PROTOCOLS FOR MEASURING ECONOMIC IMPACTS OF ATP'S DIGITAL VIDEO PROGRAM

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The Principal Investigator on the project was David Burress, Associate Scientist and Research Economist at IPPBR, who also was lead author for this report. Additional economic analysis and drafting were provided by Joshua Rosenbloom, Professor of Economics, Patricia Oslund, Research Economist at IPPBR, and Robert Glass, Assistant Scientist and Research Economist at IPPBR. Brian Harris, Research Economist at IPPBR and Susan Mercer, Assistant Director at IPPBR, assisted with conducting focus groups and drafting Chapter 2. Other members of the research team included Un-Ja Chae, Graduate Research Assistant; Kristin Chow, Undergraduate Research Assistant; and Yi Geng, Graduate Research Assistant.

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The views and interpretations expressed in this report are those of the authors alone, and do not necessarily represent the views of the Institute for Public Policy and Business Research, the University of Kansas, the Advanced Technology Program, the National Institute of Standards and Technology, or any of the consultants engaged on this project.

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Purpose and context

- This report is part of a series of reports on the economic impacts of the Digital Video Focused Program Area of the Advanced Technology Program (ATP). ATP is a division of the National Institute of Standards and Technology (NIST), US Department of Commerce. This series is being prepared by the Institute for Public Policy and Business Research (IPPBR) at the University of Kansas.

- Three previous reports in this series provided a preliminary analysis of the digital video (DV) market place and its economic impacts.

    - Burress *et al.* (1998) established an approach for mapping complex marketplaces in terms of the general attributes of goods (based partly on Lancaster's (1971) model of demands for attributes). The approach was then applied to provide a detailed empirical description of existing and potential DV-related markets.
    - Burress *et al.* (1999a) extended this approach to provide a map of technologies needed to implement the identified types of DV goods. It also provided theoretical and empirical maps of the spillovers and other channels through which innovations in digital video technology could potentially affect the US economy. And, it proposed a Computable General Equilibrium (CGE) model of the US to be used as an accounting frame and aggregation method for summarizing economic impact channels. (A CGE model is one that numerically calculates the effects of all interactions of all markets in the economy, based on moderately to highly aggregated markets.)
    - Burress *et al.* (1999b) proposed general methodologies for the entire study, including possible follow-ons and *ex post* economic impact analyses; proposed specific methodology for gathering the baseline data (but not the detailed protocols); and proposed a research plan for gathering and analyzing the baseline data needed for the over-all study.

- The present report describes methods and protocols for gathering the baseline data and analyzes some of the test data we have gathered.

- A final planned report in this series will describe empirical baseline data on the economic impacts of the Digital Video Focused Program Area and analyze its significance.

- It is anticipated that follow-on research will track the Digital Video Focused Program Area over time, and then provide comprehensive *ex post* (i.e., retrospective) measurements of its economic impacts on the US.

Substantive findings

- While primarily technical in nature, this report does include some original research findings.

- Consumer focus groups were conducted to explore attitudes toward attributes of DV technologies. While primarily intended to support development of consumer survey protocols, the focus groups also generated comments about DV that are interesting in their own right.

- According to participants in the focus groups, not all consumers agree with the "natural" quality scales ordinarily assumed by DV technology developers.
  - Some consumers continue to feel that analog vinyl recordings of music have a "warmer" and "more alive" sound than digital CD recordings.
  - Some photographers who develop their own film prefer editing conventional film over editing digital still images, not so much because conventional editing methods give more control over the image, but rather because the method of control has a different feel. Working with film is more tactile than working with digital images.

- A data set of patents was compiled and used to perform initial tests of the hypothesis that DV patent announcements have systematic effects on stock market values.

- For firms below a certain size, we find that DV patent announcements have a significant and permanent positive effect on prices of stock in the firm that owns the patent. The effect appears during a "window" that extends from 1 working day prior to the announcement through 5 working days after the announcement.

- This "own-firm" effect is sufficiently strong that we think it may be useful to look for "cross-firm" effects in the next phase of research. These effects consist in the influence of one firm's patent announcement on the market value of another firm that makes or uses the same technologies. These effects would measure the expected net value of all spillovers from the first firm to the second, in the view of stock market participants.

Protocols and test data

- We have designed and tested a consumer survey instrument that elicits willingness-to-pay values and trade-off rates for selected attributes of consumer video, together with income and price data needed to estimate demand functions for DV-related goods. It also contains demographic information that could be used to link this data into other consumer data sets.

