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Deb Tech
Dakota State University

Jack Walters
Dakota State University

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Deb Tech, Ph.D.

Assistant Professor, Dakota State University

deb.tech@dsu.edu

East Hall 205, 820 N. Washington Ave., Madison, SD 57042

1-605-256-5173

Jack H. Walters, Ph.D. (corresponding author)

Associate Professor, Dakota State University

jack.walters@dsu.edu

East Hall 204B, 820 N. Washington Ave., Madison, SD 57042

1-605-256-5162

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Abstract

Purpose - This paper proposes a model of the decision factors used by countries to decide which digital television (DTV) broadcast standard to adopt. The focus is on countries in Latin America that are in the midst of adopting and/or implementing new standards.

Design/Methodology/Approach – This paper uses a multiple case study approach and independent inter-rater techniques to extract a set of decision factors used by four Latin American countries to select a digital broadcast television standard.

Findings – Two decision factors expected by the researchers were confirmed. In addition, two additional decision factors were identified.

Research limitations/implications – This research is valuable in developing a deeper understanding of governmental decision-making processes regarding technology, but is not intended for predictive purposes.

Originality/value – This paper provides an overview of the different global digital broadcast standards and adoption processes that are underway. It uses this information to develop a set of factors that encompass the decision process for DTV standards adoptions at the national governmental level.

Keywords: digital television, Latin America, technology adoption, decision making, broadcast format standards, DTV

Paper type: Case study

1. Introduction

The world is in the midst of the first major change in how television signals are transmitted since the beginning of the industry over 80 years ago. The transition from analog broadcast to digital television (DTV)[1] will provide improved viewing quality and open parts of the broadcast spectrum for allocation to other providers such as advanced wireless services and public service agencies. Nations around the world are making broadcast standard transitions and are at various points along a continuum that runs from analog-only broadcasts to digital-only broadcasts. An analog switch-off date (ASO) is defined as the cessation of analog broadcasts through "terrestrial" (over-the-air, as opposed to cable or satellite) stations. From those dates forward, viewers of traditional broadcast stations will receive only digital signals.

This transition will have significant impacts on society for a long time into the future. The current market for television services is astounding: There are over 995 million television households in the world. With a population approaching 7 billion and with industrialization sweeping the least economically- and technologically-developed areas, this number can be expected to grow rapidly in the coming decade.

Digital television is the umbrella term adopted by the U.S. Federal Communications Commission (FCC) in 1996 to refer to all digital broadcasts (Kaet-Dt, 2006). DTV is different than analog broadcast technology, which uses a series of wavelengths, in that it encodes a broadcast signal via the use of zeroes and ones – the same methodology used in computers. The benefit of DTV technology lies in its ability to compress four or more channels into the same

[1] It is important to distinguish between DTV, which refers to the use of digital signals to deliver programming and HDTV, which refers to High Definition Television, a higher density (and therefore more vivid) image available to individual television sets because of the advent of digital television.

bandwidth that is required for a single analog broadcast, thus freeing bandwidth for other uses such as mobile telephone and government emergency broadcast channels (Digital Television, 2004).

Four major standards have been developed over the past 15 years, each representing the effort of a nation or region. The first deployed standard, Integrated Services Digital Broadcasting (ISDB), was developed by the Japanese. For technical, transition and other reasons, the United States-backed Advanced Television Systems Committee developed the ATSC standard as a successor to the existing NTSC analog standard. Europe developed the Digital Video Broadcast (DVB) standard. Later, the Chinese entered the competition with Digital Media Broadcast (DMB) standard.

2. Initial Expectations

One might expect that the adoption of digital standards would follow patterns similar to the diffusion of analog standards, due to embedded technologies. Our attention was initially drawn to these issues by DTV standards adoption decisions in Brazil and Columbia. Before investigation of those decisions, we would have predicted that DTV implementation would be driven by two major factors: historical/technological and sociopolitical. Historical/technological decisions are driven by a desire to remain consistent with decisions that have been made in the past. For example, one might assume that a country using the NTSC analog standard would adopt the digital ATSC standard because ATSC is designed to accommodate NTSC technical requirements while the transition to ATSC is underway.

