

CATEGORY CURRENCY: THE CHANGING VALUE OF CONFORMITY AS A FUNCTION OF ONGOING MEANING CONSTRUCTION

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ABSTRACT

In markets, audiences generally discount offerings that fail to fit established product categories, but when misfit offerings change category meaning, the effects of conformity and deviation can reverse so that previously overlooked or unappealing offerings become popular while previously appealing products fall into disfavor. After introducing the idea of category currency to explain how the value of conformity changes with ongoing meaning construction, we use it to make sense of the emergence of nanotechnology. In conclusion, we argue that category currency is useful for explaining the changing value of conformity both in and beyond markets.

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When firms develop capabilities they view as sources of competitive advantage (Barney, 1991; Penrose, 1995), exploiting these capabilities is often a path to further success and growth (March, 1991). When firms hope to exploit capabilities associated with one market by applying them to a new or apparently unrelated market, however, success depends on reactions of audiences crucial to judging the sense or utility of firms' moves to leverage their capabilities. In the social movements literature, studies show that activists broaden the appeal of their causes by framing them in ways that expand or bridge their concerns to intersect the concerns of broader audiences (Benford & Snow, 2000; McAdam, McCarthy, & Zald, 1996; Snow, Rochford, Worden, & Benford, 1986). In the market context, however, stretching to reach a new audience risks running afoul of the ecological principle of allocation (Freeman & Hannan, 1983), the idea that firms face tough tradeoffs when they attempt to widen their niches by addressing multiple audiences (Hannan & Freeman, 1989; Hsu, 2006b). On the one hand, serving multiple audiences offers the promise of growth and scale economies. On the other hand, it threatens to undermine a firm's appeal to each audience and, therefore, its fitness within each niche (Carroll, 1985).

This tradeoff is clearest when market categories have relatively fixed meanings. In what Zuckerman calls the "illegitimacy discount," analysts and investors overlook and undervalue firms with strategies that involve participating in market categories not typically associated with the industry category they fit best. In organizational ecology, such strategies are conceptualized as occupying a wide niche (Freeman & Hannan, 1983), but as this niche width increases, the greater the risk audiences will overlook or discount the organization because it is spread too thinly across multiple demand categories (Hannan & Freeman, 1989; Hsu, 2006b).

While market categories are often durable elements of institutional environments (Tilly, 1998), treating them as fixed misses the creative destruction that occurs as innovation stimulates shifts in demand from established categories to new ones (Schumpeter, 1934). As Zuckerman (1999, p. 1410) puts it, analysts and investors routinely face "events that defy the categories of existing models," and this means "the very question of whether a new era or 'paradigm' has been reached is a perennial issue in the financial community."

To address this question, we treat market categories not as fixed, but as changing to reflect consensus about whether and how events that defy existing market categories amount to defining new ones. This consensus emerges when market audiences come to see unfamiliar and anomalous market offerings as having a logic and pattern that makes them worth

naming – this is a market-level analog of what Weick (1995) calls sensemaking. As Jensen (2010) argues and shows in another chapter of this volume, illegitimacy is legitimized when sensemaking yields new “market identities” for offerings that recombine elements of existing categories to do something new and different while partially fitting what people already understand. Such recombination is a mechanism or institutional change (Powell, 1991). When offerings based on recombination meet with enough success to encourage imitation, sensemaking reworks category systems to fit major new developments, gradually producing new market and product classifications (Lounsbury & Rao, 2004). In some cases, new offerings will undermine the perceived usefulness and appeal of categories they blend together. For example, computer manufacturers in the 1980s blended elements of the market categories for minicomputers and personal computers (PCs) to produce a new product market category, the computer workstation. As workstation producers found each other as rivals and increasingly agreed on how to define the new category they were creating, the producer population grew (Kennedy, 2008). As the market for computer workstations grew (Bell, 1986), for example, the minicomputer market gradually shrank and became less attractive (Kenney & von Burg, 1999).

Thus, we argue that strategies that blend elements of multiple categories can and do create value when they change the meaning of categories as defined at an earlier point in time to establish new categories for organizations to fit. This occurs when ongoing market sensemaking transforms yesterday’s category blend into a new “pure play” strategy. As meaning construction processes alter how audiences interpret categories, they transform the landscape of categories over which firms are seen as allocating – or concentrating – their efforts, attention, and identities.

This argument supports the principle of allocation because it continues to emphasize the importance of audience perceptions about category conformity based on collective agreement as the standard of category meaning. Following Hannan and Freeman (1977, p. 934), studies of organizational populations and their niches commonly selected research sites based on category definitions assigned, and for purposes of analysis, keep these definitions mostly fixed. While practical, this research strategy yields errant conclusions when category definitions change. If labels for two previously distinct market categories are gradually becoming synonyms, for example, firms that identify themselves with both labels may reach a broader audience without being penalized for lacking a clear identity. Thus, the principle of allocation depends on fitting a set of targets for conformity that are moving, not fixed.

Besides its implications for research method, this argument matters theoretically because it raises questions for niche width theory (Freeman & Hannan, 1983) as applied to organizations and markets. Specifically, if meaning construction can narrow niche width by naturalizing hybrids, when does this happen? Furthermore, when niche width is measured in terms of dispersion of an organization's attention and effort across a number of distinct categories (Freeman & Hannan, 1983; Hsu, 2006a, 2006b), changing category meaning alters not only the number of categories organizations draw on, but also the degree of difference between them. For example, combining a toothpick, corkscrew, tweezers, scissors, screwdriver, nail clipper, and a knife might have seemed odd in the 1890s when Victorinox introduced the multi-function pocket knife now known as a Swiss Army knife. Today, however, this combination is now widely recognized as a category – even as a metaphor for other combinations. Consider also how word processing applications have gradually subsumed separate utility programs for doing things like spell or grammar checking so that, over time, the market audience has all but forgotten the pieces were ever separate. Netbook computers are another example of category change; they combine features of laptops and smartphones. To be sure, knowing that a category blend will be naturalized is easiest in hindsight, but the fact that some blends are naturalized begs explaining.

