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BEYOND A BETTER MOUSETRAP:

A CULTURAL ANALYSIS OF THE ADOPTION OF ETHANOL IN BRAZIL

LUCIARA NARDON

Luciara.Nardon@vlerick.be

KATHRYN ATEN

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LUCIARA NARDON
Vlerick Leuven Gent Management School
KATHRYN ATEN
Charles H. Lundquist College of Business, University of Oregon

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Contact:
Luciara Nardon
Vlerick Leuven Gent Management School
Tel: +32 16 24 88 35
Fax: +32 16 24 88 00
Email: Luciara.Nardon@vlerick.be

ABSTRACT

Complex technologies develop within technological systems, which include, in addition to discrete technologies, organizations such as manufacturing firms and investment banks; scientific elements, such as teaching and research programs; and legislative elements, such as regulations. The tangible aspects of such technologies do not alone determine their end configuration or success; rather, social and cultural practices, expectations, and relationships influence the development of technologies just as technologies influence these factors. We argue that culture provides actors with logic principles with which to construct action, influencing the trajectory of the technological system development, in a reinforcing system of path dependency. We analyze the case of ethanol adoption in Brazil and find that Brazil's adoption of an ethanol-fueled transportation system derives from a pattern of adaptation in response to salient issues. We argue that a unique characteristic of Brazilian culture, the Brazilian *Jeitinho* - a logic of action of adaptation - influenced the development of the Brazil's ethanol-fueled transportation system.

BEYOND A BETTER MOUSETRAP:

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> "*Brazil will be the largest supplier of renewable energies in the 21st century… We will no longer talk about prospecting petroleum; we will talk about planting petroleum"*
> *Luis Inacio Lula da Silva, Brazilian president (Exame, April 07, 2006)*

The world is currently facing an energy crisis. There is a growing realization that fossil fuels contribute to global warming and may be close to depletion. Additionally, nations lacking substantial petroleum reserves are increasingly concerned about the security implications and economic costs of petroleum fuels. At the same time, experts estimate that worldwide energy demand will grow by more than 50% by 2025 (Ragauskas et al., 2006). Alternative fuels, many requiring the support of compatible technological systems, will be required. As the world struggles to find a solution, Brazil has emerged as a leader in ethanol production and utilization. In 2005, ethanol accounted for 40% of Brazil's fuel consumption, whereas in the U.S. and the EU it accounted for only 2% of the fuel market (Ragauskas et al., 2006). Brazil currently produces 18 billion liters of ethanol a year and exports 4 billion liters. Given the complexity of the technological system required to produce, distribute, and use pure ethanol as a fuel it is unlikely that any other country will catch up with Brazil in the near term (*The Economist*, 2007). Currently, the U.S. is producing ethanol at comparable levels but pure ethanol is available in only a few hundred gas stations, primarily in the Midwest, and analysts speculate that it would take decades before the level ethanol adoption in the U.S could equal that of Brazil (CBS News, 2006).

Brazil's lead in ethanol utilization is surprising. Both conventional wisdom and extant literature suggest that Brazil is an unlikely innovator or early adopter of technology. Brazil's consistent failure to invest in the future is illustrated by the prevalent adage "Brazil is the country of the future and it always will be" (*The Economist*, 2007). This tendency suggests that a long-term development strategy focusing on ethanol is unlikely. Brazil is also criticized for its lack of environmental concern and destruction of the Amazon rainforest, suggesting that ethanol adoption is probably not the result of a long-term concern for the environment.

Technology researchers attempting to explain why and how a particular form of technology becomes dominant have traditionally viewed technology evolution as an efficient, linear process. From this perspective, the development of Brazil's ethanol-fueled transportation system would have required a long-term perspective and coordinated investment in the many linked elements of the system. This would likely have required heroic leaders or technological visionaries. Yet, history illustrates a tale of short-term reactions, policy reversals, suboptimal choices, accidents, luck and coincidences. Brazil's adoption of ethanol cannot be explained as a triumph of leadership or visionary policies or as the outcome of the rational expectations model. This begs the questions "How and why has Brazil emerged as a leading adopter of ethanol?"

When considering this question, it is important to recognize that Brazil's utilization of ethanol required the adoption of a technological system rather than the adoption of a single, discreet technology. Technological systems, such as the one involving ethanol, encompass many elements. These elements include organizations such as manufacturing firms and investment banks; scientific elements, such as teaching and research programs; and legislative elements, such as regulations in addition to discrete technologies (Hughes, 1983). The development of the ethanol industry in Brazil, for instance, required ethanol distilleries, ethanol distribution systems, and an automotive fleet adapted to ethanol utilization as well as capabilities and technologies to support the production of the raw material, sugar cane.

The development and adoption of technological systems has received limited attention in the management literature. Researchers have shown that path dependency created by technological systems influences the development of technologies (Dosi, 1982; Tushman & Anderson, 1986; Utterback, 1994), but we know little of how or why technological systems are adopted. Nevertheless, the evolution and structure of a technological system influences the trajectories of the individual technologies that make up the system and thus has a great influence on the focal questions of technology research.