A second example of historical/technological factors might be found when considering how television content is delivered. Large proportions of content are transmitted by satellites in geosynchronous orbits around the Earth, meaning that the satellite is positioned to orbit the

planet at the same rate as the Earth spins and therefore remain continuously over one geographic area. Because North and South America occupy some of the same longitudes, and because neither occupies the same longitude as any other major continent or country, it is reasonable to assume that countries in South America would be interested in maintaining contact with the North American content providers that use geosynchronous satellites positioned over the northern regions of South America.

Sociopolitical factors could emerge from long-term political and trade relationships between standards-developing and standards-adopting countries. We would expect, for example that extant trade agreements might have an influence on adoption decisions.

The Brazilian and Columbian adoption decisions, however, contained elements that do not support our initial suppositions about historical/technological and sociopolitical factors, and led to investigation of other factors that could influence DTV standards adoptions. After years of using PAL-M, a modification of the European PAL analog standard, Brazil chose to adapt to the Japanese ISDB standard for digital television. This represented not only a departure from the existing analog standard, but also a rejection of the ATSC standard, which might have aided the use of geosynchronous satellite content. We also wondered how a standard created by the Japanese could spread halfway around the globe in ways that previous Japanese standards had not.

In Columbia the existing analog television standard is NTSC, developed by and in use in the United States from the beginning of television until June of 2009. Throughout the history of analog television in Colombia, the NTSC standard has been used. It is reasonable to believe that, because ATSC is designed as a successor to NTSC and incorporates transitional elements that makes the changeover more efficient for broadcasters and viewers, Columbia would select the

ATSC standard. However, Columbia adopted the European digital television standard, DVB, the successor to the standard that Brazil had just abandoned. This decision had another interesting effect – two countries with a 1644 km (1021 mile) common border would be using conflicting standards, though it is reasonable to note that the border in question is in the mostly sparsely populated Amazon basin (and that standards conflict, between NTSC and PAL, had previously existed on that border).

Clearly our initial assumptions about DTV standards choices – that there is some pressure to maintain technological and/or sociopolitical choices from the past – were not the only drivers of the digital television decisions in Brazil and Colombia. In reviewing cases where the adoption of a DTV standard did not follow our preliminary model, we realized that a more robust explanation of adoption decisions was needed, as existing research does not explain how these decisions are made. We believed that careful consideration of all factors – economic, political, technological, socio-historical – would lead to the most complete and useful conceptual model of the decision process.

We chose to treat the adoption of DTV standards as a classic decision model, out of the belief that knowledge gained by developing a list of criteria, based on actual decisions, would provide the increased explanatory power that we sought.

3. The Decision Making Process

In a typical compensatory decision rule model (Shull, et al., 1970), the user first identifies a problem, defined as a gap between existing conditions and desired conditions in the future. The user then identifies evaluative criteria, those aspects of the problem that are believed to have the greatest impact on the choice that is ultimately made. Based on those criteria, a list of alternatives is created. In the acquisition of products or services, the list of alternatives is

frequently a set of vendors. Weights are applied so that the importance of various criteria can be reflected in a simple multiplicative process that results in a range of scores over the alternatives. In the simple case, the alternative with the highest score is selected.

Because we applied a decision making model in the midst of change rather than at the beginning as is usually the case, some of the steps must be taken out of order or limited in their implementation. For example, the alternatives in DTV adoption, meaning the standards developed by nations/continents around the world, are given. Rather than a subset of providers as would be typical in a normal product or service acquisition process, we assumed that all four standards would be considered by any country going through an adoption process.[2] Similarly, it could be difficult or even impossible to assign meaningful weights to the criteria that are derived in a study of this type. However, we believe that the development of criteria suitably frames the key issues involved in the adoption of new digital television standards without the application of weights. Finally, it could be presumed that mathematical calculations which emerge from a model designed by this process would, by their nature, be somewhat predictive in operation. In other words, it could be presumed that possessing the set of developed criteria for a particular country's upcoming decision could allow prediction of the choices that will be made. We strongly urge caution in using the model in this way, as our intention was to develop a descriptive rather than predictive model and predictive validity cannot be established by the study design used here.

[2] The Chinese standard was not in place when the Brazilian and Mexican choices were made.

