architecture.

Tactical decisions deal with optimizing performance given a variety delivery system. Tactical decisions may occur every product cycle or more frequently and include: (1) the specific number of levels of each product attribute (e.g. sizes, colors) to offer, (2) the bundling of combinations of these attribute levels, (3) the extent of parts sharing across the product line, (4) the lot sizing policy, (5) inventory management policy, (6) production scheduling, and (7) promotion plans.

These two sets of decisions, strategic and tactical, are a somewhat arbitrary classification of myriad managerial decisions, however we find the classification useful in organizing the information about the four companies we examine.

## 4. Case Studies

In this section we give a brief description of the four companies in the sample and then discuss each of the six strategic decisions in the context of the four firms.

*Company Backgrounds*

Founded in 1974, Specialized Bicycle Components (Morgan Hill, California; http://www.specialized.com/) quickly developed a reputation as one of the leading mountain bike

brands. In 1996, it had the second largest domestic mountain bike market share of 17%. Two of Specialized products, the *Rockhopper* and *Stumpjumper*, are arguably the best known models of mountain bikes in the United States. The Stumpjumper was the first commercially available mountain bike. Specialized maintains market leadership through close contact with consumers. Many Specialized employees are current or former bicycle racers or bicycle enthusiasts. Specialized offers bicycles in the mountain, road, and hybrid categories. Much of Specialized's success results from innovative and popular mountain bike accessories such as helmets, water bottles and tires.

Since its inception in 1971, Cannondale Corporation (Georgetown, Connecticut; http://www.cannondale.com/) has developed a reputation for innovation and skilled craftsmanship. In 1983, the firm introduced the industryís first affordable aluminum bicycle and in 1991, the first fully suspended mountain bike. Cannondale has the third largest domestic mountain bike market share at 11%. Cannondale products span several product categories including mountain bikes, road bikes, hybrid bikes, and tandem bikes. The companyís products are distributed in Asia, Europe, and America. Cannondale is one of two publicly owned bicycle companies, and its stock trades on the NASDAQ exchange.

VooDoo Cycles (Palo Alto, California; http://www.voodoo-cycles.com/) was founded in 1994 by Joe Murray, an original inventor of the mountain bike. VooDoo quickly capitalized on the cult reputation of its founder to create a highly recognizable brand. Although its current market share is relatively low, a recent survey by *Mountain Bike* magazine listed VooDoo in the top quarter of bicycle brands U.S. consumers are most likely to purchase. In 1996, VooDoo sold only mountain bikes.

Founded in 1952, National Bicycle Company (Osaka, Japan) produces and sells bicycles under the Panasonic and National brand names. National is not currently active in the U.S. market, and Panasonic's U.S. market share is therefore minimal. In Japan, National is a market leader with market share of 22%. National is a wholly owned subsidiary of Matsushita Electric and is the only Japanese firm in our study.

*Dimensions of Variety*

Many marketing and product design methodologies treat products as bundles of *attributes* or *dimensions* (Green and Krieger 1996, Ulrich and Eppinger 1995). In a well-specified product category such as mountain bikes, differences among products arise from differences in the values of well-defined product attributes. Four of the fundamental dimensions on which mountain bikes

vary are: frame material, frame geometry, component group[2], and frame color. Exhibit 2 shows the number of variants each company offers on each of these dimensions. To facilitate comparison, we use as metrics: number of unique frame geometries in a product line, number of frame materials in a product line, component groups per unique frame geometry, and colors per model[3]. We also list the resulting number of mountain bike *end items*[4]. Each frame geometry would also typically be offered in a number of different sizes. We have omitted comparison on this dimension of variety since most manufacturers offer a comparable level of size variety[5].

Exhibit 2 demonstrates two important concepts. First, at the end-item level, VooDoo and National appear to offer much more variety than Specialized or Cannondale. In fact, Cannondale appears to be the low-variety producer. However, analysis of variety at the level of end items masks substantial differences in the variety offered by each firm along the underlying dimensions. For example, Cannondale offers twelve unique frame geometries, while Specialized offers six, National three, and VooDoo two. A customer seeking choice of frame geometry will view Cannondale as the high-variety producer. The frame geometries for each company are shown schematically in Exhibit 3. Second, each firm has chosen to offer variety in its product line along a different dimension. Cannondale offers substantial frame geometry variety. Specialized offers frame material variety, selling bikes of steel, aluminum, and metal matrix composite. VooDoo offers variety in component group and front suspensions providing each frame in a choice of six component groups and eight forks. National offers color variety by allowing the customer to choose from 104 different colors or color combinations[6].

*Customer Interface and Distribution Channel*

Firms currently sell over-$200 bicycles through three different channels— independent bicycle dealers, "wholesale clubs" such as Samís Club and Costco, and mail order services such as Colorado Cyclist. Ninety-five percent of these bicycles are sold through independent bicycle

[2] The component *group* generally refers to the crank set, derailleurs, brakes, and hubs. It may also include the front suspension, pedals, seat post, headset, and bottom bracket. For our purposes, we define a component group as a unique combination of crank set, derailleurs, brakes, hubs and front suspension.
[3] A model is defined as a frame/component group combination.
[4] We use the term *end item* instead of *stock keeping unit* (SKU), because VooDoo and National do not hold finished goods inventories and therefore do not "keep stock."
[5] We gloss over a subtlety here. The exact angles between frame tubes may change slightly as the size of a frame is changed. For the purposes of this analysis, we do not consider these size-related changes as different geometries.
[6] Much of our information about National was obtained during visits in conjunction with writing a teaching case (Fisher 1993). The process in place at the time of that case provided a large number of frame sizes for brazed steel frames and was used predominantly for road bikes. At that time and for the road bike segment, size was an important dimension of variety. Data for Exhibit 2 is based on the 1996 catalogue for mountain bikes which features titanium and TIG-welded steel frames that cannot be produced on that process.

dealers. Each firm in our analysis distributes and sells bikes through bicycle dealers. In the case of National, the dealers are owned by the same holding company that owns National. For all other firms, the dealers are independent and carry multiple brands.