Some recent conceptions of technology evolution suggest that technologies result from many possible paths, which are the object of political maneuverings and conflict. Technologies are embedded in an institutional environment such that social practices, expectations, and relationships influence the development of technologies just as technologies influence these factors (Garud & Karnoe, 2003).

Complex technological systems such as transportation systems have national consequences, suggesting that political and institutional forces will have an even greater influence on technological systems development than on discrete technologies (Tushman & Rosenkopf, 1992). Governments become involved in standard setting and constituent groups attempt to influence government actions. In other words, the adoption of technological systems is a collective effort.

Consonant with this perspective, we argue that technologies and technological systems are embedded in national culture. If the ultimate use of a technology is preordained by its attributes, then technologies and technological systems should develop along similar trajectories in all countries. However, they do not. For example, governments, industries, advocate groups and consumers world-wide are currently considering and discussing several alternative solutions to petroleum shortages. Among fuel alternatives, there are electricity, hydrogen, and bio-fuels such as ethanol (*Business Week*, 2006). Different forms of ethanol are being pursued in various countries. In addition, there are also conservation alternatives, some of which rely on technological developments, such as fuel-efficient cars and public transportation systems.

With a few exceptions, (i.e., Garud & Rappa, 1994; Hargadon & Douglas, 2001) most management research ignores the creation of macro systems and the interaction of technology, organization, and national cultures (Constant II, 1987; 241). The dearth of studies in this area justifies exploratory research. Brazil's unique adoption of ethanol given the widespread nature of the problem, the existence of alternative solutions, and Brazil's unlikely emergence as a leader in ethanol production and utilization makes it an extreme case of technological systems adoption supporting a case study (Yin, 1984). Building on prior research on technological systems and technology adoption, we undertake a case study of Brazil's adoption of an ethanol-fueled transportation system to explore the role of culture in the adoption and evolution of technological systems.

The process culminating in Brazil's leadership in production and utilization of ethanol is illuminating. It suggests that persistent, culturally embedded "logics of action" (DiMaggio, 1997) shape the evolution of technological systems.

The case also highlights the relevance of unique, rather than general, cultural characteristics in explaining national interpretations and actions. In the case of Brazil, we argue that a unique cultural characteristic termed *jeitinho,* meaning "flexible adaptation," is more explanatory than general cultural dimensions.

We begin this article with a review of relevant literature on technology adoption and culture influences on technology. We then present the case of ethanol adoption in Brazil. We conclude with an analysis of the case and discussion of the role of culture in shaping technological systems.

TECHNOLOGY DEVELOPMENT AND ADOPTION

The question of how and why certain technologies are adopted has received attention from scholars from diverse fields, approaching the problem from various perspectives and exploring multiple levels of analysis. Management scholars have explored technology cycles and radical innovations (Tushman & Anderson, 1986; Utterback, 1994), and organization and network characteristics influencing technology adoption by organizations (Majumdar & Venkataraman, 1998; Suarez, 2005). Information and communications technology scholars have sought to identify characteristics leading to the adoption and use of particular information technologies (Davis, Bagozzi, & Warshaw, 1989; Rogers, 1995). This research has traditionally focused on the functional and economic advantages of new technologies.

However, recently management scholars have called for research exploring wider institutional and societal influences on the adoption of new technological systems, arguing that traditional explanations neglect the social embeddedness of the process through which technologies become accepted (Garud & Rappa, 1994; Garud, Jain & Kumaraswamy, 2002; Hargadon & Douglas, 2001). These researchers adopt a constructionist perspective suggesting, in contrast to traditional arguments, that the tangible aspects of a technology do not alone determine its end configuration or success. Rather, social and cultural practices, expectations, and relationships influence the development of technologies just as technologies influence these factors (Bijker, 1995; Pinch & Bijker, 1987). Thus, the relationship between technology and culture is bi-directional.

Alternative paths of technological development exist and the initial interpretations of the uses and meanings, problems to be solved and desirable solutions related to a technology are flexible. Although in hindsight its development may appear to be inevitable and determined by efficiency, the observed configuration of an existing technological system is but one of many possible configurations. This perspective suggests the importance of institutions including national culture in the development of technological systems. However, while researchers have alluded to the importance, and in one case called for greater exploration, of the role played by national culture in technology adoption (Garud & Karnoe, 2003; Kedia & Bhagat, 1988) this aspect of technology adoption has been explored only in studies of consumer and organizational adoption of information technology.