- We have designed and tested an instrument for interviewing ATP's DV client firms. The interviews capture data on ATP's degree of causal responsibility for the initiation and/or success of the client's DV R&D project; on economic effects of the project; on potential knowledge and network spillovers from the project; and related topics.

- We developed interview questions for a very detailed qualitative model of ATP's degree of attribution (i.e., causal responsibility) for the client's DV project. (The model itself is described

in Burress *et al.*. 1999b, Appendix 1.) However, we omitted those questions from the interview protocol because of practical limitations on interview time. In particular, we judged that the basic interview for a firm could not much exceed two hours without exhausting the patience of the interviewees.

- We developed a data set of DV-related patent issue announcements during 1996-99 and linked this data set with stock price data for relevant publicly-traded firms that own the patents.

New models

- This report also includes four new models that may play supporting roles for analyzing the economic impacts of digital video. The models are included in this report because they were developed in conjunction with specifying the protocols.

- One model shows how to measure the utility placed by consumers on a bundle of video attributes, making use of time use data as well as consumer expenditure data. This model will be used to analyze consumer survey data that is now being gathered.

- One model describes a general approach for integrating consumer data at the level of individual observations from different surveys, using what Pechman and Okner (1974) called a "synthetic match." This approach could be used in subsequent research to form a highly disaggregated picture of consumer demands for both video and non-video goods.

- One model shows how to integrate income and price elasticities of demands from various published sources into a coherent utility model. This model provides an alternative way to disaggregate consumer demands.

- One model addresses the problem of interpreting the responses when interviewees are asked to give a range of likely times for an innovation to have appeared in the market place, in the absence of ATP intervention. In particular, the model gives an axiomatic approach for gathering and analyzing data on the subjective probability distributions of timing for a counterfactual event.

1. INTRODUCTION

Purpose

This report describes protocols and test data for measuring the economic impacts of digital video (DV) on the US economy. It also includes selected preliminary findings on those impacts. This report is part of a series of reports on the economic impacts of the Digital Video Focused Program Area of the Advanced Technology Program (ATP). ATP is a division of the National Institute of Standards and Technology (NIST), US Department of Commerce. This series is being prepared by the Institute for Public Policy and Business Research (IPPBR) at the University of Kansas.

Three previous reports in this series provided a preliminary analysis of the digital video (DV) market place and its economic impacts:

- Burress *et al.* (1998) established an approach for mapping complex marketplaces in terms of the general attributes of goods (based partly on Lancaster's (1971) model of demands for attributes). The approach was then applied to provide a detailed empirical description of existing and potential DV-related markets.
- Burress *et al.* (1999a) extended this approach to provide a map of technologies needed to implement the identified types of DV goods. It also provided theoretical and empirical maps of the spillovers and other channels through which innovations in digital video technology could potentially affect the US economy. And, it proposed a Computable General Equilibrium (CGE) model of the US to be used as an accounting frame and aggregation method for summarizing economic impact channels. (A CGE model is one that numerically calculates the effects of all interactions of all markets in the economy, based on moderately to highly aggregated markets.)
- Burress *et al.* (1999b) proposed general methodologies for the entire study, including possible follow-ons and *ex post* economic impact analyses; proposed specific methodology for gathering the baseline data (but not the detailed protocols); and proposed a research plan for gathering and analyzing the baseline data needed for the over-all study.

The present report describes methods and protocols for gathering the baseline data, and also analyzes some of the test data we have gathered.

A final planned report in this series will describe empirical baseline data on the economic impacts of the Digital Video Focused Program Area and analyze its significance. It is anticipated that follow-on research will track the Digital Video Focused Program Area over time and then provide comprehensive *ex post* (i.e., retrospective) measurements of its economic impacts on the US.

Research approach

While primarily technical in nature, this report does include some original empirical research findings in two areas. First, consumer focus groups were conducted to explore attitudes toward attributes of DV technologies. While primarily intended to support development of consumer survey protocols,

the focus groups also generated comments about DV that are interesting in their own right. Second, a data set was compiled and used to perform initial tests of the hypothesis that DV patent announcements have systematic effects on stock market values.