The retailer performs the critical roles of displaying product offerings, fitting bikes to customers, and to some extent promoting different bicycle brands. However, the form of the product to be displayed and the involvement the retailer plays in fitting a bicycle differs by company. Specialized and Cannondale explicitly enumerate the end items that are available in their catalogs, and all are available through the retailer. A customer generally chooses a model from those displayed in the retail showroom. The retailer tries to fit the customer to the correct frame size using the bicycles in stock. The larger retailers, such as Bike Line, use regional warehouses to pool inventory for several stores so that the correct size is often available within a few days from the warehouse. Customers unable to find their correct size either choose a different model, wait for the correct size to be ordered from the manufacturer, or find the desired item at a different retailer.

Rather than explicitly enumerate end items, VooDoo and National describe their bicycles through a menu of "ingredients." The menu is similar to those used in sandwich shops where a customer builds a custom sandwich by choosing from a list of fillings, breads, and condiments. In the case of VooDoo, a customer chooses between two different frame geometries, three materials, eight forks, and six component groups. The customer also chooses tires, handlebars, saddles, etc. The retailer takes an active role in assisting the customer to choose the correct configuration and size. VooDoo retailers maintain a sample stock of bicycles to assist them in displaying options and fitting customer size. VooDoo also employs a rich web site on the Internet to educate customers about the choices available to them. National retailers use a sizing machine designed specifically to fit customers to any of six pre-specified sizes. Customers choose the remaining options from a catalog. Pricing for both VooDoo and National is determined after the customer decides the final configuration. The ingredient menu approach allows a customer to conveniently search thousands of possible end items in a way that would not be feasible in the tradition approach of simply displaying all possible end items. Once the final bicycle configuration and price have been determined, the retailer places an order to the manufacturer. Delivery occurs within two weeks for National and five days for VooDoo.

*Vertical Integration*

Decisions about vertical integration address the issue of which tasks in a supply chain will be performed by the company and which tasks will be performed by other firms. The key vertical

integration decision in the bicycle industry is whether or not to outsource frame fabrication. For U.S. firms, the low labor costs and economies of scale of Asian suppliers motivate the outsourcing of frame production, and both Specialized and VooDoo outsource frame production. Specialized further outsources final assembly, so that completed end items are shipped from its suppliers' factories to its warehouse. Specialized outsources its low-end bicycles to Giant, Merida, CBC, and Shin Nomura, which are East Asian suppliers, and outsources its high-end bicycles to a U.S. supplier. VooDoo outsources its frame production to A-Pro, a Taiwanese supplier. Cannondale and National fabricate their own frames. Cannondale has further integrated into fabrication of front suspensions (Headshok brand) and component groups (CODA brand).

*Process Technology*

In the context of variety management, an important element of the process technology choice is flexibility, or the ability "to change or react to a different product mix with little penalty in time, effort or cost performance" (Upton 1994). In bicycles, the frame fabrication processes, tube cutting and welding, present the critical technology decisions. The cutting process produces tubes of proper length and joint angle. To create proper fit, a ìfish mouthî must be cut in the end of a tube so that it mates with the adjacent frame tubes with no gaps. Exhibit 4 is a schematic description of two alternative technologies that accomplish this task. A die-cutting process uses a vise to hold and position a tube while a machine "cookie cuts" through the tube using a pair of matched dies[7]. The die-cutting process requires a new die for each change in frame geometry. There is also a set-up time associated with each die change. In contrast, a computer-controlled laser cutting process uses a pre-programmed laser and rotary fixture to cut the tubes. The rotary fixture holds the tube and rotates it through 360 degrees. As it rotates the laser moves axially so that an arbitrary trajectory can be cut around the perimeter of the tube. After initial programming, there is no set-up cost to change between tubes for different frame geometries. However, an investment in computer-aided design and computer-controlled machines is required to acquire this capability.

Welding flexibility is largely determined by the means used to hold tubes in place before they are joined. Three technologies are used in the industry: hard fixtures, flexible fixtures, and a slot-and-tab approach. Exhibit 5 illustrates a typical hard fixture. A large steel plate with a set of mounting features clamps each of the frame tubes in its predetermined location. Each different

[7] Some frame fabrication operations also use machining to cut tubes. However, the same arguments about set-ups and tooling apply to machining.

frame geometry requires its own fixture. The fixture often allows different positions for the mounting features, but this flexibility generally only allows for frame size variations. Angle and tube diameter changes require a substantial set-up and a change of fixture. National Bicycle developed a flexible frame fixture (not shown) for its lugged steel frames (used primarily in road bikes) that uses computer controlled servo-motors to adjust the fixture for a particular frame size. The slot-and-tab process (Exhibit 6) does not require substantial set-up effort as frame geometries or tube diameters change. During the laser cutting process, tabs and slots are cut in adjacent tubes. Tubes are placed together with the tab mating with the slot. In a sense, the tab and slot system creates a self-fixturing frame. This frame assembly is then held in position for welding with a relatively simple clamping system.