NATIONAL CULTURE AND TECHNOLOGY ADOPTION

Researchers seeking to identify the factors leading to the adoption of information technology by individuals and organizations have begun to explicitly explore the role of both institutions and national culture. These scholars have argued that the adoption of more complex technological systems, such as the internet, cannot be adequately understood without an analysis of the role of society and culture because, by definition, technological systems are collective creations (King, Vijay, Kraemer, McRarlan, Raman, & Yap, 1994; Montealegre, 1999). In other words, the adoption of technological systems is a collective, rather than individual process. However, while a handful of empirical studies support the importance of national culture in technology adoption, researchers have not yet focused on the role of national culture in shaping the adoption and development of entire technological systems.

In an empirical study of Chinese industries' adoption of foreign technologies, Phillips, Calantone, and Lee (1994) found that cultural affinity—the degree to which the rules, customs and communication of a foreign culture resemble the usual way of doing business in the home culture—(Phillips et. al., 1994), is an important predictor of the acceptance of foreign technologies. Yap and colleagues (Yap, Das, Burbridge, & Cort, 2006) utilized Hofstede's (2001) cultural dimensions to explore how characteristics of national culture influence the adoption of e-commerce finding that countries with stronger acceptance of uncertainty, greater emphasis on relationships, and higher individualism are more likely to adopt e-commerce technologies. While these findings suggest the importance of the role played by culture in the adoption of technology, they fail to elaborate on the constructive process of the adoption and development of technology suggested by scholars of technological systems. In a study of computer technology adoption in Saudi Arabia, Al-Gahtani (2003) comes closer to addressing this question. Drawing on Rogers (1995), Al-Gahtani finds that compatibility—the degree to which an innovation is perceived as consistent with the existing socio-cultural values and beliefs, past experiences, and needs of potential adopters—has a significant, positive effect on the adoption of computer technology.

These studies support the argument that national culture significantly influences technological systems adoption and should be considered when seeking understanding of how and why technological systems are adopted. However, our knowledge of the role of national culture in technology adoption is severely limited. First, very few studies directly explore the relationship between national culture and technology adoption. While a few researchers exploring the socio-political aspects of technological systems adoption allude to the likely influence of national culture, they do not explore it directly. Researchers who do explore the role of culture in technology adoption directly, have tested the influence of general cultural characteristics on the adoption of information and computer technologies but, other than noting their importance, have neglected technological systems.

In consonance with the recent conceptions of technology development, we assume that the adoption of an ethanol-fueled transportation system in Brazil is not solely a reflection of the intrinsic characteristics of ethanol, but a result of the interaction between the technological system that encompasses ethanol and the economic, institutional, political, social, and cultural environment of Brazil.

While acknowledging that the development of the technological system encompassing ethanol has been influenced by economic pressures, political maneuvering, and a unique institutional environment, we follow Denzau and North's (1993) argument that the institutional, economic and political environments in which technological systems are embedded are strongly influenced by ideology and culture. Given this, and the dearth of studies on the topic, we focus our analysis on the role of culture in shaping the adoption of technological systems.

RESEARCH DESIGN

Our objective is to explore the neglected role of culture on technological systems adoption. We do not claim to develop a full-fledged theory. Rather, we seek to provide observations that may form the basis for a conversation among technology and culture scholars. As researchers have recognized, social practices, expectations, and relationships influence technological development just as technology influences these factors (Garud & Karnoe, 2003). This magnifies the complexity of the process of technological adoption and evolution. This complexity suggests that naturalistic inquiry is an appropriate way to investigate the phenomena (Garud, Jain, & Kumaraswamy, 2002). Following this approach, we explicate the unfolding of events by tracing their historical roots using inductive logic (Garud, Jain, & Kumaraswamy, 2002).

We selected the case of Brazil's adoption of an ethanol-fueled transportation system purposively. As nations struggle to decrease petroleum consumption, Brazil has emerged as a leader in ethanol production and utilization. Brazil's leadership is both unique—few countries are even close to Brazil—and surprising. The uniqueness of the case suggested it would be revelatory (Yin, 1984), providing insights into the role of culture in technological systems development. Additionally, the current worldwide interest in alternative fuels and in Brazil's use of ethanol makes the phenomena accessible and "transparently observable", making this case a particularly valuable research setting (Eisenhardt, 1989, Pettigrew, 1990).

We collected data from newspapers, magazines, academic publications, and specialized web-portals utilizing snowball sampling of an internet Google and Yahoo search. Snowball sampling is a multistage procedure through which an initial sample of a specific population whose members are difficult to locate "snowballs" into a much larger sample (Hoyle, Harris, & Judd, 2002). For this project, we took a small, initial sample of the coverage of ethanol available on the internet then collected additional reports and articles mentioned in the initial sample. The data included reports from the Brazilian and international media, the Brazilian government, trade journals, the World Bank, Brazilian trade groups, and academic publications. We continued to collect data in this manner, allowing information gathered from one search to guide subsequent searches, until we reached theoretical saturation. This sampling technique takes advantage of the Google search algorithm that ranks pages on relevance based on the number of links attributed to this page and the importance of the pages linked to it (Google, 2004).