This report also contains details of several theoretical models that will be used later for data analysis. As a check on consistency of consumer survey questions with their intended uses, we developed a model of demands for video attributes derived from an indirect utility function. We also developed models concerned with integrating our original survey data with detailed public-use survey samples from other sources. Additionally, we developed a model for gathering and analyzing subjective data on the *range* or *distribution* of changes in timing of DV innovations that may have resulted from ATP's intervention.

Protocols and test data

We designed and tested a consumer survey instrument that elicits willingness-to-pay values and trade-off rates for selected attributes of consumer video, together with income and price data needed to estimate demand functions for DV-related goods. It also contains demographic information that could be used to link this data into other consumer data sets.

We also designed and tested an instrument for interviewing ATP's DV client firms. The interviews capture data on ATP's degree of causal responsibility for the initiation of the client's DV R&D project, for the success of the project, for the potential knowledge and network spillovers from the project, and for other related economic effects.

We developed interview questions for a very detailed qualitative model of ATP's degree of attribution (causal responsibility) for the client's DV project (the model itself is described in Burress *et al.*. 1999b, Appendix 1). However, we omitted those questions from the interview protocol because of practical limitations on interview time. In particular, we judged that the basic interview for a firm could not much exceed two hours without exhausting the patience of the interviewees.

We developed a data set of DV-related patent announcements during 1996-99 and linked this data set with stock price data for the firms that own the patents.

2. CONSUMER FOCUS GROUP METHODS AND FINDINGS

Introduction

The Institute for Public Policy and Business Research at the University of Kansas conducted two focus groups in Kansas City, Missouri, at the KCPT Public Television station in January, 2000. The purpose of the focus groups was to explore the potential consumer uses of new digital communications technologies. This report describes the results of the digital video focus groups. It summarizes the overall findings, organizing the results by topic areas. The report includes many verbatim quotes illustrating the various topics.

The focus groups were intended to give us insights that could be used to develop our consumer survey. In addition, the focus groups did yield some empirical results that could be interpreted as "cautions" concerning the assumed quality improvements of digital media. Of course, care should be taken in generalizing any focus group findings, since the groups are too small to be representative of the general population.

Protocols

Participants were recruited by random digit dial telephone call and were screened to ensure they were at least 18 years old. A protocol outlining questions to be asked and topics to be discussed was used to direct the discussions (see Appendix 2.1). A demonstration of digital video was played as participants entered the meeting room. Participants were encouraged to have informal discussions about the digital video demonstration before the meeting began. Two focus group facilitators from IPPBR were present at each meeting to lead the discussions. In addition to leading the discussions, the facilitators tape recorded the sessions, took notes, and analyzed the results. Each focus group lasted approximately two hours.

The main topics of discussion included:

- General impressions of entertainment and communications methods;
- Present entertainment and communications technologies;
- Emerging digital communications technologies and quality scales.

General impressions of entertainment and communications methods

Focus group participants were asked about a number of new entertainment and communications technologies. Included in the list were:

- High definition television (HDTV);
- IMAX, OMNIMAX, and 3-D IMAX movies;
- Video walls or very large video displays such as Mega Vision;
- Movies on DVD disks;

- Home theaters;
- Satellite digital television;
- Internet;
- Web TV;
- Video on demand;
- Digital still and video cameras.

For each of the technologies, participants were asked:

- Have you heard of it?
- Do you know what it is?
- Have you seen it demonstrated or advertised?
- What did or do you think of it?

Many of the focus group participants were familiar with many of the technologies discussed. Participants were most familiar with the Internet, digital still and video cameras, video walls, satellite digital television, and IMAX movies. Participants had much less familiarity with HDTV, DVD movies, home theaters, web TV, and video on demand. Most said they had heard of the technologies and had some idea of how they worked.

The participants were generally excited about the new technologies but were concerned about issues of privacy, ease of use, affordability, access to material, and longevity in the marketplace. Participants did not think these new digital technologies would replace older communications technologies; rather, they thought that new technologies would be used in addition to old. For example, many said they preferred to watch movies or sporting events live and in-person rather than through video, no matter how sophisticated the technology. Just as television did not replace going to movie theaters, most did not think new digital video technologies would replace the experience of attending an event in person. Some respondents pointed out that older analog technologies have qualities that will be lost in going to digital.

The following are comments about the various kinds of emerging technologies discussed.