Cannondale owns process patents on a system combining laser cutting with the slot-and-tab assembly scheme. The process allows any type of frame geometry to run through its production process in any sequence with very little set-up. Although laser cutting is now being adopted by some other firms, most of the frames made by the other firms in our sample use die cutting with hard fixtures for frame fabrication.

*Location of the Decouple Point*

A critical decision in any supply chain is determining how production will be linked with actual demand (Fisher 1997). We define the *decouple point* as the point in a supply chain where a specific customerís name or order number is associated with a specific product[8]. This concept requires a definition of the customer, and the decouple point may be different for an end consumer, a retailer, or a distributor. For all of the firms in the sample, the retailer and the end consumer are both important customers to consider.

Ideally, the decouple point would be located before the point in supply chain where high variety is created. Operations "upstream" of the decouple point operate in a make-to-stock mode and fill inventories of partially completed goods. Operations "downstream" of the decouple point operate in a make-to-order mode and produce goods associated with specific customer orders. This approach buffers the upstream operations from unpredictable fluctuations in end customer demand, while allowing the firm to avoid holding inventories of every possible end item.

[8] The decouple point is sometimes also called the *push/pull boundary*, however "push" and "pull" have very different meanings in the operations management and marketing communities and so we avoid these terms for clarity.

While in the ideal case, the decouple point is upstream of the point at which variety is introduced, locating it as close to the customer as possible is also highly desirable to minimize order lead time (Lee and Tang 1997). *Postponement* and *process reversal* are strategies which allow firms simultaneously to locate the decouple point close to customers and upstream of the point at which high variety is created. See [Lee 1996] and [Davis and Sasser 1995] for examples. Process reversal strategies require firms to sequence steps so that steps with long lead-times that do not differentiate products precede those steps that differentiate the product (Lee and Tang 1995).

In the case of VooDoo, the greatest amount of variety arises in the assembly process. VooDoo locates the decouple point at the assembly process and interchanges the transportation and assembly steps so that frames and components are shipped from Asia and then assembled in the United States. Assembly occurs only after a customer order has been received. Customers receive their bicycles within five days. Because it offers bicycles in 104 colors, National locates the decouple point at the frame fabrication step so that frames may be painted to customer specifications. Customers receive their bicycles within two weeks.

Locating the decouple point upstream of the process step at which variety is introduced is a heuristic. The optimal location of the decouple point depends in a particular situation on the cost structure of the production process, the costs associated with inventories, and the value to the customer of short order lead time. For example, the high variety of Cannondaleís bicycle frames suggests that the decouple point should be located before the frame production process. However, aggregate bicycle demand is seasonal and skilled welders are a scarce resource. Rather than allow the welding process to suffer downtime due to seasonal demand swings, Cannondale locates the decouple point after welding. Welders produce at a constant rate throughout the year. Unpainted bicycle frames are stored in an “unfinished goods” buffer until customer orders arrive (from retailer customers) specifying the color and components to place on the bicycle. The materials variety offered by Specialized suggests that the decouple point be placed at the tube cutting operation. However, there are substantial economies of scale in frame production, with different processes required for each material. As a result, Specialized cannot achieve these economies on its own. To benefit from these scale economies, Specialized must outsource bicycle production to suppliers who produce for many different firms. This outsourcing increases production and transportation lead time, which in combination with seasonality, requires Specialized to hold finished goods inventory of each end item in the United States.

*Product Architecture*

Product architecture is the scheme by which the function of a product is allocated to physical components (Ulrich 1995). A product architecture may be *modular* or *integral*. In a modular architecture, a one-to-one mapping exists between the function of a product and its components, and the interfaces between components are decoupled. In an integral architecture, the mapping between functions and physical components is not one-to-one and/or the interfaces between components are coupled. Modular architectures facilitate variety in that combinations of components can be assembled to form many different products. Bicycles as a category are extremely modular; components are commonly interchanged with frames to form different models. However, two key architectural decisions exist in mountain bike design: (1) the degree of modularity of the suspension and (2) the geometric similarity between sizes of a particular frame geometry.

Specialized, VooDoo and National use modular front suspension designs in which a third party provides a front suspension fork which fits any bicycle headset. Rock Shox and Manitou, two front component suppliers, provide 74% of all front suspensions to the industry. In the case of VooDoo eight different front suspension forks, from both Rock Shox and Manitou, fit any frame. Cannondale uses an integral front suspension design known as the HeadShok. The HeadShok integrates the fork travel and damping mechanism with the head tube of the frame. A Cannondale frame design differs depending on whether the bicycle will include a HeadShok suspension or not. As a result, Cannondale's suspension can not be assembled on any bicycle frame.

For Specialized, VooDoo, and National, most of the angles between the tubes in a frame design do not change for several different sizes of the frame. The frame is simply "stretched" with respect to the seat tube and head tube of the frame. This allows the same hard-fixture to be used, with minor dimensional adjustments, for several frame sizes. In contrast, Cannondale modifies the angles and tube lengths of the frame when changing the size of the frame. This is an example of the coupling found in an integral architecture; changes in one of the frame tubes requires changes to the other frame tubes. This integrality is enabled by the laser cutting and slot-and-tab assembly used in Cannondale's frame production process.