We employed several "sensemaking" strategies described by Langley (1999) and Miles & Huberman (1994) to conduct our analysis. First, we constructed a detailed story and chronology. The chronology provided grounding and an overall understanding of the case. Next, we identified key events in the development of Brazil's ethanol-fueled transportation system. We defined key events as occurrences that garnered attention in the national and world press. In accordance with recent arguments that interpretive processes connect cognition and technology outcomes (Kaplan & Tripsas, 2006) we then categorized key events into issues and answers (Ocasio, 1997). Issues and answers make up "the cultural and cognitive repertoire of schemas available to decision makers… to make sense of, and respond to, environmental stimuli" (Ocasio, 1997, p. 194). We categorized key events that occurred in the general environment as "issues" and actions taken or advocated by Brazil's government and industry as "answers."

Finally, we created a visual map linking issues to answers and technological system outcomes. Graphic representations of data are useful tools for developing and verifying theoretical ideas and allow the efficient presentation of large quantities of information (Miles & Huberman, 1994), simultaneous representation of multiple dimensions, and the passage of time (Langley, 1999).

We drew on our visual map to conduct our subsequent analysis. Iterating between the data, our developing ideas, and extant theory, we examined the events preceding the adoption of an ethanol-fueled transportation system in Brazil to identify the role played by culture in the adoption process (Eisenhardt, 1989, Glaser & Strauss, 1967).

THE CASE OF BRAZIL'S ADOPTION OF ETHANOL

The use of ethanol as a fuel is not a new idea. Ethanol was discovered in the nineteenth century in Germany. By the early twentieth century, Henry Ford had developed cars fueled by ethanol. However, despite early efforts by the Brazilian sugar industry to promote ethanol as an alternative fuel, petroleum remained the fuel of choice until relatively recently. The chronology of events preceding the adoption of an ethanol-fueled transportation system in Brazil is depicted in Table 1 and described below.

The case begins in the 1930s when Brazil was a petroleum importer. As the need to decrease oil imports became salient and received national attention, the government regulated the addition of 5% of ethanol to imported gasoline to reduce oil consumption. In 1938, this law was changed to include the addition of ethanol to all gasoline consumed, domestic and imported. The policy of mandating the addition of ethanol to gasoline has been persistent in Brazil. The government has intervened in fuel composition several times in the last century, requiring varying proportions of ethanol in accordance with the economic needs of the time. During the World War II, as an answer to the severe oil crisis, the mandated proportion of ethanol in gasoline peaked at 42%. Today, ethanol is mixed with gasoline at a rate of 20% and the government is considering increasing this to 25%. The regulation of fuel composition in Brazil, initially an isolated action, has become institutionalized and has influenced subsequent actions.

In the 1970s, oil prices in Brazil skyrocketed following a severe oil crisis and concern about petroleum supplies. In response to this crisis, and in addition to regulations governing fuel consumption, the Brazilian government launched the Proalcool (Programa Nacional do Alcool), a government program intended to support ethanol production. This program included significant investments in sugar cane plantations and ethanol distilleries.

The Proalcool initiative was welcomed and advocated by the sugar industry as developing one of the few segments of the economy not dependent on foreigners. At the same time, concerns about global warming became salient and public figures and experts theorized that carbon dioxide emissions were the primary culprit. In a number of countries, including Brazil, petroleum based fuels were taxed highly in an attempt to curb consumption. Disincentives to use petroleum by means of high taxation coupled with incentives to increase production through the Proalcool initiative made ethanol a cheaper and more viable fuel alternative than petroleum in Brazil.

In 1980, following the implementation of the Proalcool program, industry adapted gasoline-powered cars to run on ethanol with governmental support. These vehicles were quickly available and accepted despite performance problems. Ethanol fueled cars accounted for 94.4% of car production in Brazil in 1984. Fuel distribution systems were adapted and ethanol became available in most service stations.

In 1986, the oil crisis passed and petroleum prices fell dramatically from $30-$40 to $12-$20 a barrel pushing the market price for ethanol down. At the same time, in an attempt to curb inflation, the newly elected government launched an economic program that included a decrease in incentives for ethanol production. Lower oil prices and consequent lower ethanol retail prices coupled with the elimination of ethanol incentives made ethanol production unattractive. However, demand for ethanol continued due to the ethanol-fueled fleet, leading to an ethanol supply crisis. The Proalcool program lost credibility. To address the ethanol crisis, a new fuel was developed for use in ethanol-fueled cars, termed MEG, a blend of ethanol, methanol, and gasoline.

The ethanol supply crisis and global pressures on automakers to reduce costs and standardize car models worldwide drove purely ethanol-fueled cars out of the private consumer market during this period. However, the demand for ethanol production was guaranteed by regulations requiring the addition of ethanol to gasoline: Brazil was the first country to prohibit tetraethyl lead as a gasoline additive and used ethanol instead.

In the past decade, illustrated by the signing of the Kyoto protocol by several countries including Brazil, the need to reduce oil consumption became salient once more.