In this chapter, we relate the naturalization of category-blending innovation to an idea we call category currency, a measure of the extent to which audiences view categories as having both clear meaning and positive appeal. As we explain in more detail below, we used this to assess the relative currency of a focal category scheme versus an alternative by dividing the two. By category scheme, we mean one or more related categories for making sense of a particular field of exchange, whether this field is clearly recognized yet or not. This measure of relative currency reflects how an audience regards the same level of fitness in two separate schemes. If a focal category's currency is greater than an alternative's, relative currency is greater than 1; when the reverse is true, it is less than 1. By examining changes in currency and relative currency, it should be possible to gauge audiences' changing reactions to strategies that fit previously established categories versus possible new ones based on, for example, blending elements of several others.

Before going into the theoretical argument and definition for currency, let us illustrate the idea briefly with a concrete example. Take the case of slide rules and calculators. Both are calculating devices, so they are – or at least were – economic substitutes. As slide rules have become more obsolete over the last few decades, fewer and fewer people even know what one is, and

their appeal has declined as well. In contrast, people these days know what calculators are, and they are generally viewed as useful tools, especially for students who do not yet need the power of a spreadsheet or mathematical modeling software. Assuming we can develop reasonable measures of the coherence and appeal of the two categories (more on that below), the product of the coherence and appeal measures ought to be greater for calculators than for slide rules, so the quotient of the two will be greater than one. When electronic calculators were first introduced, however, the lack of understanding about them and lower appeal would have produced the opposite situation – that is, the currency of slide rules would have been greater than the currency of calculators. This example shows the importance of the rate of change of currency – something like a category’s momentum. Fitting a category with high but declining currency may be less valuable than fitting one with low but rising currency.

After developing the theoretical underpinnings of category currency, we put the idea to use in a discussion of the rise of nanotechnology, an emerging field of interdisciplinary research and a less clearly formed proto-industry emerging around efforts to define markets around several nano-related product categories. From this discussion, we hope it becomes clear that the idea of category currency provides language that is helpful for clarifying and discussing theoretical questions that arise when category meaning is changing. When category meaning is changing in ways that erode its currency, for example, the resulting negative trajectory has consequences for propositions about the value of conformity, even if the category has a long history of legitimacy. For a category like nanotechnology, the reverse could be true. As an emerging category acquires clearer meaning, its increasing currency moderates the disadvantages associated with early nano-related efforts that did not fit more established categories; at least in research, the increasing currency of nanotechnology eventually led to advantages for projects that could be framed as fitting the emerging new field. In conclusion, we speculate on how this new language and its related theoretical view add to organization theory by relating the construction of meaning to the institutionalization of ecologies that are themselves constructed.

CATEGORY CURRENCY

Quantitative analysis of meaning is theoretically and empirically challenging enough that, at least historically, studies in organizations and markets have

generally simplified things either by treating market categories as fixed or, in the case of emerging categories, by beginning with categories known to have emerged. Following Hannan and Freeman, organizational scholars select organizational populations or niches for study not based on “immutable objects in nature” but because they are “abstractions useful for theoretical purposes” (1977, p. 934). In Zuckerman’s (1999) study of mismatch between corporate portfolios and industry categories, for example, the theoretical focus on financial analysts made it natural to use a single set of SIC codes to define industry categories for the entire period 1985–1994, but any decade of business history offers a number of cases where new developments shift the boundaries of industry or market categories and thus result in changes to analysts coverage patterns.

As mentioned above, researchers have tended to cope with the challenges of allowing category definitions to vary with contemporary thinking by selecting organizational populations or niches based on definitions usually clear in hindsight and held constant throughout the analysis period, even if they may have changed during it. This could be said of, for example, studies of computer workstations (Sorenson, 1997), disk arrays (McKendrick, Carroll, Jaffee, & Khessina, 2003), and microbreweries (Carroll & Swaminathan, 2000), to name a few. Even in studies where category definitions are allowed to vary to see how they emerge, researchers select product markets or organizational populations based on knowing in hindsight that their definitions eventually became clear. This was the case, for example, in studies of minivans (Rosa, Porac, Runser-Spanjol, & Saxon, 1999) and computer workstations (Kennedy, 2008).

Elements of Category Currency

The currency of a category or a set of market categories depends on the market audience’s time-varying views about whether their associated labels refer to niches in the overall demand environment widely seen as both real (Kennedy, 2008) and legitimate, or positively valued (Hsu, Hannan, & Koçak, 2009). Following Zuckerman’s (1999, p. 1400) call for greater attention to the role of market audience perception in determining category legitimacy, currency emphasizes the coherence of collective agreement about not only what a category means, but also the value of conforming to it. Both inputs to currency are matters of degree, not dichotomies.

Category Coherence as Consensus about Meaning

A category's currency is a function of the *coherence* of its meaning. The more clearly a market audience sees a category label as referring to a stable pattern of defining features, the more likely audience members are to see this pattern as referring to a plausible or real dimension of the demand environment (Weick, 1995), and increasing consensus about category meaning unlocks demand by decreasing uncertainty (Rosa et al., 1999). More precisely, demand is related to intensional consensus about a category label, which is just the extent to which audience members see the label as referring to substantially the same patterns of defining features (Hannan, Pòlos, & Carroll, 2007). As the label is used in ordinary language, this consensus is seen most clearly in the emergence of consistent relations between the category label and other labels for its defining elements. Specifically, audience members iteratively refine their understanding of a category label with each usage they encounter by hypothesizing about the recurring patterns that relate labels for defining synonyms, instances, and attributes. As these hypotheses are shared and agreed to be useful descriptions of the environment, the process reifies the category so that it is increasingly seen as real (Kennedy, 2008).