## 5. Evaluating and Selecting a Variety Strategy

The four firms in our sample make very different strategic choices in the six areas we have outlined. (Exhibit 7 is a summary of these choices.) This raises the question of which strategy is

best, and how a firm can evaluate and select a strategy. In this section, we argue that a variety strategy can be evaluated and selected based on the satisfaction of these criteria:

- The dimensions of variety offer perceived value to the customer.
- The dimensions of variety are competitively distinct.
- The product architecture and production/distribution system choices minimize costs given the chosen dimensions of variety.
- The firm possesses design/operations capabilities to support the dimensions of variety.
- The strategy exploits the unique context and resources of the firm (e.g., location, history, and relationships).

The last two items on this list are similar but we think worth differentiating. By *capabilities* we mean features that any firm could acquire with an investment of time and money. By *context and resources* we mean inherent features, like location and history, that would be difficult, if not impossible, to change.

This section also provides an answer to the question posed at the beginning of this paper - how can firms producing the same product pursue such diverse variety strategies? We shall see that the differences can exist in part because there is value in having a differentiated product positioning in the marketplace and in part because a firm's unique history, resources, and capabilities greatly influence its strategic choices.

*Dimensions of Variety Add Perceived Value to the Customer*

The dimensions on which firms offer high variety should offer value to customers (Porter 1985). Variety with perceived value to customers enhances revenues while variety without perceived value may only increase cost. Evaluating the value to customers of a dimension of variety involves understanding (1) the degree to which customers have heterogeneous preferences along that dimension and (2) the level of importance a customer places on the particular dimension. For example, Nationalís strategy of offering 104 colors per bicycle model is extremely successful in the Japanese market where apparently the opportunity to ride bicycles with distinctive color patterns offers customers a way to differentiate themselves that is highly valued in Japan[9]. However, this same strategy was not successful when National attempted to enter the United

[9] This strategy is echoed in an interesting Harvard case - Tombow Pencil (Mishina 1991). Tombo has succeeded in turning pencils into a fashion product sold to school children who have precious few ways to be different in the uniformed regimented Japan's school system.

States market, and where its models were perceived by consumers as undifferentiated[10]. National withdrew from the United States market after a short period of time.

*Dimensions of Variety are Competitively Distinct*

Most firms offer some variety on every dimension (e.g., different sizes, different component groups, and different colors). However, as in positioning a single product, a firm enjoys a competitive advantage in the form of a "local monopoly" when it is alone in offering high variety on a particular dimension. For example, National is the only major firm offering high color variety. Nationalís color strategy allowed the firm to increase market share in Japan by 35 % while overall sales in the mid- to high-end bicycle segment declined 40 %. Specialized created a proprietary material, the metal matrix composite, which combines aluminum with ceramic particles. The resulting composite weighs the same as titanium and carbon fiber, but is produced at a fraction of the price. This move allowed it to offer a distinctive selection of frame materials. VooDoo offers component variety, typically only available from small custom bicycle shops or by retro-fitting stock bicycles, by allowing consumers to select each component of each bicycle. No firm in the industry offers the many different types of frame geometries available from Cannondale.

*Given Variety, the Product Architecture and Production Systems Minimize Costs*

This criterion relates to the coherence of a variety strategy. Given a decision about the dimensions on which to offer variety, has the firm chosen the product architecture and production system that minimize its costs. For example, National and VooDoo combine a make-to-order delivery system with an enhanced customer interface to minimize the supply chain costs associated with delivering hundreds of color and component variants. This system minimizes both retailer and manufacturer costs. Cannondaleís frame fabrication process allows any type of frame geometry to be produced with very little set-up cost. Cannondale regularly produces one-of-a-kind bicycles for celebrities or racing teams in batch sizes of one. These batch sizes run through the plant without disruption of normal production. For Specialized, vertical integration of frame production would require an investment in process technology for each new frame material. Specialized mitigates this cost by outsourcing frame production, capitalizing on the economies of scale of other frame manufacturers.

[10] This is a perception by a few observers. There were probably several factors contributing to the lack of success, including brand image and exchange rate issues.

*Design/Operations Capabilities Support the Dimension of Variety*

A distinctive strategy may require distinctive capabilities (Prahalad and Hamel 1990; Stalk et al. 1992). Cannondale has developed a reputation for offering a frame for every bicycle use. For example, Cannondale makes mountain bikes for downhill, cross country and city riding. Cannondale also produces track cycles, touring bikes, triathlon bikes, tandem bikes, and road racing bikes. Each frame incorporates a different geometry to meet the specific riding needs of each customer. Cannondaleís frame strategy requires three capabilities: Computer-aided design (CAD), laser cutting, and skilled aluminum welding. CAD linked to cutting capabilities allows designers to produce tubes for diverse frame geometries. Welding is performed by a highly skilled work force that can easily adapt to the different geometries which are run through the production system. Nationalís custom order system requires two capabilities: short production lead time and tight links to retail outlets. Short production lead times allow customers to receive custom orders within two weeks. Tight links to retailers help simplify the communication that must occur between customer and manufacturer. Nationalís ownership of retail outlets facilitates this link. The ability to locate and structure contracts with partners is vital to Specializedís materials strategy. For example, Specialized not only outsourced frame production, but development of their metal matrix composite material. VooDoo is developing a reputation as a company that caters to consumers who wants to choose the exact components of their bicycles. To effectively communicate choices available to customers, VooDoo developed Internet capabilities which integrate the actions of customers, manufacturer, and retailers. A customer may select a VooDoo bicycle via an Internet web page. The web page directs the customer to a retailer where the finished bicycle may be obtained.