The government's answer was once more regulating the mix of ethanol to gasoline, this time at a rate of 24%. Additionally, in 1998 the government offered incentives to taxis and official cars fueled by ethanol: theses vehicles became known as the green fleet.

In the late 1990s, the Brazilian subsidiaries of the German firm Bosch and the Italian firm Magneti Marelli joined forces to develop a new engine that would run on gasoline, ethanol, or any mix of the two. In 2003, as a result of this partnership, the *flex fuel* car became commercially available in Brazil. The flex fuel car automatically adjusts to run on varying compositions of gasoline and ethanol. The acceptance of the flex fuel car by the Brazilian customer was immediate and surprising even to the car industry. In 2007, 83% of the cars sold in Brazil used this technology. The flex fuel car is a success in Brazil, supported by the ethanol distribution system that has been in place since the early 1980s, when gasoline cars were adapted to run on ethanol. Currently there are over 25,000 gas stations distributing ethanol in Brazil. The distribution system for ethanol was developed in the early 1980s when cars were converted to use ethanol and remained in operation over the past 20 years despite a decrease in interest in ethanol during the 1990s. In 2007, as the world faces a new petroleum crisis, Brazil has adopted ethanol as its main source of fuel for transportation and become the world leader in ethanol production. Incremental adaptations led to Brazil's fuel self-sufficiency in 2006 and the country's world leadership position in ethanol production and utilization.

ANALYSIS AND DISCUSSION: THE ROLE OF CULTURE IN THE DEVELOPMENT OF TECHNOLOGICAL SYSTEMS

As discussed previously, the development of Brazil's ethanol fuel system is not consistent with extant theories explaining the development of technologies. The development of Brazil's ethanol production, distribution and transportation system proceeded in a series of incremental, non-linear steps including reversals and suboptimal choices. The development was thus not likely driven by an enduring preference for a particular technology. This suggests that cultural values cannot fully explain the role of culture in Brazil's answers to salient issues and subsequent adoption of an ethanol-fueled transportation system.

Figure 1 illustrates the process leading to Brazil's leadership in ethanol production and utilization. Issues are shown linked to the Brazilian answers they stimulated with doted lines.

Insert Figure 1 About Here

The path of logic influenced actions is shown with solid lines. The grey arrow depicts the path of development of key technology system elements. Figure 1 is based on public accounts of facts and represents an accepted version of the process of ethanol adoption. It reveals a collective understanding of historical facts and their causal ordering. Answers in each period causally influenced answers and technology systems outcomes in subsequent periods.

The sequence of Brazilian answers to issues reveals a non-linear and at times inefficient process of technological development. Ethanol adoption in Brazil was the result of a series of incremental decisions by government and industry including short-term reactions to jolts, policy reversals, and suboptimal choices that culminated in the development of a technological system. While in hindsight Brazil's ascension to leadership in ethanol production and utilization may seem linear and efficient, it was actually a process marked by periods of expansion, contraction, and costly policy reversals. In the 75 years between the first utilization of ethanol as a fuel and Brazil's fuel self-sufficiency, the nation took many incremental steps to adapt the fuel and the transportation system to meet immediate needs.

Beginning in the 1930s, the Brazilian government responded to the issue of fuel scarcity by taking incremental steps to change the fuel composition and then encouraging subsequent adaptation of the transportation system. The same response was employed to deal with ethanol supply problems. Through a combination of government and industry initiatives, the transportation fleet was adapted to run on ethanol in the 1980s, back to gasoline in the 1990s, partially converted to ethanol in 1998—the green fleet—and finally, adapted to run on any mix of the two in 2003.

Notably, the gasoline-powered cars adapted to run on ethanol in the 1980s were not efficient or reliable, but were quickly available in the market and provided a temporary solution to the pressing problem of oil scarcity.

The adapted cars were just as quickly discarded and replaced by gasoline-powered cars when ethanol became a less desirable alternative. As the need to decrease petroleum consumption again became salient, Brazil's industry launched the flex-fuel car with great success.

The non-linearity of this sequence suggests that real or perceived technological characteristics were not the main drivers of ethanol adoption. Through the 20th century, the Brazilian government oscillated between encouraging and discouraging ethanol production and utilization. It is thus unlikely that ethanol was seen as a uniquely superior technology for dealing with the issues of petroleum shortages and environmental problems. Ethanol adoption in Brazil was not the result of technological characteristics per se.

Likewise, the sequence cannot be explained as the result of a cultural preference for ethanol over other alternatives, as would be suggested by the explanations of culture that dominate management studies. Traditional views imply that culture influences technological outcomes by influencing how a technology is perceived. That is, some technologies are more compatible with the values of a particular culture, and therefore are more likely to be adopted within that culture (Leidner & Kayworth, 2006).