HDTV (after seeing a demo at the focus group site)

"Very vivid, very sharp."
"The colors didn't bleed."
"The colors appear to be true."
"When will the cost be affordable?"
"When will there be enough material to make it worth owning?"
"I don't know what the difference is between HDTV and DVD."
"There's no question there's a dramatically increased clarity. I've been watching TV a long time, and I've never seen color like that on my TV at home."
"What does HDTV have to offer that isn't already available. Is it going to mean my TV will become obsolete?"

IMAX/OMNIMAX

“I was really impressed with IMAX. That was breathtaking. That was something.”

“Film is on the way out even for personal photography. Film degrades, and once people start seeing HDTV, they’re not going to put up with a degraded picture anymore.”

Video wall/video board

“I think they’re distracting. If I wanted to watch television, I’d stay at home.”
“I like them because they make it possible to see something you might have missed.”

Home theater

“I have a friend who has a home theater, and it is cool. But, there’s a point at which having your own theater loses its effectiveness. Part of going to a movie theater is not the great sound and big picture, it’s sitting with a bunch of other people and experiencing what goes on together and laughing and being scared with other people.”
“All the electronic stuff that’s going on is great, but people will still want to be there with the crowd screaming, smelling the popcorn and hotdogs, feeling the air, that kind of stuff. I think there’s a limit as to what people want to do in so far as creating a theater in your home.”
“There’s a social component that you miss at home.”
“When you go to the basketball game, you select what you want to watch. When you’re watching at home, the director selects what you watch.”
“But, with multiple carrier waves on DVD, you *can* select what you want to watch.”
“I like DVD, so I can listen to the director’s comments.”
“..as with all things digital, we do want the enhancements. But (digital media) are not the same. I keep referring back to my own thing, music. I know that they have digitally reproduced every sound that a Steinway can make, but it is not the same.”
"The home theaters that I’ve seen and been with are really nice. But going back to kind of the feel thing, and actually, I’ve thought about, back to the DVD and while film is sort of digitized because of the way the film actually works, you’ve got it frame by frame, but the soundtrack is digitized as well. So, recently there’s sort of been a resurgence of going back to vinyl for music because it’s analog and music is analog. It’s not every half microsecond or something. Something is sampled when you hear it. I mean, I don’t know, I mean I can tell the difference if I listen to the same exact record player vs. a CD player and in a lot of cases the record actually sounds better than the CD does. And I, sort of going to DVD, I can see losing a lot of that analog the continuation of the music and the soundtrack and things, you’re not, by digitizing everything, you miss something instead of everything being in a linear arrange it’s going to be sample, sample, sample"

Satellite digital television

“Am I wrong? No matter how many TVs you have in your house, you still have a finite number of stations you can choose from? How does that work with the smaller dishes? Does everybody have to watch the same thing?”

Internet

"What I would like is to have my screen when I'm on the Internet be like my TV screen – be bigger, clearer, higher definition."
"Are we excluding people who can't afford a computer?"
"With a cable modem, you're online all the time and you have a constant IP address. It makes it very easy for people to access your computer unless you have a firewall."

Web TV

"What I like about it is you don't have to have two phone lines. If you have to disconnect, it places a bookmark so you can easily go back to where you were if you have to make a phone call."
"It's pretty cool if you don't have a computer because it's inexpensive and easy to use."

Video on demand

"I'm ready. You know the Quest TV commercial where they talk about any movie available 24 hours a day in any language? I'm ready."
"I think it would be really convenient to have at home because with a three year old we can't always get out."
"It depends on what it costs."
"If you rent videos, pay per view is a good deal. You don't have to worry about going to the store and returning the video on time and paying late fees."
"I think it would be fun if films that weren't shown in your area were available. Most of the stuff out there now is "top 40" type stuff. I'd like to see films that don't get to Lawrence."

Digital still cameras and video cameras

"The definition and clarity of digital still cameras hasn't caught up to traditional film cameras yet."
"No matter how good digital gets, it's a different experience than film."
"I took my regular photos and got them on a disk. But, I don't have a high enough definition printer to print out my pictures."
"There is something kinesthetically pleasing to working with film as opposed to digital."
"We have a digital camera, and it's great. You can take the picture and look at it right away. We send our pictures to our family all the time over the Internet, and they can see what we did the same day."
"I got a digital camera, and we tried to use it at Christmas. But, we couldn't figure out how it worked. It wasn't very easy for me to use. But, I'm not into computers that much."
"I have one and I like the fact that it's so easy to manipulate the pictures and transfer files, but when you digitize something, you loose resolution. The resolution is infinitely better when you have film."