*Variety Strategy Exploits Unique Resources and Context*

Our observation is that variety decisions at each firm are driven by the unique resources and context of the firm[11]. Cannondale created a reputation for building high quality hand-welded frames in the United States. Because of this reputation and the associated brand equity, the firm has resisted the temptation to outsource production to regions where labor is cheap. Instead, Cannondale chose to enhance its reputation for high-quality frames by investing in laser cutting capabilities which challenge its skilled labor force with varied frame geometries. Nationalís custom order system was motivated by languishing sales of mountain and sport bicycles, and a senior management imperative to improve. National's very existence as a division of Matsushita is due in part to the chairman's fondness for the bicycle. Their location in Japan allowed them to

[11] Unique resources and context could be viewed as a special kind of capability, but we list this criterion separately.

build to order with a two week lead-time, something that was impossible for their off-shore competitors. From the first model of the STUMPJUMPER, Specialized created a reputation as an innovator in mountain bicycling. Ground control tires, water bottles and head protection all number among the Specialized mountain bike innovations. As innovation grew expensive and technologically sophisticated, Specialized sought out partners to create new frame materials and to produce bicycles made from new composites. Founded in 1994, VooDoo found itself competing against well established competitors. It has creatively combined internet technology with a traditional retail network to build a strong brand reputation in a saturated market.

## 6. Concluding Remarks

*Generalizing Key Insights*

Our analysis is of a single product category in a single industry. An important question is the extent to which these ideas apply to other situations. Distinguishing characteristics of the bicycle industry include: a relatively stable, modular product architecture within which component innovations appear to flourish; a blend of "fashion" elements and technology "elements"; the presence of many competitors; and relatively fragmented distribution channels. Like any case analysis, extrapolation must be done carefully. However, we believe these cases illustrate several key ideas for managing product variety that apply to most industries:

- Variety management presents challenges at both strategic and tactical levels. Strategic decisions involve creating an effective variety delivery system. These decisions are made relatively infrequently and include: (1) the dimensions of variety offered, (2) the nature of the customer interface and distribution channel, (3) the degree of vertical integration, (4) the process technology, (5) the location of the decouple point, and (6) the product architecture. Tactical decisions are made more frequently, perhaps every product cycle, with the objective of optimizing the short term performance of the variety delivery system. Each decision will take on varying degrees of importance in different industries. For example, due to standardization of the product architecture in the bicycle category, firm-level architectural decisions do not play as prominent a role in the bicycle industry as they may in, for example, the automobile industry (Robertson and Ulrich 1997). Mountain bicycles are a relatively young product category. Firms continue to experiment with designs, materials, and processes. As the category becomes more mature, there may be less discretion on the

part of the manufacturer with respect to the dimensions of variety; consumers may simply require variety on certain dimensions.

- Variety is multidimensional. When comparing the level of product variety among companies, comparisons must be made along a particular dimension of variety in addition to analysis at the level of end-items. In the bicycle industry, analysis only of end items would belie underlying differences in variety along the dimensions of frame geometry, component groups, colors, and materials.

- Key criteria for evaluating and selecting variety strategies are: perceived value to the customer, competitive distinction, cost effectiveness, firm capabilities, and firm context.

- Variety strategies are dynamic, path dependent, and context dependent. Changes in strategy are constrained by existing firm resources and capabilities as well as by changes in the competitive context. A start-up faces different constraints than a division of a large corporation.

- No single variety strategy dominates. An effective variety strategy is a coherent set of marketing, design, and manufacturing decisions. Given that every firm possesses a different set of capabilities, a unique context, and a distinct competitive position, no single variety strategy will be appropriate in all settings. This is directly analogous to the idea that no single product positioning is appropriate for all firms.

*Managerial Decision Process*

We have argued that variety strategy involves managerial decisions and that these decisions should be coherent. However, we have not discussed the managerial process for arriving at a variety strategy. We are not privy to the details of the process by which the managers at the firms in our sample decided on their strategies. However, three questions seem especially important: (1) Should a variety strategy by *market driven* or *capabilities driven*? (2) What information is required to formulate a variety strategy? and (3) How often should a variety strategy be revisited? These same questions have been posed more generally in the literature on corporate strategy, and the insights from the general case seem to apply here as well.

While regular debates occur over whether firm strategy should be driven by capabilities or opportunities in the market, we argue that successful variety strategies must both be market driven and capabilities driven. A unique firm capability creates little advantage if it cannot be

exploited in the market (Day 1990). In Nationalís case, misreading the U.S. market resulted in deployment of color delivery capability which was largely ignored by consumers. Conversely, effective exploitation of a market opportunity requires unique capabilities. We cannot imagine Specializedís material delivery capability effectively offering colors to the Japanese market. New capabilities would have to be developed.

Planning an effective variety strategy requires information about product lines, consumer behavior and tastes, growth rates, market segmentation, suppliers, technological innovation, and the strengths/weaknesses of competitors (Porter 1980). Common sources of information include annual reports, trade journals, and previously published industry studies. Detailed insights may be gained from field interviews with key industry personnel. Because of the daunting nature of the data gathering task, it is important to focus and limit the data search to the relevant data needed for strategy formulation. A framework may be useful in organizing the data collection efforts. For example, competitors strengths and weaknesses may be analyzed by examining the six decision areas we have suggested in this paper.