4. Overview of the development DTV Standards

The proliferation of digital broadcast standards can be traced back to the introduction of color television and the development of analog standards. In 1941, the U.S. Federal Communications Commission's (FCC) National Television Systems Committee (NTSC) created a standard, named after the committee, in an attempt to prevent the proliferation of conflicting standards by television manufacturers. While this standard was adopted in much of the Americas, it was not successful in some other countries due to the inferior display of color on 50 Hertz (Hz; cycles per second of alternating electrical current) systems. Subsequently, the Phase Alternating Line (PAL) standard was developed and adopted by most countries that used 50Hz electrical systems. A third standard, Sequential Couleur Avec Memoire (SECAM) was introduced by the French in 1967 (Lee, et al., 2007).

ISDB: The Japanese Standard

Although digital television research began as early as the 1960's, intense DTV development activity began with the invention of Multiple Sub-nyquist Sampling Encoding (MUSE) at the Japanese Broadcasting Corporation in 1980. MUSE, the first DTV video compression and transmission system, was demonstrated to U.S. government officials and broadcasters in 1987 (Hart, 2004). Continued work on this standard led to the development of the ISDB standard, which allowed Japan to begin digital broadcasts in December of 2003 and set an ASO date of July 2011.

ISDB touts its ability to simultaneously broadcast high definition and handheld content. This standard accommodates building the Digital Terrestrial Television (DTT) system from the ground-up, allowing for greater flexibility in the design of the broadcast infrastructure as well as receivers (ARIB, 2007).

According to the Digital Broadcasting Experts Group (DiBEG), 80% (approximately 77.7 million receivers deployed) of Japanese households were equipped with ISDB receivers in 2010 (Dibeg.org, 2010). A concern voiced by industry experts may be the increased cost of receivers due to the small market size as compared to ATSC and DVB (Gutierrez, 2008).

ATSC: The U.S. Standard

Although the Japanese sought to have ISDB adopted as the global HDTV standard (García Leiva, et al., 2006), the U.S. developed its own terrestrial digital standard to be compatible with the existing NTSC modulation scheme. U.S. Analog broadcasts ended on June 12, 2009 and the ATSC standard is in use across the country.

The ATSC standard was developed to allow analog NTSC broadcasts to co-exist with digital broadcasts during the transition, and is oriented to a single-broadcaster approach, making signal interference between channels non-existent and ideal for transmissions in large geographic areas (Villa, 2008). Other benefits touted by the ATSC commission include better coverage with less power utilization, use of existing broadcast towers, and more efficient use of the broadcast spectrum (Graves, 2008).

Sales of ATSC-equipped units in 2008 were near equivalent to total ISDB receivers in 2010, at 80 million units. (Graves, 2008). Underscoring the size of the ATSC receiver market, the total number of television sets in the U.S. is approaching 250 million, based on an estimate of 2.24 televisions per household (www.csun.edu/science/health/docs/tv&health.html).

DVB: The European Standard

European broadcasters, equipment manufacturers, and regulatory agencies formed a group in the early 1990s to oversee the development of digital television. The Digital Video Broadcasting (DVB) project was established in 1993 (Villa, 2008).

DVB proponents claim that it allows mobile broadcasts as well as single frequency broadcasts to exist within the same geographic area, use of the broadcast spectrum for emerging technologies (Brennan, 1997), updating of systems during the transition, and lower cost receivers.

DVB was first deployed in Luxembourg and the Netherlands in 2006, followed by Finland in 2007 (Dudek, 2008). To date, over 500 million DVB receivers have been deployed globally (DVB Project, 2008), with much of the African continent under plans of DVB adoption.

DMB: The Chinese Standard

A fourth standard, Digital Multimedia Broadcast (DMB), was introduced by the Chinese in August of 2006. Positive claims for DMB include combining the modulation schemes of other standards with the low power consumption found in ISDB, allowing signals to travel longer distances with less power, and supporting HDTV on handheld devices (Clendenin, 2006).

It is projected that China will have 100 million users of its DMB system by 2013 (Gallen, 2008) and that the total Chinese television equipment market could be worth $125 billion (Farivar, 2006). Mobile television is expected to comprise about 35% of all of all digital viewing in China during this period.