To more clearly define this consensus, we turn to research in the ecology of identities applied to various types of organizations (Hannan et al., 2007; Hsu et al., 2009; Koçak, Hannan, & Hsu, 2009). Building on ideas from set theory and formal logic as applied to semantics, this program of research links the meaning of categories – that is, particular sets of things – to either an enumeration of their members or rules about membership. When users of a category label extend it to sets of instances that are largely overlapping, the label or term is said to have high extensional consensus. When users of a category label refer to objects that largely fit a common set of criteria, the label or term is said to have high intensional consensus. Both extensional and intensional consensus contribute to category coherence.

Category Valence as Consensus about Appeal

For a given audience, a category's currency is also a function of *valence*, the degree of positive versus negative appeal it is seen as having. In institutional theory as applied to categories for describing organizations, markets, and fields (e.g., see Lounsbury & Rao, 2004; Zuckerman, 1999, 2000), the more legitimate the category, the greater the appeal of conformity to it. Hannan et al. (2007) and Hsu et al. (2009) extend this insight to distinguish categories as positively valued when greater conformity is associated with greater appeal for the typical audience member. This extends theory about

categories developed by cognitive scientists. In studies where participants with normal knowledge and beliefs are asked to compare various items that could fit a category to relevant category prototypes (Rosch, 1983), higher typicality boosts appeal for positively valued categories, but it lowers appeal for negatively valued categories (Herzog & Stark, 2004).

Our concept of category valence merely collapses the idea of positively and negatively valued categories into a single scale that can have positive or negative values. That is, category valence is an audience-specific measure of the degree to which an audience sees conformity as appealing versus unappealing and, therefore, the degree to which category members' self-identifications are likely to feature the category or omit it. We say valence is audience specific because it changes depending on whom you ask. For example, the ultimate confidence artist generally inspires admiration among thieves, but loathing among cops. Put simply, valence captures the degree to which a particular audience sees a category as appealing or unappealing.

Definitions

For a category u at time t , the currency (ϕ) of a category can be represented simply as the product of its coherence (c) and the valence (v) to a focal audience:

$$\phi(u)_t = c_t v_t \quad (1)$$

Using this basic scheme, changes in category currency for a focal audience can be measured by comparing values for a single category from two different time periods, values of two different categories for a single time period, or a time series of values comparing two different categories.

Within-Category Change

Category currency can be measured using values of a single category from different time periods, as follows:

$$\Delta\phi(u)_{t1,t2} = \frac{\phi(u)_{t2}}{\phi(u)_{t1}} \quad (2)$$

In Eq. (2), values greater than 1 indicate that currency increased from the first time period to the second, while values less than 1 indicate a decrease in currency.

Between-Category Shifts

For two categories that are potential substitutes, category currency can also be measured relatively by comparing values for the different categories for the same time period. The relative currency of a potential challenger or upstart category (u) versus an established or incumbent category (i) can be calculated as the quotient of the two, as follows:

$$\Delta c(u, i)_t = \frac{c(u)_t}{c(i)_t} \quad (3)$$

In the case of calculators (u) and slide rules (i), for example, values greater than 1 would indicate that calculators have greater currency than slide rules.

Substitution Trends

The relative currency of two categories that could be substitutes for each other can also be measured over time as the slope of the line given by a time series of currency values computed using Eq. (3). For such lines, negative slopes indicate the focal category z has currency that is decreasing relative to the alternative y , and positive slopes indicate the focal category z has currency that is increasing relative to the alternative y .

ILLUSTRATION: THE RISE OF NANOTECHNOLOGY

To illustrate how the idea of category currency informs analysis of situations where the meaning of categories changes over time, we use it to describe two important developments in the emergence of nanotechnology. Nanotechnology is an excellent context for this purpose for two reasons. First, it emerged as a new field of research and development (R&D) from projects that blend elements of a wide variety of distinctly categorized disciplines in science and engineering. Second, while efforts to commercialize these have produced much talk about nanotech as an industry made up of several related market categories, neither the industry – or proto-industry, to be more accurate – nor its markets have yet fulfilled the of aims of the public policies that fueled its development as a field of R&D.

Coining a Term: Early Nanotech

In English, attempts to introduce a new word or phrase into the language have long been referred to as “coining” a term. The Oxford English

Dictionary credits an early use of the phrase to a late 16th century book on English poetry. Writing of “young schollers not halfe well studied”, the author lamented that they “seeme to coigne fine wordes out of the Latin, and to use new fangled speaches, thereby to shew themselves among the ignorant the better learned” (Puttenham, 1589, Chap. XXII). This swipe at neologisms presages Bourdieu’s argument that “generative discourse,” or the power to create new language, “lies not in the language itself but in the group which authorizes it and invests it with authority” (1977, p. 21). That is, coining a new term requires “symbolic capital” (Bourdieu, 1991). For Bourdieu, the ability to sell others on the use of a new term – to coin it, so to speak – “depends to a large degree on the objective structure of the relations between the interacting agents’ objective positions in the social structure” (Bourdieu, 1977, p. 25, footnote 31).