Traditional methods of strategic planning assume a relatively slow rate of strategic change. However, todayís turbulent business environments may require firms to adjust quickly to competition and emerging market trends. This environment requires flexible planning processes that continuously revisit strategies and adapt to environmental contingencies (Day 1990). This type of review fosters incremental changes in variety strategies, but allows firms to identify opportunities for major strategic change.

*Future Challenges*

The case analysis raises several questions which merit further investigation.

<u>How can the profitability of a variety strategy be estimated?</u>

Ultimately, a firm must justify a variety strategy in terms of profits, yet the sensitivity of profits to changes in product variety is difficult to predict. What tools may be useful to estimate and compare the profitability of different variety strategies before committing resources? Profit is the result of revenue and cost. Cost seems to be the easier of these two dimensions to estimate. Product and process engineers often estimate the cost impact of product and process choices and have developed tools of accepted validity, which appear to be adaptable to estimating the cost implications of a variety strategy. By contrast, forecasting the sales of even a single new product is challenging. The market research tools that have been developed for this task, like conjoint

analysis, are designed for an environment with just a few product variants and it is not obvious how to generalize them to estimate revenue when there are thousands of potential product variants.

How can distribution channels be configured to eliminate the ìvariety bottleneck?î

Cannondale possesses the capability to offer infinite variety along the dimensions of frame size and configuration. However, many believe that the current distribution channel cannot efficiently promote, display, fit, and deliver more frame variety. We call this situation a *variety bottleneck*. The variety bottleneck also appears in the auto industry: auto plants can generally produce extreme levels of variety, yet consumers often face only limited selections at their local dealer. When faced with this challenge, VooDoo and National implemented a make-to-order delivery system with an enhanced customer interface, yet their sales remain small in comparison to those of stock products. When several firms sell products through the same retailer, there appears to be an incentive for the retailer to sell what is stocked before pursuing the make-to-order business. The emergence of the internet as used by VooDoo may serve as a solution to categories of products where the actual product does not need to be physically experienced. What other options are available to firms facing a variety bottleneck in distribution?

How does variety relate to changing roles in the supply chain?

In the bicycle industry we observe interesting changes in the boundaries of the firm and in the roles played by manufacturer and retailer. There are many "manufacturers" who do not manufacture (e.g., Specialized). Yet there are retailers who do manufacture, or at least assemble bicycles to order. For example, Colorado Cyclist, a top mail-order retailer, sells bicycles in much the same way as VooDoo, allowing a customer to select a frame along with any desired components (down to the last spoke nipple). In a modular system like bicycles, what role does the traditional manufacturer play? Who brands the bicycle?

How can promising new dimensions of variety be identified?

In the last five years, frame material and suspension design both emerged as critical dimensions of variety. Successful firms quickly developed strategies to address the emerging new dimensions. For example, Specialized created partnerships to develop new materials. Some of these new dimensions arose because of technological innovation, others because of changes in consumer tastes and behavior. Given that early detection of emerging dimensions of variety is an important capability, how can the detection process be improved?

Can the emergence of variety as an important strategic variable be predicted as a function of rates of technological innovation, industry structure, and market maturity?

Several strands of research suggest general conditions exist where variety may become an important strategic attribute. Utterback (1994) suggests that peripheral variety appears after the technology matures and a dominant design emerges. Lancaster (1979) points to issues of industry structure and market maturity. Can the antecedents of these conditions be recognized in order to predict when firms must develop variety delivery capabilities?

Can coherence in variety strategy be measured and/or correlated with firm performance?

The variety strategies of the four firms appear to be relatively coherent. Cannondale competes on frame variety and invests in flexible frame technology. National used its dealer network to create a custom color delivery system. Is coherence a purely conceptual idea, or are there metrics of coherence and ways of identifying coherent strategies?

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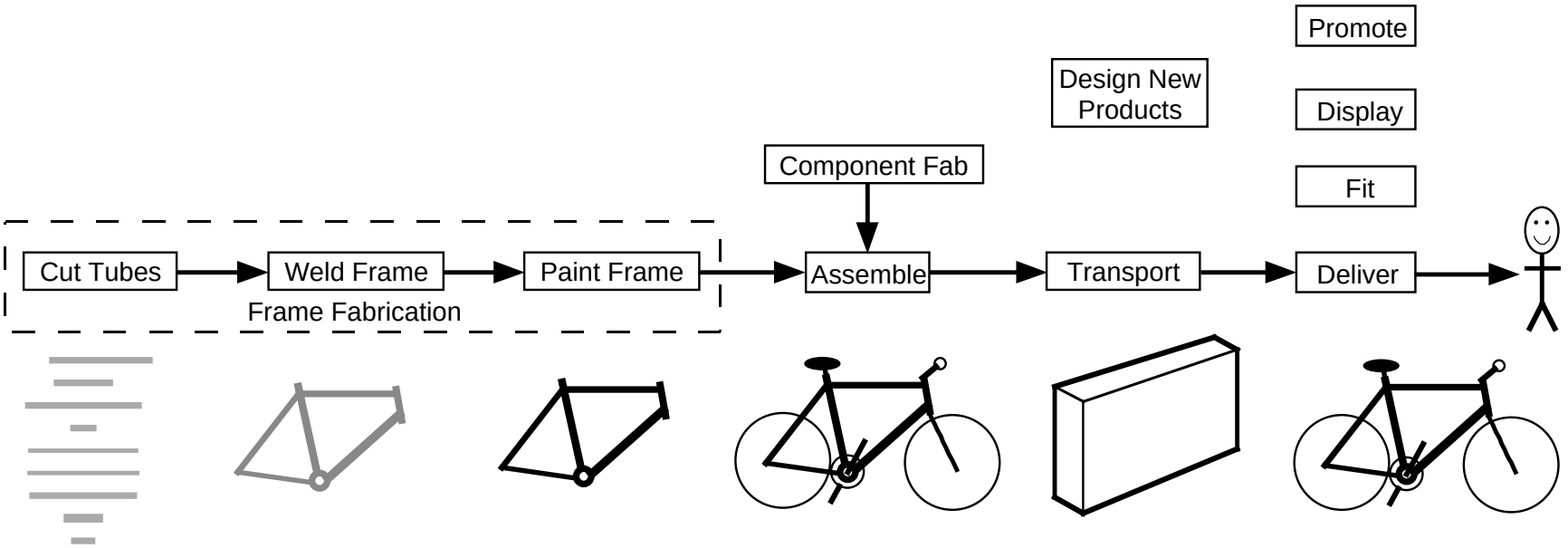
**Exhibit 1:** Generic variety delivery system.