5. Status of DTV Standards Adoption

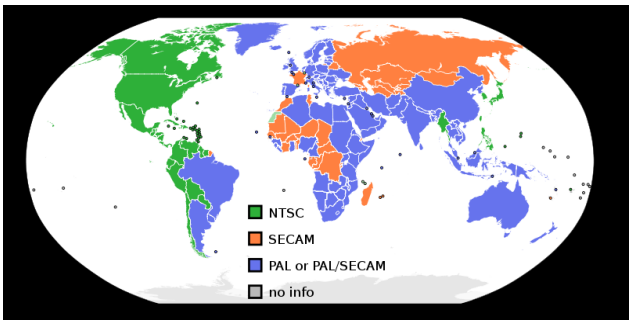

Figure 1

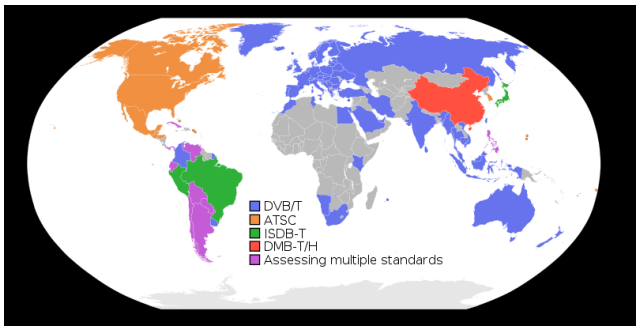

Figure 2

As shown in figures 1 and 2, the diffusion of digital standards has followed the NTSC and PAL paths to a limited degree. However, the increased number of standards and the fact that many countries have not yet implemented DTV leaves an open question about how non-standards-creating countries decide which system to adopt – and why.

6. Methods

Observations of the digital television standards development processes in the United States, Japan, and Europe revealed that they involve numerous complex choices affecting not only technology but also user cost, implementation effectiveness and efficiency, and flexibility for content providers over the intermediate time horizon. Given the significant complexity of the technology development process, and assuming that this complexity would also appear in the technology adoption process, we set out to develop a method that would allow us to extract key decision elements by observing decisions that have taken place.

For those countries and continents that have developed their own standards, the adoption process is a given. In other words, the development of ATSC in the United States predestined the adoption of ATSC in the U.S. The development of ISDB in Japan makes it the new Japanese standard, DVB in Europe, and DMB in China. Even with these decisions pre-made, only 30 countries of the world's almost 200 countries and containing approximately 2,000,000,000 of the world's almost 7,000,000,000 people will be “locked in” to a DTV standard. This paper deals with the decision process affecting the remaining countries.

The South American transition is particularly interesting because the continent’s 371 million people live in 12 countries with large differences in population and economic power. For example, Brazil's economy, as measured by GDP, is five times larger than the next largest, Argentina. While Spanish and Portuguese are both spoken by scores of millions of people, it is

perhaps more important to acknowledge significant cultural differences among the countries, both relating to their historical links to Europe and to how immigrant European populations have interacted with native peoples. The global impact of South America is increasing as both economic power and political sophistication grows on the continent. In South America there is no presumed agreement that standards and practices will be the same across countries, as is the current fashion in Europe. All of these conditions make adoption decisions in South America interesting to study in terms of the development of common factors.

We chose a model development process that is based on multiple case studies and concepts from grounded theory (Glaser and Strauss, 1967). Without the advantages provided by grounded theory approaches, study of issues such as DTV standards adoption processes could end up as a series of anecdotal accounts from which little useful information can be gained. If we treat each case study as a possible source of useful information which can be layered on in the construction of a theoretical model, review of multiple decisions could allow us to create a more elaborate set of decision factors, providing additional explanatory power in describing DTV adoption decisions.

The remainder of this paper reviews the status of DTV technology and standards transitions underway in four Latin American countries and extracts common structural and decisional elements. We used a multiple independent rater technique to arrive at agreements about interpretation of events that occurred in standards adoption processes in four nations. Our repeated case study approach provides two benefits:

(1) Factors that recurred in multiple studies gave weight to their importance as influencers in the decision process.

(2) Factors that did not recur can be considered as extensions to the factor set and perhaps be used to refine and expand the overall group of factors, subject to later review of additional cases.

7. Adoption decisions in Latin America

Mexico

Mexico announced its decision to adopt the ATSC standard in 2004. The country had participated in the ATSC development process for 15 years before the announcement, showing little consideration of other standards (ATSC.org, 2004). The transition to ATSC is seen as a direct replacement of the NTSC standards, similar to the strategy used in the U.S. Mexico's ASO date is projected for 2012.