However, the case of ethanol adoption in Brazil challenges this assumption. If a set of values and beliefs lead people to prefer certain outcomes over others, we would observe changes in strategies to maintain a consistent end goal. For instance, if Brazilian values led to a preference for ethanol over other alternatives, we would observe the use of different strategies through time in order to maintain ethanol as the main source of fuel. However, what we observe is that the strategy of adapting fuels was more persistent than the use of ethanol as the fuel of choice.

Culturally-based Logics of Action

The persistence of adaptation to address salient issues is a manifestation of culture. We argue that culture affects technological system adoption by influencing the incremental give and take process through which technology systems develop rather than by shaping the definition of a preferred end system or technologies.

Brazilian culture did not influence the adoption of a culturally congruent technology system. Rather, the logic of flexible adaptation facilitated a pattern of decisions and actions, which led eventually to Brazil's adoption of an ethanol-fueled transportation system.

While the majority of management researchers studying culture have sought to identify general cultural values, beliefs and characteristics and to predict their influence on behavioral outcomes, our analysis supports the observation that every culture is a complex, paradoxical configuration and presents exceptions and qualifications to general classifications (Bird & Osland, 2003). We adopt a cognitive conception of culture, which recognizes the limitations of classifications and suggests that an exploration of accepted schemata or frequently used "logics of action" will provide a useful foundation for an explanation of culturally influenced behavior. (DiMaggio, 1997; Swidler, 1986).

We argue that culture provides agents with logic principles from which they construct actions rather than driving perceptions of a particular technology. Culture is a tool kit of symbols, stories, rituals, and world views (Swidler, 1986). The knowledge structures represented by these symbols, stories, rituals and world views interact with the institutional environment to produce logics of actions. Culturally derived logics of action are mental structures representing accepted reasoning, which individuals and organizations can use in varying configurations to solve problems and advance ends (DiMaggio, 1997; Ocasio, 1997; Swidler, 1986).

For example, consider the tool kit metaphor: environmental cues, such as a nail sticking up in a fence, and logics of action together help people to define a problem and select a tool to deal with it. A tool kit contains many different tools that might work, such as a hammer, pliers, or hacksaw. As individuals use one tool more than others, they become more proficient at using it and develop a preference for that tool. This tendency is recognized in the adage, "If you have a hammer, everything looks like a nail." Logics of action are similar to a favorite hammer. Like the hammer in the adage, they influence both the definition of the problem—the need for something with which to pound down the nail—and the appropriate solution—the hammer.

Brazil's answers to the problem of fuel scarcity follow a logic principle of flexible adaptation, which influenced and constrained the alternatives available to individuals, organizations, and institutions.

The logic of adaptation was applied to both fuels and cars. Initially, gasoline-powered cars were adapted to run on ethanol. These adaptations were reversed when ethanol became less attractive. In 2003, new technology allowing any mix of ethanol and gasoline was introduced in the flex fuel car. The flex fuel car is the ultimate legitimization of the logic of changing fuels to adapt to external circumstances. The power of deciding fuel mix has now moved away from the government and into the final customer's hands.

The logic of action evident in Brazil's answers to issues–incremental adaptations to fuel composition and adaptations the transportation fleet—is a product of culture. Other countries have faced similar oil supply problems but took different actions. Additionally, the strategy of adaptation was enduring, manifested in different situations, and used by different groups of people within the country. Various reining governments and industry groups were involved in the process at different times and, while the specific responses changed—encourage or discourage ethanol utilization—the underlying strategy of flexible, incremental adaptation remained constant. Culture did not suggest a preferred fuel, but rather provided a logic of action for dealing with fuel problems.

Flexible Adaptation: A Unique Cultural Characteristic

Logics of action are likely to be unique and comprehensive, accounting for common cultural characteristics as well as idiosyncratic information. Brazil's responses to issues were influenced by a logic of flexible adaptation, which we argue is a culturally derived, enduring logic of action. The pattern of flexible adaptation is an important Brazilian cultural characteristic captured in Brazil by the term *jeitinho*. The Brazilian *Jeitinho* is one of Brazilian culture's most visible idiosyncrasies and is frequently referred to as a key characteristic of Brazilian culture (Schneider & Barsoux, 1997; Steers & Nardon, 2006). It stands out as a key to interpreting Brazilian culture (Amado & Vinagre Brasil, 1991). The Brazilian *jeitinho* is not a value or belief. Rather it is a logic of action of flexible adaptation used to deal with various problems, including a soccer opponent, a failing constitution, or fuel scarcity.

An understanding of Brazilian *jeitinho* requires an understanding of Brazilian history. Brazil is the world's sixth largest country in landmass and was initially colonized by the Portuguese. Brazil was a major player in the global slave trade for several centuries, importing over three million slaves between the 1500s and 1800s (compared to about 750,000 in the U.S.). Slaves were forced to work Brazil's sugar cane plantations and shared with their Portuguese owners their natural environs and means of living. Africans and Portuguese exchanged culture and blood to create a unique Brazilian culture, which includes the *capoeira,* a martial art performed as a dance by African slaves, music, food, and religion. For example, the melding of African and Portuguese beliefs resulted in a unique Brazilian version of Catholicism permeated by symbols and rites from African religions. Such western and nonwestern customs and symbols coexist side-by-side, even in the world of business (Amado & Vinagre Brasil, 1991).