**Strategic Decisions**
(every 5-10 product cycles)

Dimensions of variety

Distribution channel and customer interface

Vertical integration of production

Production process technology

Location of decouple point

Product architecture

**Tactical Decisions**
(every product cycle)

Number of levels of attributes

Bundling of combinations

Parts sharing

Lot sizing

Inventory policy

Production scheduling

**Exhibit 2:** Dimensions of variety for example companies.

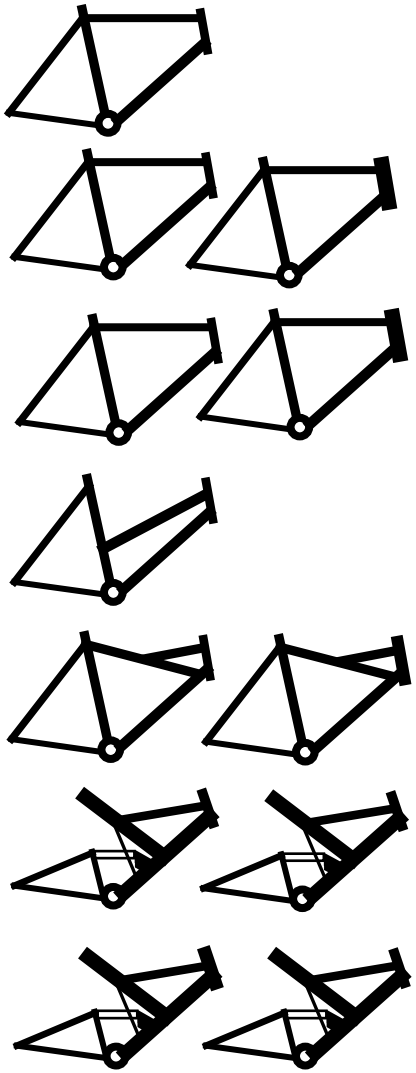
| | Cannondale | Specialized | VooDoo | National |
|---|---|---|---|---|
| **End Items** | 110 | 134 | 1728 | 6240 |
| **Frame Geometries** | **12** | 6 | 2 | 3 |
| **Materials** | 1 | **6 (3 basic)** | 3 | 2 |
| **Components per frame*** | 2 | 1.4 | **48** | 6 |
| **Colors per model**** | 1.25 | 1.25 | 1 | **104** |

*A frame is a material/geometry combination

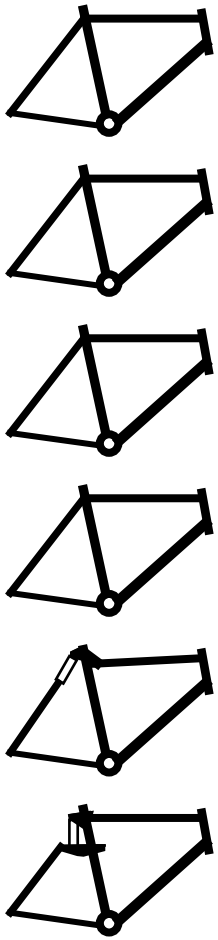
**A model is a frame/component combination

**Exhibit 3:** Schematic illustration of frame geometries offered by each firm. (Slight geometric variations associated with different sizes are not shown).