In a 2006 report to the Canadian Radio-Television and Telecommunications Commission (McEwen, 2006), several reasons for Mexico's selection of the ATSC standard were presented, including:

- Protection of the U.S./Mexico border markets by beginning digital transition in the 6 large border communities by the end of 2006.
- Making sure that the flourishing Mexican programming content industry remained competitive and dominant in the international market.
- Staying competitive with North American counterparts in distribution and production of HD programming, as Mexico is the largest exporter of Spanish language programming in the world.
- Participating in the production/marketing of wide screen HD televisions.

In addition, cable and satellite broadcasters tend to have cross ownership with U.S. entities, and this likely reinforced the choice of ATSC.

Brazil

With more than 120 million TV viewers and sales of 10 million televisions annually (Mitsui Co., 2008), prior to its decision to adopt an existing standard, Brazil was lobbied by representatives from the three then-active standards – ATSC, DVB and ISDB. ATSC proponents argued that a common digital television standard could be created throughout the Americas. A huge export market would exist for Brazilian manufacturers of set-top boxes and receivers and offer a potential boost to its economy (U.S. Embassy, 2006). In addition, the U.S. Overseas Private Investment Corporation had set aside $150 million for U.S. companies to invest in information technology development projects in Brazil, with several U.S. companies expressing their intention to make significant investments in ATSC-related manufacturing facilities in the country (Wayne, 2006).

During the same timeframe DVB representatives, including executives from Nokia, Philips, ST Microelectronics, Siemens, and the DVB Project lobbied the Brazilian commission. DVB representatives also claimed a large number of countries had committed to the DVB standard, ensuring a low-cost receiver.

In 2006, the Brazilian National Agency of Telecommunications (Anatel) announced that it would adopt a modification the Japanese ISDB standard (AMEC, 2008), SBDTV. In a report that year, the Inter Press Service (Osava, 2006) provided an overview of several factors related to the adoption decision, including:

- Broadcasting companies lobbied the government for the adoption of ISDB, claiming that it was the only standard which provided HD services for cell phones.
- Telephone companies did not support the choice of the ISDB standard, which would allow broadcasters to reach cell phones without going through phone companies.

- Helio Costa, the Brazilian Communications Minister, had a previous affiliation with the largest South American broadcasting company, TV Globo (headquartered in Brazil), and may have influenced the decision to follow the broadcaster's preference.

A memorandum of understanding between Brazil and Japan, written before the adoption decision was made, focused on Japan's involvement in developing Brazil's electronics industry as well as providing training to local engineers (DVB Project, 2006). This included the possibility of building a new semiconductor factory.

- The Brazilian government obtained agreement from the Japanese to localize the standard to better fit Brazilian needs. This was emphasized by President Luiz Inacio da Silva when announcing the decision: "We are not only going to absorb Japanese technology but will creatively contribute to perfect the system." (Advanced Television Ltd, 2006).
- Other factors, detailed by the NHK Science & Technical Research Laboratories (Takada, 2008), included the exemption from some of the royalty payments associated with the ISDB technology.
- The transition from the analog PAL to Brazilian ISDB is being financed by the Japanese Bank for International Cooperation and the Brazilian Development Bank (Takada, 2008).

Colombia

Breaking from its previous technology affiliation with NTSC (analog predecessor to ATSC), Colombia announced its decision to adopt the DVB standard in 2008. In 2006, the Colombian government established priorities for technology, information, and computers. Those goals, which might have influenced the country's DTV decision, included:

- All Columbians connected and informed

- Institutional consolidation and modernization that will generate a strategic sector for the country
- Development and competitiveness of the telecommunications and computer industries.
- Policy for public television and radio.
- Potential social benefits such as a decrease in the digital divide, increased social inclusion, and increased democratization of access to information (del Rosarios Guerra, 2007).

During the decision process, a series of 13 open forums was held to discuss the different standards. The forums were open to the public and included industry representatives, citizens, and representatives of the four standards. Notably, this was the first public entry into the competitive arena by the Chinese DMB standard (CNTV, 2008). Additionally, the Colombian government established an official website providing information on the four standards as well as highlights of the forums and meetings that were held regarding this topic.