From this perspective, the rise of nanotechnology may owe something to the provenance of its name. The core idea behind nanotechnology can be traced back to a 1959 keynote speech given by Caltech physicist Richard P. Feynman to members of the American Physical Society. Entitled “There’s Plenty of Room at the Bottom,” Feynman’s talk extolled the possibility and benefits of “manipulating and controlling things on a small scale.” Although this idea became more reasonable with the advent of microelectronics, it was somewhat fantastical concept during times when computers occupied entire rooms. The actual label “nanotechnology” first appeared in a Taniguchi, 1974 conference proceedings paper by Japanese scientist Norio Taniguchi. Specifically, Taniguchi used the term to describe semiconductor processes such as thin film deposition and ion beam milling (Taniguchi, 1974). At a time when microelectronics and integrated circuits were still very new ideas, Taniguchi’s phrase suggested blending ideas that had previously been conceptualized as distinct domains. The prefix “nano” refers, of course, to the measurement prefix used to denote a scale of 10^{-9} . Even at that time, the properties of items at 10^{-9} m nature’s building blocks were still matter of speculation, theorization, and investigation, so the idea of manipulating remained at least a bit fantastical. The very idea of technology, on the other hand, is the manipulation of materials for some practical purpose.

The history of nanotechnology suggests coining a new term takes more than cleverness with words, however. The idea of nanotech gained traction in the early 1980s with several events that began to make nanoscale research plausible. In 1981, researchers at IBM Laboratories in Zurich, Switzerland developed the scanning tunneling microscope (STM). For the first time, the STM enabled scientists to see atomic-scale images. In short order, this led

to the ability to manipulate individual atoms on the surfaces of materials (Darby & Zucker, 2003). Inventors Gerd Karl Binnig and Heinrich Rohrer received the Nobel Prize in Physics only five years later in 1986. In that same year, another group of scientists invented the atomic force microscope (AFM), a tool that broadened the range of materials viewable at nanoscale and enhanced the ability to manipulate individual atoms and molecules. The AFM triggered tremendous growth in the microscopy of surfaces. Together, the STM and AFM offered powerful “enabling inventions” (Darby & Zucker, 2006).

At the same time, a best-selling book promoted nanotechnology to the status of a real word and established its related ideas as deserving of serious consideration. In *Engines of Creation: The coming Era of Nanotechnology*, author and MIT PhD student K. Eric Drexler extended ideas developed in an earlier scientific paper (Drexler, 1981) to reach nonscientists with what nanotechnology could mean for technology and society. Essentially a futurist treatise, this book promoted the viability and significance of nanoscale devices. Although Drexler waxed utopian in description of possible futures that read more like fiction than science, he had a profound influence on serious thinkers. This is somewhat remarkable since Drexler did not receive his PhD until 1991, and only then from MIT’s Media Lab, not from any program in natural sciences or engineering. Drexler’s power as a proselytizer had less to do with his status as a scientist and more to do with the fame he achieved as a popularizer. To leverage this fame and push the cause of nanotech, Drexler and partner Christine Peterson cofounded a futurist think tank called Foresight Institute in the same year that *Engines* was published. Through this organization, they spread faith in the nanotech message by facilitating conversations among researchers, investors, and policy makers in universities, industry, and government (Grodal, 2008; Thurs, 2007).

In nanotech’s early years, more established disciplines certainly had more legitimacy, but its valence wasn’t negative as such. Incoherence about what the label meant was a bigger problem. When would-be field pioneers coin a new term to refer to what they hope will be a new category of activity and a related field, the category gains currency only when public discourse about it coevolves with events and artifacts that build consensus about whether it is real and what it means. For nanotech, talk about it had to move from futurist fantasy to scientific specificity, and from fuzziness to sharper delineation about the category’s defining attributes and instances. While talk about the possibility of doing nanoscale work probably encouraged the developers of tools that enabled it become more real than imaginary,

the currency of the newly coined term grew with the development of tools like the STM and AFM because they provided clear anchors for the term – objects and activities it was uniquely well-suited to describe. If ideas about what nanotech meant had not been supported by the development of tools that made it seem more real, usage of the term would be more infrequent and less coherent. As a result, patent examiners, grant committees, journal reviewers, and the like would have placed less stock in the idea, so to speak, and scientists and scientific entrepreneurs would certainly see less benefit to designing and framing their R&D activities as being nanotechnology.

Making Change: From Coinage to Greater Currency

The 1990s saw changes that distanced nanotechnology from the more fantastic visions popularized in the futuristic writings of Eric Drexler, and MIT-trained scientist whose early scientific articles and popular books writings earned him controversial notoriety among scientists and public recognition as the new field's most visible spokesperson (Drexler, 1981, 1986; Drexler, Peterson, & Pergamit, 1991). Drexler's vision of nanotechnology featured tiny autonomous machines capable of repairing the human body, eliminating unwanted pests, or building structures of enormous size and complexity. And, thanks to the power of simple principles, this would happen all without direct control, much as chemical processes work. Especially for the scientifically curious, the concept of "nanobots" entered the public imagination as a fanciful but comprehensible term.

To get taken seriously as a research and development enterprise, scholarly participants in the emerging field began to voice the feeling that nanotech needed to be more about contemporary research and development and less about utopian visions of the future. In particular, Nobel prize-winning chemist Richard Smalley was a vocal and influential advocate for this point of view. Whereas Smalley shared Drexler's belief in the potential of nanotechnology to benefit humanity, Smalley did not think much of Drexler's vision of molecular assemblers. Moreover, he worried that the image of microscopic robots would fuel unfounded fears about the potential dangers of nanotechnology and hence threaten public support for it. In a now-famous debate with Drexler, Smalley wrote:

You and people around you have scared our children. I don't expect you to stop, but I hope others in the chemical community will join with me in turning on the light, and showing our children that, while our future in the real world will be challenging and

there are real risks, there will be no such monster as the self-replicating mechanical nanobot of your dreams. (Baum, 2003, pp. 10–11)