The Brazilian that emerged from this historical context is a citizen "*seeking for his soul in the dialectic profusion of his physical and spiritual components, who has to develop a flexible, labile, plastic personality in order to survive, live, and build a country*" (Amado & Vinagre Brasil, 1991). Brazilians have developed *jogo de cintura,* a flexibility of body and spirit allowing deviation from obstacles. The expression *jogo de cintura* was originally used to describe the way Brazilians play soccer. They use a swing of their hips to avoid their opponents. This expression has come to mean ways to avoid difficult situations and has become prevalent in Brazil's public discourse. The flexibility of *jogo de cintura* is the building block of *jeitinho,* a unique Brazilian characteristic.

Jeito translates as a way, manner, aptitude. *Dar um jeito* is a very common expression in Brazil meaning "to find a way out". *Jeitinho* is the diminutive of *jeito,* which in Brazil is used to signal intimacy and endearment. Therefore, *jeitinho* not only represents finding a way out, it also represents an intimacy with this adaptive answer (Amado & Vinagre Brasil, 1991). *Jeitinho* is most commonly referred to when explaining the Brazilian adaptive response for dealing with one of the most bureaucratic environments in the world (*Exame*, 2004). However, *jeitinho* permeates Brazilian life. When facing problems, Brazilians tend to look for alternative creative solutions, in order to get *around* the problem.

Such creative solutions often include the use of personal influence or relationships to evade official rules, avoidance of conflict, a wait and see attitude, and *gambiarras. Gambiarra* is another facet of *jeitinho* and refers to a culture of improvisation in which provisory solutions may become permanent. Brazilians use *gambiarras* to quickly patch up anything that is broken, including equipment, laws, or even the constitution. In a positive sense, *gambiarra* is a reflection of flexibility. Flexibility is such an important aspect of Brazilian culture that in a recent study, Brazilian managers were ranked as the most flexible managers of the forty-eight nationalities studied (*Gazeta Mercantil*, 2002).

The Brazilian answer of changing fuel composition to address the issue of fuel scarcity demonstrates a flexible approach to problem solving. This adaptive change required only incremental modifications to other system elements. This approach can be contrasted for example with the American cultural pattern of technological breakthrough based on a desire to come up with radically new solutions (Garud & Karnoe, 2003) or to the European cultural pattern of conservation. American interest is consistently directed towards perfecting a new technology such as a car powered by a hydrogen fuel cell. In 2006, facing an oil crisis and catastrophic forecasts of global warming, the European Commission suggests "walking, biking, taking public transportation or car sharing".Brazil's adaptation of gasoline-powered cars to run on ethanol is also a typical example of a *gambiarra*, a quick fix that lasted quite a long time. The Brazilian market quickly embraced the modified cars, despite performance problems, and discarded them when gasoline became more attractive.

Historically Brazil has dealt with oscillating levels of ethanol and gasoline attractiveness by adapting the content requirements of gasoline and influencing the make up of the national transportation fleet through legislation. Continuing with the same pattern of adaptation, today's fuel flex car, introduced by the Brazilian car industry in the early 2000s, shifts the power to select fuels to the final consumer. The adaptability of the flex fuel car is an additional incremental adaptation, which takes advantage of previous actions and is aligned with a preferred Brazilian logic of action. The innovation was rapidly and widely accepted.

SUMMARY AND CONCLUSION

We examine the case of Brazil's adoption of an ethanol-fueled transportation system through a cognitive cultural lens. Our analysis suggests that culture influences the adoption and evolution of technological systems by providing actors with logic principles with which to construct action. These logic principles influence and constrain action and overtime shape the configuration of the institutional environment surrounding the technological system.

In the case of Brazil, the use of the logic of action *jeitinho* resulted in the adaptation of the fuel composition in the 1930s and influenced the subsequent development of the transportation system. Once the Brazilian government identified an issue—fuel supply—and dealt successfully with it by changing the fuel composition, subsequent problem identification and resolution were influenced by this logic of action. Successful actions are incorporated into the cultural logic facilitating some patterns of action and discouraging others (Swidler, 1986). Cultural behavior is dynamic, as agents can elaborate on existing logics of action to develop answers to problems.

The new answers may become institutionalized, constraining the availability of solutions to similar, subsequent problems. Therefore, by restricting the availability of solutions considered, culture may enable or constrain the evolution of technological systems. In other words, culture influences the adoption of a technological system by shaping the trajectory of the system's evolution. While in hindsight it may appear as though a particular logic of action is more effective in dealing with institutional and economical constraints than others, several different evolutionary paths are possible. The end result of the use of persistent logics of action is time and context specific, suggesting that no particular logic of action is inherently better than another.