Upon announcing the decision to adopt the DVB standard, the National Commission for Television (CNTV) stated that the decision was affected by:

- DVB's ability to respond to the high penetration of terrestrial TVs and a relatively low income population by offering lower-cost devices (DVB Project, 2008).
- A comparison among the proposals regarding cooperation and technology transfer (Europa Press, 2008).
- DVB's ability to adjust for the needs of the television viewers, the audiovisual industry, and Colombian topography.
- DVB's mobile services, multi-channel broadcasts, HDTV, SDTV, and interactivity.

- DVB's broader installed based and claims of lower-cost devices and better technical support.
- A desire to be a technology leader in DTV transition. As stated by María Carolina Hoyos Turbay, CNTV Director, "Colombia… will lead the process of technology change in all of Latin America. The ears of neighboring countries are listening to Colombia's decision" (Europa Press, 2008).

Chile

Showing one of the most pragmatic approaches to analyzing the situation, Chile began evaluating the different standards by contracting with Pontifical Catholic University of Chile's School of Engineering to evaluate ATSC, DVB, and ISDB. Since this study was conducted, the Chinese DMB standard has been introduced, providing a fourth alternative. The Chilean government subsequently contracted with seven universities to study all standards, including the Brazilian version of ISDB.

To underscore the pragmatic approach employed by Chile, it is useful to evaluate the efforts to date in testing the different standards. Since 1999, ATSC, DVB and ISDB have been transmitted in Santiago in a testing format via the government-owned television station, TVN. However, the Chilean government has decided to delay the digital television decision until 2009. That delay notwithstanding, a goal of transition by 2010 for the major cities in Chile has been set (SUBTEL, 2007).

These criteria have been identified in the Chilean research about DTV standards:

- DVB and ISDB allow a mix of different content in one stream (i.e., radio and television or fixed and mobile reception). ATSC does not have this feature.

- ATSC was developed with HDTV in mind, but the other two standards now include specifications for HD transmission.
- Topographical conditions in Chile are such that immunity to multi-trajectory propagation (ghosting) provided by ISDB and DVB is an important consideration.
- ISDB and DVB have similar capabilities in mobile and portable transmission/reception. The ATSC standards committee is currently in the process of vetting alternatives.
- DVB more efficiently uses bandwidth.
- ISDB and ATSC were developed for co-existence with NTSC (existing analog standard) until ASO.
- ISDB receivers could be higher in cost than DVB and ATSC, due to the smaller market size of ISDB. The cost differential among receivers could be moderated by world market size (e.g., Brazil's planned implementation of ISDB).

On the basis of the analyses above, it was recommended that Chile adopt the DVB standard for open terrestrial digital television. Contrary to the recommendation, Chile chose to adopt the modified ISDB standard, SBDTV in September, 2009 with a digital switch-over planned for 2010.

8. Development of common decision factors

As noted earlier, diffusion patterns of analog format television led us to speculate that technology-succession relationships (e.g., NTSC to ATSC, PAL/SECAM to DVB) and in-use standards would be the principal drivers of the decision about which DTV standard to adopt. However, the adoption of ISDB by Brazil and DVB by Columbia led us to search for a set of factors with greater explanatory power.

Inter-rater-agreement-based content analysis was used to review key events from four Latin American countries' DTV standards adoption processes and develop an expanded set of factors (see Table 1).

Table 1: Decision Factors and Supporting Evidence

Country

Factor	Brazil	Chile	Colombia	Mexico
Economic, market, and within-country political	• Lobbied by 3 of the 4 standards (DMB did not participate) • U.S. Overseas Private Investment Corporation had set aside $150 million • Possibility of Japan's investment in Brazil for semi-conductor facility • Exemption from some of the royalty payments associated with the ISDB technology • Transition financed by the Japanese Bank for International Cooperation and the Brazilian Development Bank • Brazilian Communications Minister favored cable company approach – not telephone companies.	• Limited political / stakeholder related behavior.	• Open forums were held across country • Stated priority of Colombian government to advance in the IT/Communications sector – to obtain first-mover advantage in the region • Consideration of standards-developing countries' proposals regarding cooperation and technology transfer • Perceived lower-cost advantage of DVB receivers	• Participated in the ATSC standards development process • Protect the U.S./Mexico border markets • Mexican programming content production industry remains competitive • Cross-ownership with US entities