At the same time, Smalley became a leading proponent of a coordinated national research effort in nanoscale science and technology. His vision of nanotech was influenced by his work on carbon nanotubes, a material that was then quite new and still in search of applications. Thus, we see in Smalley's work both the "from" and "to" states that marked nanotech's move out of its nascent period into a period of rapid growth: from fantastic promises based on futuristic nanobots to smaller more tangible developments based on technologies already poised to make the leap from lab to fab, so to speak. As these competing interpretations of nanotechnology vied for recognition as the real thing, Drexler's vision lost ground to Smalley's. Just as Fligstein (1996) argues that shared conceptions of markets are subject to the politics of meaning-making contests, the emergence of fields like nanotech is also subject to debates that become quite political. In 2003, *Wired* magazine summed up this contest as follows:

This should be Eric Drexler's moment in the sun. Instead, his colleagues are treating him like the crazy uncle in the attic. Nanotechnology, the field Drexler helped kick-start, has become a far-flung, multibillion-dollar discipline, sparking innovations in medicine, consumer products and pure science. But most of today's nanotech specialists say Drexler's vision of molecule-sized robots is science fiction, not science fact.

For working scientists, therefore, nanotech gradually changed to mean something quite different from the big ideas in Drexler's books. As materials scientists long concerned with things that happen at a molecular scale began to use the new term, reframing their work as nanotechnology, their successes in winning research funding solidified an alternative conception of nanotech. Rather than autonomous nanobots, this new conception emphasized materials with special but explainable properties. Overall, the field moved from being a newly coined term with little else to show to a growing research enterprise that started to attract serious scholarly interest – and serious financial backing. In the process, the nanotech concept and related category gained greater currency.

Cashing In: Nanotech's Coming of Age

By the late 1990s, the success stories of nanotech's pioneers were attracting a much larger wave of followers looking to cash in on the funding opportunities associated with the burgeoning field's accelerating growth.

Through the gradual accumulation of grant proposals, funding decisions, and articles published in scientific journals and the business press about R&D and efforts to translate them into practical products and for-profit ventures, the changing public discourse both reflected and created a new “theory of value” (Zuckerman & Rao, 2004). Increasingly, scholars from a variety of traditions are recognizing that theories of value are constructed and legitimated discursively (Phillips & Hardy, 2004), and that the process of determining and institutionalizing these theories of value is essentially a process of categorization (Khaire & Wadhvani, 2010).

In addition, US Federal government agencies launched several high-profile initiatives and programs focused on encouraging nanotech R&D, and these programs legitimated nanotech not only as a field that had truly arrived, but one that could be expected to grow rapidly. In 1999, the Clinton administration approved and announced the National Nanotechnology Initiative (NNI). In 2005, the USPTO announced a new classification for nanotechnology patents in 2005 – patent class 977. Class 977 now serves as a cross-reference to help examiners and investors search the prior art, and the USPTO is now reclassifying pre-2005 patents that meet the definition of nanotechnology. In 2003, the US National Institutes of Health (NIH) outlined a plan to formalize support for interdisciplinary research, including special training and the establishment of interdisciplinary research centers (Zerhouni, 2003). Each of these moves reinforced the legitimacy nanotechnology had already gained from the increasing diffusion of nanotechnology as a label used to describe grant proposals. From the mid 1970s to the year 2000, the number of granted patents that could be roughly categorized in hindsight as fitting the emerging nanotech field grew from a handful per year to just over 20,000 per year.

Consistent with neoinstitutional theory, these gradual developments combine with formal events to give nanotechnology status of a field widely accepted not just as a legitimate concept but also as a real and ongoing enterprise. Following the familiar two-stage model of diffusion developed in institutional theory (Tolbert & Zucker, 1983), the growing adoption of nanotech as a way to describe R&D gradually legitimated the field so that, in time, doing nanotech-like work without positioning it as nanotech meant risking being overlooked or dismissed for not fitting the new category of research (Zuckerman, 1999). Although positioning R&D as work in nanotechnology was a potential threat to the legitimacy of scientists keen to be seen as serious researchers, it was also an opportunity for the social gains that come with being seen as a field pioneer (Kennedy & Fiss, 2009). While the early days of a field like nanotech present opportunities for field

pioneers to shape what the field's defining category and identity will mean, successful field formation should eventually create pressures for conformity that foreclose these opportunities (Lounsbury & Glynn, 2001). As empirical support for this proposition, Kennedy (2008) showed that trying to shape the market category by suggesting connections to other producers went from having positive to negative effects on survival.

From humble beginnings as an idea in search of a name, therefore, nanotech made a number of important transitions that collectively boosted the growing currency of the nanotechnology label, the category of research it referred to, and the related organizational field. From a newly coined term in search of work to which it could refer, the meaning of the term became more coherent with enabling technologies that made nanoscale work practically feasible. With the emergence of these technologies and related visions of what they could support, nanotechnology came to be associated with grand promises that captured the imagination of both the public at large and, crucially, working scientists. As scientists began to use the nanotechnology label to describe and categorize their work, grand promises gave way to concrete R&D breakthroughs. In time, the breakthroughs went from being materials and processes in search of practical applications to, at last, commercial products developed around nanotech-inspired R&D.