Present entertainment and communications technologies

Participants were asked to discuss how they and their families used present entertainment and communication technologies and what technologies they might use in the future. The types of activity participants were asked about included how they and their families used technology to:

- Keep in touch;
- Keep and share a visual record of their life (photographs, video recordings, etc.);
- Protect or check on their home;
- Be entertained by sports or drama;
- Passively receive advertisements;
- Shop for goods and services;
- Locate information.

For each activity, participants were asked:

- How do they accomplish it?
- What are the barriers?
- What new methods might they use in the future?
- What methods might they use less in the future?
- What would they like to see happen?
- Would they pay extra to get new technology?
- What ideas do they have for additional products?

Keeping in touch

"I like email for sure! It still doesn't replace hearing their voices on the phone, but it's the most convenient way to keep in touch."
"There's something about hand writing a letter that is better than email or even typing a letter. It's more gratifying than any electronic communication. It says something if someone takes the time to sit down and hand write a letter."
"Long distance will be a thing of the past because you can make free calls over the Internet."
"If I were still young and dating, I would hate video conferencing!"
"My siblings and I have a teleconference once a month, and I would like to be able to have a videoconference instead."
"I would like to be able to see my grandkids' faces when I'm talking to them."
"I use video phone over the Internet because I don't get to see my family very much, so I really like the ability to see them when I'm talking to them. There is a lag between the audio and video, but lately it's getting much better, and if I go to campus to use it, it's actually not bad at all."
"I don't like video conferencing. There's a lag that makes it really confusing to communicate because you're not sure if someone else is about to say something or not."
"I don't like long distance education because you don't have any of the input from the rest of your classmates or the teacher. Even if you have discussion sections, it's not like being right there and interacting in real time. You can't stop the teacher and say. 'Oh, wait. I have a question about that. Can you explain it further before you go on.'"
"If we were doing this over the phone, it would be hard for us to talk that much because you miss out on a lot of visual cues."
"It would drive me crazy if the picture or sound were 2-3 minutes behind. I need it to be like I'm talking face to face."
"I had a customer who used distance learning over the Internet to get her degree in nursing. She was a single mother with four kids, so it worked out real well for her."

"The biggest thing about the Internet that bothers me is the loss of privacy and the fact that you can't really screen very much what people send you."
"Basically, a lawless society is what we have on the Internet."
"I don't take classes over the Internet. I don't think I could stare at a screen that long. Plus, I think interaction helps."
"I've taken some programming courses on the Internet. I like doing that because I can't work for 2 or 3 hours, so I can do 15 minutes at a time, if I want to. Being able to be self-paced. But, I miss the interaction of an instructor."
"There could be some potential for video on demand for educational programs. My wife and I wanted to watch a program on art history, but we couldn't watch it at the time we wanted to."
"They could have a virtual professor like a help screen."
"There's something tactile that's pleasing about reading words on a page versus reading words on a screen."

"I think it's nicer to read reflected light than to read projected light on a screen."
"I like that email is when I want it, and I don't have to drop what I'm doing and be interrupted by it."
"What if a chat room was really a chat room? What if you could use a microphone?"

Keeping and sharing a visual record of your life

"I like to post photos of my family on the Internet so my family and friends can see."
"I'd like to be able to digitize images and search for the picture I'm looking for or find things on a video tape without having to search through the tape for two hours."
"Random access, that's what you really want."
"I like the DVDs because they're easier to store than VHS tapes, especially if you have a two hour tape with only 15 minute of filming on each tape. Plus the DVD will make it easier to edit things and get them how you really want it."

Checking on your home when you are away

"I used to have a job in which I traveled a lot, and I used to call up my answering machine in the middle of the night when I was away and listen to my apartment just to feel at home. I could hear the clock chime, the refrigerator, etc. I'd like it a lot better if I had a camera that could sweep through the apartment."
"We got my daughter a video monitor to watch her baby when she's in the crib."
"I would like to be able to call up a video monitor and see my child in daycare. But, I would be worried that it could be abused by voyeurs."
"I would like to be able to see the rooms and exterior of my house from a monitor in my bedroom. That would make me feel a lot better."
"It seems like it would be convenient to have your computer hooked into your house, but it also seems like it would be easy for somebody to break into the system and get into your house."

Being entertained by sports or drama

"I would love to be able to choose the camera angle when I watch a game."