Logics of action are culturally embedded, and only partially captured by common cultural dimensions. They are broad and encompass general values and beliefs as well as idiosyncratic cultural characteristics. Therefore, in order to understand culture's influence on technological systems adoption it is fundamental to consider unique cultural characteristics dealing with *means*, or *how* things are done, and not only *ends*, or *why* things are preferred.

The case of ethanol adoption in Brazil suggests that culture influences the evolution of technological systems by providing actors with logics of action that are used to solve different kinds of problems. This finding is contradictory to the current paradigms found in both culture and technology literatures, which would suggest that culture influences technological adoption by providing actors with preferences that would lead to the acceptance or rejection of a given technology. While cultural values and preferences may be instrumental in influencing the acceptance of a technology by end users, it does not seem to be the main driver behind a technological system's evolution. We speculate that this discrepancy is a product of the complexity of technological systems development as compared to end user technologies and the number of actions required and actors involved in the process.

However, it is possible that cultural values favoring or hindering end users' acceptance also affects the development of technological systems. For example, one could argue that end users' acceptance of the flex-fuel car in Brazil facilitated the use of ethanol and that such acceptance was influenced by a Brazilian preference for adaptability. While the development of the technological system was influenced by logics of action, or means, one should not disregard the role that acceptance of the end product may play. Future research needs to further investigate how *means* and *ends* are related and how cultural influences on both affect the development of technological systems. This paper provides a starting point from which to begin exploring the role of culture in the process of technological systems adoption. While both theory and observation suggest a relationship between culture and technology adoption and evolution, research on this relationship is very limited.

This paper also calls attention to the importance of idiosyncratic cultural characteristics in explaining outcomes. Despite calls for a new paradigm (Earley, 2006), most extent cross-cultural studies focus on predictive models in which a cultural value predicts a dependent variable of interest (Kirkman, Lowe, & Gibson, 2006). While this body of research suggests, that culture does matter, it also suggests that the influence of culture is frequently overshadowed by other variables such as individual, organizational, or situational characteristics (Leung, Bhagat, Buchan, Erez, & Gibson, 2005).

In face of this dilemma, researchers have called for a shift in paradigms, some arguing that part of the problem stems from the fact that while values are an important part of culture they are only *one* component of culture (Earley, 2006). In this paper, we call attention to a rarely acknowledged yet vital component, the role of logics of action in influencing outcomes.

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TABLE 1

Chronology of Ethanol System Adoption in Brazil

Date	
XIX century	Discovery of ethanol in Germany
Early XX century	Invention of cars fueled by ethanol by Henry Ford
1905-1920	Sugar industry pushes for ethanol as alternative energy source
1927	Ethanol fueled engine created in Brazil
1931	Law requires mixing 5% ethanol to all imported gasoline
1938	Law requires mixing 5% ethanol to all gasoline consumed
1942-1946	World War II initiates oil crisis Ethanol is mixed to gasoline at 42%
1950-1960	Petroleum prices fall; Ethanol is mixed to gasoline at 3-7%
1973	First petroleum shock Low sugar prices
1975	Creation of the Proalcool—National Alcohol Program—to support ethanol production resulting in high levels of investment in sugar cane plantations and ethanol distilleries Ethanol used as 20% gasoline additive
1970-1980	Fuels are taxed based on pollution to deal with petroleum scarcity and CO2 emission Ethanol becomes economically viable
1980	Second petroleum shock
1980	Gasoline-powered cars are adapted to use ethanol Ethanol distribution system in place
1984	New car models introduced Ethanol fueled cars account for 94.4% of car production
1986	Oil crisis passes Prices fall from $30-40 to $12-20 Inflation control measures decrease incentive for ethanol production Ethanol demand higher than supply, ethanol becomes expensive
1989	Ethanol supply crisis
Early 1990's	Brazil begins importing ethanol MEG (fuel made of a mix of ethanol, methanol, and gasoline) created as a substitute for ethanol
1992	Tetraethyl Lead prohibited as gasoline additive in Brazil
1989-2001	Demand for ethanol fueled cars drops Ethanol fueled car production drops from 63% in 1988 to 1.02 % in 2001
Early 1990s	Car industry strategy shifts to production of same car models in all markets Government creates incentives for gasoline fueled cars of 1000 cylinders
1995	Fuel incentives are dropped
1998	Law requires 24% ethanol as additive to gasoline
1998	Government supports the "green fleet"—ethanol fueled taxis and official cars
2003	Introduction of the "flex fuel" car
2001-2006	25,000 gas stations offer ethanol
2004	Signatures of the Kyoto Protocol use ethanol as a fuel additive Brazil becomes ethanol exporter
2005	Kyoto Protocol
2006	Brazil becomes fuel self-sufficient
2007	All auto makers produce flex cars 83% of cars sold are flex

FIGURE 1

Process of Ethanol System Adoption in Brazil