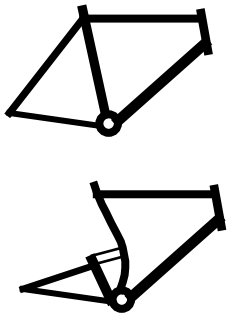
**Cannondale**



**Specialized**



**VooDoo**



**National**

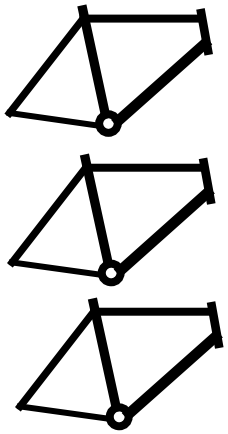
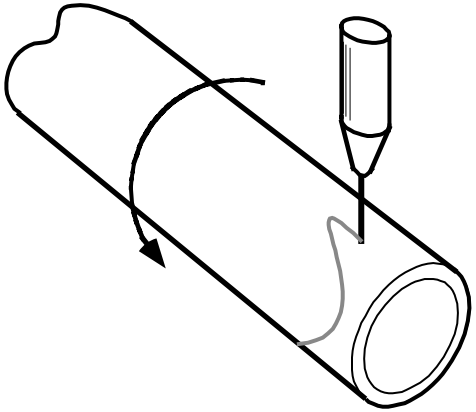
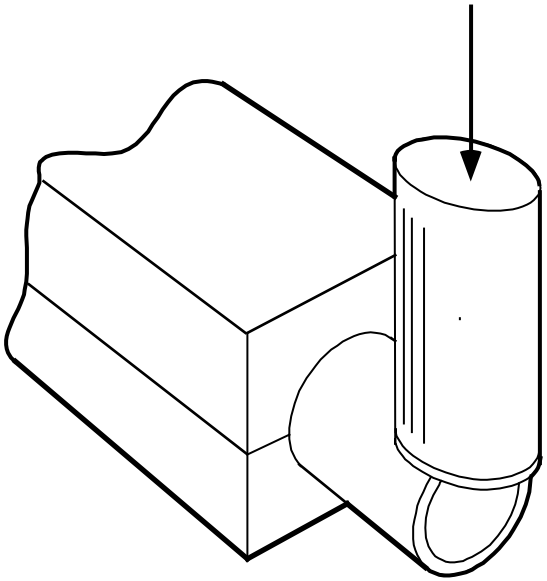


**Exhibit 4:** Schematic description of two alternative tube cutting technologies.



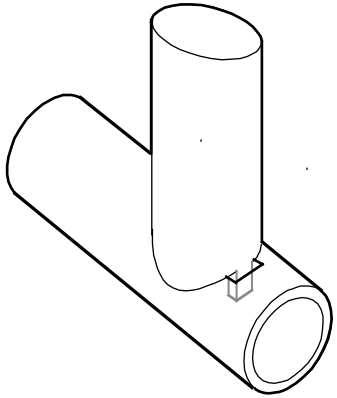
Computer-Controlled Laser Cutting



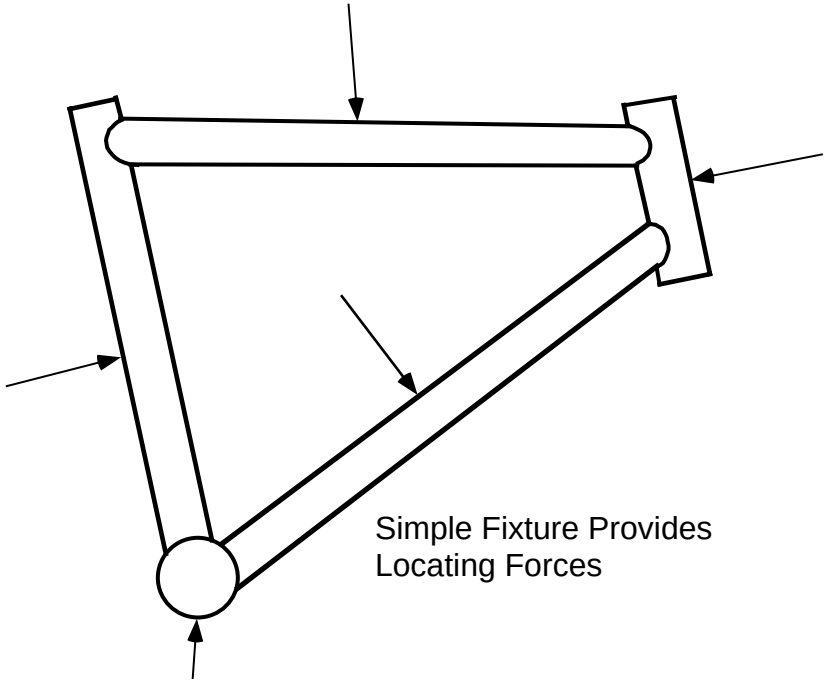
Die Cutting

**Exhibit 5:** Conventional hard fixture for positioning tubes for welding.

**Exhibit 6:** Slot-and-tab approach to positioning tubes for welding.



Slot and Tab Detail



Simple Fixture Provides
Locating Forces

**Exhibit 7:** Summary of variety strategies.

| | Cannondale | Specialized | VooDoo | National |
|---|---|---|---|---|
| **Key Dimensions of Variety** | Frame geometry | Frame material | Component group | Color |
| **Customer Interface and Channel** | Select from retailer stock<br>End items enumerated | Select from retailer stock<br>End items enumerated | Internet catalog<br>Order through retailer<br>"Ingredient menu" | Affiliated retailers<br>Order through retailer<br>"Ingredient menu"<br>Fitting stand |
| **Vertical Integration** | Frame fabrication and some component fabrication integrated | Outsource entire bicycle production | Outsource frame production<br>Assembly integrated | Frame fabrication and assembly integrated |
| **Process Technology** | Laser cutting<br>Slot and tab fixturing | Conventional dies and fixtures at supplier | Conventional dies and fixtures at supplier | Robotic frame painting |
| **Decouple Point** | | | | |
| *end customer perspective* | Retailer stock | Retailer stock | Assembly | Frame fabrication/painting |
| *retailer perspective* | Frame painting or Cannondale finished goods inventory | Specialized finished goods inventory | Assembly | Frame fabrication/painting |
| **Product Architecture** | Integral front suspension<br>Substantial geometric differences among different sizes | Modular front suspension<br>Minor or no geometric differences among different sizes | Modular front suspension<br>Minor or no geometric differences among different sizes | Modular front suspension<br>Minor or no geometric differences among different sizes |