APPROACHES TO MEASUREMENT

Following Jepperson and Swidler (1994), we view the task of measuring meaning as no more challenging than measuring other elements of culture, and we thus argue that meaning coherence can be measured empirically using any of a number of approaches for assessing audience consensus about what category labels mean. At the intersection of cultural and structural sociology, for example, Mohr (1998) offers an approach that emphasizes the analysis of relational data to assess similarity. Paraphrasing Mohr's framework, we suggest meaning of category labels can be modeled using data about relations among synonyms, instances, and attributes. When modeled as graphs, further refinement of these models of meaning can be obtained by interacting them. For example, a two-mode graph of relations between instances and attributes can be multiplied by its transpose to give a one-mode map of category instances where links and clusters are based on having similar attributes. While the relational data needed for such analyses can be obtained by survey as marketers commonly do, a more practical approach to gathering longitudinal data is to extract relations from

media discourse that reflects and shapes what market audiences are seeing (Rosa et al., 1999). In a study of computer workstations, Kennedy adapts this technique to measure the changing coherence of category meaning as the saturation density of relations among producers (category members) based on media co-mentions (Kennedy, 2009). This analysis strategy also fits in with recent organizational research that stresses the role of the media in shaping the meaning of offerings and markets (Pollock & Rindova, 2003; Rao, Greve, & Davis, 2001).

As a complement, Green, Jr. and colleagues (Green, 2004; Green, Li, & Nohria, 2009) offer an approach to the meaning and cultural significance of new ideas that build on rhetorical theory. In a study of the diffusion of TQM, they blend rhetorical theory and structural sociology to show that the status of meaning can be seen through the gradual collapse of justification arguments that are increasingly taken for granted as new ideas diffuse and institutionalize. That is, as a new and unclear idea first appears, arguments that justify its value typically feature all three elements of a syllogism: a major premise, a minor premise, and the inferred conclusion. As ideas become clearer and more accepted, however, the argument structure collapses with its institutionalization, and the pieces of the argument co-occur with the term less and less often.

In this spirit of these efforts, we propose general approaches for measurement of coherence and valence, fully expecting that empirical work will refine these proposals.

Coherence

In the early days of a category such as nanotechnology, the options for measuring coherence are limited: it requires collecting and analyzing discourse that discusses the concept to extract patterns of association among terms that define it – a technique generally referred to as relational content analysis (Carley & Palmquist, 1992). While one can use a qualitative inductive reading of collected discourse to determine which terms to associate, techniques for information search and retrieval can also be used to identify unique terms the co-occur with the category label. Either way, extracting category maps from the text requires the use of text-mining techniques (Carley et al., 2009; Carley, 1997; Carley & Diesner, 2005). Given human cognitive limitations, the number of attributes essential to defining a category must be small – generally on the order of short-term memory. If attribute co-mention graphs are extracted and analyzed, coherence should

be associated with increasing density and an increasingly stable ordering of eigenvector centralities for the defining attributes.

Later, widespread category acceptance generally brings new options for measuring coherence. For example, growth in National Science Foundation (NSF)'s interest in nanotech research eventually led to programs and initiatives to catalog the characteristics of nano-related research. These programs have facilitated the collection and analysis of, for example, data on nano-related patents and grant applications. As with the relations among co-mentions of attribute labels, the unfolding category meaning can be seen in changing patterns of, for example, the classes of prior art combined in patents.

Valence

As with coherence, measuring appeal can be done through standard marketing surveys, but measuring appeal over time requires panel data for periods that often make survey methods impractical, if not impossible. When longer analysis periods are required, the relative appeal of an offering can be measured through crude proxies such as differences in quantities sold, price, or, for some industries, the number of distributors or competing producers. In markets mediated by powerful critics (Hirsch, 1972), however, critics' ratings may provide more direct measures of audience appeal (for example, see Hsu, 2006a; Negro, Hannan, Rao, & Leung, 2007). With the advent of the Internet, ratings are available from both critics and customers for an increasingly wide array of goods and services (Koçak et al., 2009; Leung, 2009). Such ratings provide evidence that is useful for detecting category change. When the ratings of a particular type of product increases even though it does not unambiguously fit an established category scheme, the category's meaning is most likely changing (Negro et al., 2007). Thus, we see the use of ratings as a particularly desirable measure for the appeal of offerings.

Compared to fitting into a clearly established category, conforming to a nascent category in its very earliest days is not likely to be viewed as positively. Drawing on institutional theory and organizational ecology suggests two ways to measure this.

First, recognizing the legitimating effects related to the growing adoption of a new idea (Tolbert & Zucker, 1983), numerous studies have treated increasing counts of various types of practices or organizations not only as evidence of their legitimation, but also as a factor that contributes to legitimation (see Carroll & Hannan, 2000). Consistent with this tradition, the increasing count of category's membership – its density – can be used as

a measure of its valence that, though simple, is often both practical and convincing.

Second, Hannan et al. (2007) propose category contrast as a construct for measuring the degree of separation or overlap between a focal category and relevant alternatives. When contrast is low, the benefits of conforming to an established category are also low, and when contrast is high, the value of conformity is also high. In effect, changing contrast thus reflects whether a category is understood as gaining or losing positive appeal. That is, changing contrast provides a way to measure changing valence. For illustrations of measurement, Negro, Hannan, and Rao (2010) use category contrast to explain critics' ratings of fine Italian wines. They find that critics give higher ratings to wines that clearly belong to an established category, but as offerings that span multiple categories grow in number and market significance, they blur the definitions of the categories drawn on and lower the contrast between them.

IMPLICATIONS

When nanotechnology was no more than a newly coined term for an imaginatively conceived but not yet realized category of R&D, positioning work as "nanotechnology" was hardly a formula for attracting serious money or credibility. As new technologies enabled more of what people imagined nanotechnology could be, serious scientists began to use the label to explain their proposed research to funding agencies. Their efforts helped change the meaning of the newly coined term, turning nanotechnology into an idea that became helpful to scientists seeking research funding. As this change became apparent to scientists, university administrators, and government officials, the category's currency increased still more. As US government agencies and programs came to see nanotechnology as a potential source of economic growth and comparative advantage, positioning new projects as nanotech-related became a way for researchers to cash in on the strong and growing interest in this category of R&D. That is, nanotechnology became a "hot" category of R&D.