Factor	Brazil	Chile	Colombia	Mexico
Historical / Technological	• Cited technical superiority as the reason for choosing ISDB • Broke from historical technology affiliation (PAL)	• Pragmatic approach by government. Several technology-focused studies conducted. • Historical technology affiliation is NTSC • Initial report shows DVB as the best choice – still evaluating, choice not made	• Broke from the historical technology affiliation (NTSC). • DVB's flexibility/ability to adjust to needs Columbian viewers, industry needs, and Colombian topography.	• Remained with historical technology affiliation (NTSC → ATSC) without serious consideration of other standards. • Participated in the ATSC development process for 15 years before the announcement.
Sociopolitical	• No observable effect of pre-existing political / cultural relationships	• No observable effect of pre-existing political / cultural relationships	• No observable effect of pre-existing political / cultural relationships	• Worked in unison with U.S. efforts to create ATSC standard to sustain relationship with 50+ million person Spanish language population in the U.S.

9. Conclusions and Discussion

Our study validated pre-existing assumptions about the criteria that would drive the DTV adoption decision in some countries. Particularly in Mexico, the large interests in Spanish language content development for the North American market, combined with comprehensive adoption of NTSC over the preceding decades, made the decision to adopt ATSC fairly straightforward and limited consideration of other standards.

We did, however, discover other important criteria from our analyses. In particular, economic support of a particular standard by the nation in which it was developed, or by key private entities from that nation, had significant influence on the decisions made in Brazil and Columbia. A significant incident in this category was the willingness of the Japanese to allow Brazil to modify the ISDB standard, suggesting that flexibility regarding the interaction of political and technical factors could influence an adoption decision. Relationships among

political decision-makers and key players in the Brazilian decision demonstrated that within-country politics could play a major role in the selection of a standard.

We also found that technical characteristics of the standards themselves, such as the ability to deal with certain types of terrain, had influence over some countries' decisions. This factor has also been raised in the Chilean discussion and may ultimately influence that nation's choice.

This research adds to the knowledge of complex technology-based decisions in several ways. First, we learned that models of technology diffusion based on previous technologies are not always sufficient to explain diffusion of new technologies. In this case, the expansion of analog television standards around the world, as a pattern for expected expansion of digital standards, was not sufficient in explanatory power. It was necessary to search for additional decision factors that would better encompass the scope and complexity of the decisions being made about digital television standards adoption.

Second, we discovered that decision factors extracted through a process of this type do not stand alone or act independently. In many cases, it was not simply the technology that drove the decision, or the politics, but the interaction of the technology and the politics. As we saw in the Brazilian case, the ability of ISDB to provide content in certain formats interacted with political and economic power within the country, and with the behaviors of specific political leaders, to determine the choice of DTV standard. In the Mexican case, the transition from NTSC, in place in a similar technological and geographic condition to the U.S., combined with a desire to sustain politico-cultural relationships with the U.S. and its significant percentage of Spanish-speaking people, made the transition to ATSC a clear choice.

Third, we observed that the elements of the decisions, such as technical characteristics of the standards or political/economic support from the standards developing countries, might loom large at the time that the decision is made, yet not be substantively different when viewed in a strictly objective context. This is an interesting area for further research, in that the import and perceived variability of the alternatives is high at the time the decision is made but seems much less when the decision is reviewed later.

This research and its results have several limitations in how they can be interpreted and used. The most important of these is using the derived decision factors in a predictive manner. It was not our purpose to build a predictive model of digital television technology adoption. It would be inappropriate to attempt to identify events in countries that have not yet decided about a digital standard and use these decision factors to predict which standard will be selected. Our purpose was to develop a deeper understanding of the decision-making process for highly complex technological standards where significant economic and political interests and pressures are involved. Countries that remain undecided about DTV standards are primarily in South America, Africa and South Asia. Rather than attempting to use the model developed here to project what will occur in the remaining countries, we strongly recommend further research to refine the set of decision factors based on case studies of countries that have not yet decided.

Regarding the methods of this study, there is a further limitation. While it is true that content analysis and case study research exist to deal with unstructured information, we believe that further case studies of digital television adoption decisions could be enhanced by stronger efforts to structure available case study reports into a common format across countries. We believe that this approach could assist in developing information about the relative importance of the factors derived, a task not attempted in this study.

Finally, it should be noted that, despite the existence of four new and not fully implemented television standards around the world, the delivery of video content to end-users continues to evolve (e.g., internet protocol television – IPTV). We hope that this study leads to investigations of adoption decisions regarding those new technologies.

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