For Theory

What category currency offers to organization theory is a simple logic for qualifying the idea that market audiences value goods or producers more

highly when they more clearly conform to a known category. Specifically, this relationship depends on how clearly the category is defined and whether it is seen as positive or negative. Thus, as we have defined it, the two components of category currency are the coherence of a category's meaning and its valence – that is, whether category members are seen negatively or positively. To put it simply, category currency reflects the degree to which the relevant audience sees a category as hot, or not, and categories that are very hot cannot be expected to remain so in perpetuity. In the long run, even the hottest categories – those with the greatest currency – can be expected to cool down, or lose currency.

This move to qualify the value of conformity is inspired by the distinctive perspective of social movements research, which is that institutions can and do move. More specifically, they move with the purposeful efforts of savvy organizers, but there are limitations to movement. Noting that cultural and political institutions vary in their vulnerability to challenge and change, scholars talk about the need to understand “political opportunity” and “open moments” for policy change (Gamson & Meyer, 1996; Kingdon, 1984). In the absence of such opportunity, social movement organizers fight uphill battles in their struggles to mobilize resources and lobby for change. This is because political opportunity is essentially the degree to which cultural toolkits offer elements activists can credibly combine to argue that their ideas should be legitimate (Clemens & Cook, 1999; Clemens, 1997).

To explain differences in political opportunity, Gamson and Meyer (1996, p. 281) offer a framework for understanding sources of power in terms of their stability versus volatility (1990) and whether they are grounded in informal aspects of culture or formal institutional supports. In the resulting map of various constraints and enablers of political opportunity for change, they place “ideas in good currency” in the list of sources of authority that are more volatile than stable and more informally than formally protected.

Explaining the changing value of conformity with a particular environment reflects a number of theoretical themes in this volume. Bogaert, Boone, and Carroll (2010), for example, update ecology's density dependence thesis by accounting for both partial membership in multiple categories and movement between them. While their study of Dutch accounting demonstrates the appeal of this approach in a situation where there are competing associations for a single profession, this approach can be generalized to consider cases where elements of several complementary domains are combined to make a single new one whose appeal eventually eclipses that of its parent domains. In such a situation, the idea of category

currency would help explain how conforming with the previous generation of identities, so to speak, declined in value compared to fitting in with more current categories. Similarly, Kahl, Kim, and Phillips (2010) show in their study of jazz that the sequence of cross-category combinations affected both the emergence of a canon and the works that fit it best. Interestingly, our case study of nanotechnology's rise suggests the sequence of combinations mattered in that context, too.


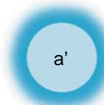


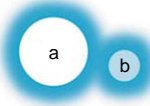
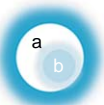
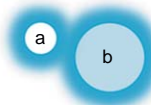
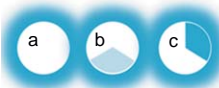

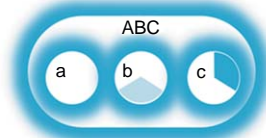
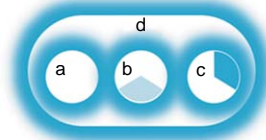
In a variety of contexts, we suggest the changing value of conforming to a focal category becomes clear by comparing its currency to that of a plausible alternative, and clearer still in comparisons made over a time period large enough to capture trajectories. The appropriate time period varies by industry, of course. In market categories for fine wines, for example, currency changes much more slowly than in market categories for high technology products such as computers or consumer electronics. In slow-changing markets or industries, deviating from established categories may present greater risk than competing by contesting and defending positions that fit established market categories. In markets or industries where categories are more volatile and not subject to regulatory control, however, strategies that stay within established categories may entail greater risk than those that involve blending elements of multiple categories or proposing new ones.

Nanotechnology is a case that emerged from the blending of elements of multiple categories. As scientists repeatedly blended elements of other disciplines in similar ways and were rewarded for doing so, the term gained coherence and valence. That is, people's ideas about what it meant became increasingly similar, and they came to see it as increasingly valuable. This pattern of category change is basically what Powell (1991) called recombination. As a category like nanotechnology comes together by blending elements of existing fields, the disciplines its key elements are drawn from need not lose any currency, at least in an absolute sense. When a category like nanotechnology becomes hotter than the categories it draws its key elements from, however, its currency may be greater than the currency of the categories it borrows from.

For Study Design

Such recombination, or blending of elements of other categories, is but one of many ways categories can change meaning and currency that future research should explore. Table 1 presents an array of eight cases to consider

Table 1. Eight Ways Category Meaning Can Change.

| Focal Categories (Time 1) | | Alternatives for Consideration (Time 2) | |
|---------------------------|---|---|---|
| | | 1 | 2+ |
| 1 |  |  1. Redefinition |  2. Subdivision |
| | | |  3. Subtraction |
| 2 |  |  4. Subsumption |  5. Substitution |
| 3+ |  |  6. Recombination |  7. Conglomeration |
| | | |  8. Incorporation |

Notes:

1. Lower case letters denote labels for category abstractions; upper case letters denote named entities.
2. A letter followed by an apostrophe denotes a new meaning for the label referred to by the letter.

when designing comparisons to analyze relative in the relative currency of a focal category scheme versus a plausible alternative. The left- and right-hand columns contain the focal and alternative category schemes, respectively. The focal scheme represents a baseline, initial or traditional understanding, and the alternatives represent schemes that could attain greater currency over time. Because category meaning can change either by changes to a single category or to multiple categories, the rows of Table 1 organize the cases based on the number of categories in the focal, or baseline, schemes. To make discussion and explanation easier, the cases are named and also numbered 1–8 from left to right, top to bottom. The following paragraphs explain the cases briefly and provide examples that illustrate them.

The first row of Table 1 contains three cases that all involve changes to a single category. In order, case 1 is redefinition, a change in which a single category shifts meaning. Next, case 2 is subdivision, a change in which a single category morphs into two variants. Next, case 3 is subtraction, a change in which a single category is divided into two categories by removing part of the baseline category and treating it as a category unto itself. To illustrate with examples from the business of computers, the personal computer (PC) category was redefined with the shift from command line to graphical user interfaces. In another important change in meaning, the PC category subdivided into desktop and portable categories, and it changed again by subtraction as small flash drives and email-based file exchange have led to the phasing out of removable media such as floppy disks as a standard component of a PC.

The second row contains cases involving changes to the meaning of two related categories. Case 4 is subsumption, the situation where one category is absorbed or subsumed into another. Case 5 is substitution, the situation where one category expands at the expense of another that shrinks; we use the word substitution because this change often results from substitute relationships between the two product categories and related product markets. These cases can also be illustrated with examples from the technology world. In personal computer software, word processing applications and spell checkers were once separate applications, but over time, the meaning of a word processing application has changed so that people expect it to include spell-checking functionality. The fact that sales of portable or laptop PCs have begun to outpace and displace sales of desktop units reflects a substitute relationship between the two product categories. If trends continue as some experts predict, desktop PCs could continue to erode as a category as they lose currency to laptops.

The third row of Table 1 contains cases involving categories built from three or more categories, or elements thereof. Case 6 is recombination, the situation where elements of three categories are combined to make a single new category. Case 7 is conglomeration, the situation where three or more categories are put together while preserving rather than dissolving the contributing categories. Case 8 is incorporation, the situation in which three or more categories are incorporated into a single new category by dissolving rather than preserving the individual definitions of the contributing categories. To illustrate these cases, we sum up the nanotechnology case and add a few examples from technology. Smartphones can be seen as the recombination of elements of personal computers, mobile telephones, and music players. The Microsoft Office suite of products is a conglomeration of word processing, spreadsheet, presentation, and email applications; that is, it is a portfolio of products seen both as separate categories and as a new kind of unit together even though they are sold separately less and less of the time. Finally, word processing software can be seen as incorporating not only spelling- but also grammar-checking applications that were previously produced and marketed as separate tools in their own product market categories.

For Practice

The cases of category change described and illustrated above and in Table 1 help explain events of consequence in practice. In the late 1990s, for example, Microsoft was sued for antitrust violations related to its intent to bundle Internet browser functionality into its Windows operating system. That is, Microsoft wanted to subsume browser functionality into an expanded definition of operating system software, but given Microsoft's monopoly power at the time, many regarded this change to the operating system category as illegal bundling with the intent to monopolize. As a result, the government intervened to protect the browser category and prevent it from being rolled into operating systems.

In the last decade or so, however, these category meanings have shifted in the expansive directions Microsoft was pushing them. For example, Internet browsing has become an increasingly standard and completely integrated capability of the operating systems of so-called smartphones. For computers, a browser is still thought of as an application and there are multiple browsers available for most operating systems, but it is hard to imagine a computer today without a browser. As browsers become

more central to computer use, the legacy of categorizing them as a distinct category of software is gradually becoming strange to those too young to remember Netscape, the original web browser application and the plaintiff that brought the antitrust suit against Microsoft. With these developments, hindsight makes Microsoft's then-controversial plan seem at least a little more reasonable.

CONCLUSION

Focusing on category dynamics is especially important and interesting because it has the promise of contributing to a revival and flowering of institutional ecology. Given the natural affinities between institutional and ecological approaches to organizational analysis (e.g., Stinchcombe, 1965), the longstanding impasse between neoinstitutionalists interested in processes of cultural meaning construction and organizational ecologists focused on developing a more approach to the dynamics of organizational forms and market niches (Baum & Powell, 1995; Carroll & Hannan, 1995), now over a decade long, has had an unfortunate chilling effect on the possibility of fruitful interactions between the two. In our opinion, the shared interests in category dynamics among ecologists and institutionalists make the controversies thin versus thick approaches to legitimacy anachronistic. The development of our ideas on category currency is, in part, motivated by optimism for the prospect of cultivating a more cosmopolitan institutional ecology. This will require a new wave of scholarship that bridges the conceptual divides and social distance among different research communities through more synthetic conceptual and methodological development.

The unifying challenge facing this convergence of common interests is clear. To the idea that markets and organizations are shaped by categorization and meaning construction processes, many scholars react with a protest that echoes the logic of Shakespeare's oft-quoted line, "A rose by any other name would smell as sweet." That is, they argue that a category by any other label would be as valuable, or as worthless. At the very least, the idea of category currency suggests this should be an empirical question. To be a little bolder, we suggest that categories with rising currency sweeten reactions to items that fit them, and declining currency undermines the previously more positive value of conforming to them.

More broadly, the cases and illustrations above illustrate two important truths worth emphasizing. First, changes in the meaning of the various categories used to understand the world are essential to stories of epic changes

in science, technology, and society more generally. Whether it is the development of a highly technical field like nanotechnology or an extremely non-technical field like feminist studies, changes in category meaning are important to both the construction and recognition of new ideas that can and do change the world as we know it. To be clear, this is true not only of fields based on the shifting meaning of categories used to parse them, but also of types of markets, organizations, and products; political parties, social movements, and issues; eras of history, intellectual movements that define them, and concepts; and schools of music, art or literature, the genres that define them, and individual works of art. Second, smaller changes to categories are happening all the time, and their cumulative effect can be extremely consequential. Organizations flourish when they go long in market categories whose currency is on the rise while shorting those on the decline, and vice versa. The same can be said for scientists, politicians, academics, and artists. It is our hope that the idea of category currency makes it easier to see and study the causes and consequences of these two truths.

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