"It would help if there were sub-titles at the opera that explains the plot and where it's going."
"It would be nice to have the option of a video monitor on your seat that you can control."
"Electronic instruments are not the same as the real thing, no matter how good they are. There is a symbiosis that takes place between the artist and the instrument that can't be reproduced with an electronic instrument."
"Are we becoming so wrapped up in technology in our own home that we're forgetting the outside world? When we go to the game, do we have to take the TV with us?"

Passively receiving advertisements

"I like the interactive ads. I look at them more. I also appreciate things that are funny."
"How much privacy do we want? That should be an individual decision."
"Some of us value advertising we're interested in."
"I think we've waited too long. We've already given too much information to too many people. We were so eager to get the technology that initially we sacrificed privacy."

What activities do you spend the most time on?

Participants were asked to rank in order the top three activities they spend the most time on. Participants said they spent the most time on keeping in touch. Second was shopping, and third was entertainment.

*What activities do you spend the most money on***?**

Participants were asked to rank in order the top 3 activities they spend the most money on. Participants said they spend the most money on shopping. Second was keeping in touch, and third was entertainment.

Emerging digital communications technologies and quality scales

Participants were asked about what features or characteristics were especially desirable or important in selecting a digital communication technology. Factors asked about included:

- Ease of use;
- Image quality;
- Sound quality;
- Variety and choice of programs;
- Powerful ways of finding programs, information.

TV or video monitors and speakers

Participants were asked if they had to choose between sound quality or picture quality, which would be more important to them. Almost all participants felt picture quality was more important than sound

quality. When asked to choose between high definition and more channels, the participants agreed that a greater number of channels was more important.

Home video cameras

Desirable characteristics of home video cameras were the ability to edit easily and quickly. However, it was also important that they have good image and sound quality.

Recording and playback devices and media (DVCR, DVD)

The most important characteristic of Digital VCRs or DVDs was that there be a wide choice of material to watch. A close second was that they must have good image quality and be easy to use.

Access channels: antenna, satellite, cable

Participants were unanimous in that ease of use was the most important quality for accessing channels. Participants said they did not want to have to buy a dish or other large, extraneous equipment to be able to access channels.

Access methods: TV guides, Internet search engines, and interactive ads

Search engines must be easy to use, powerful and relevant. However, several participants said they'd be willing to sacrifice some ease of use to be able to find what they were looking for.

Real time communication: videophones, videoconference

Participants said videophones and videoconferencing must be inexpensive and easy to use. They also said there should not be a noticeable lag in the transmission of audio and video. Participants said they would be willing to sacrifice audio and video clarity if it meant improving transmission speeds.

Other comments about equipment and technology

"I would like to see technology advance without making things obsolete. There's going to be a society of the 'haves' and the 'have nots'."
" TV stations are still broadcasting in black and white. Yet, there are almost no black and white TVs. How long do you have to keep these things around?"
"I'd like to be able to talk to my computer instead of keying it. I'd like to be able to see my front door and unlock it without having to go to the door."
"Things have to be easy to use."
"There's a lot of good that can be done. But, there's also a lot of inherent danger, and nobody's watching."
"People had concerns about the telephone. I think twenty years from now, this will be a moot conversation."
"I would like to have devices be compatible with each other."

APPENDIX 2.1. FOCUS GROUP RECRUITMENT PROTOCOL

DV FOCUS GROUP RECRUITMENT SCRIPT

Enter telephone number: (_____) _____-_____
Enter date/time: _____ _____

DIGITAL VIDEO FOCUS GROUPS

INTERVIEWER: WHEN YOU REACH A PARTY ON THE TELEPHONE, PLEASE READ THE FOLLOWING INTRODUCTION SLOWLY, AND BE SURE TO PAUSE AFTER EACH SENTENCE.

Hello. My name is _____, and I am calling from the Institute for Public Policy and Business Research at the University of Kansas. This is not a sales call. We are doing a study on behalf of the National Institute of Standards and Technology. The study is exploring consumer reactions to some present and future technologies for communicating and providing entertainment.

First, because we are studying households, can you tell me if this is a residence?

YES CONTINUE TO Q1.
NO OK. Thank you very much for your time. Good bye. HANG UP.

Q1. I would like to speak to the adult in the household who had the most recent birthday and who is over age 18. Would that be you?
YES GO TO Q3.
NO GO TO Q2.

Q2. May I please speak to the person in the household who had the most recent birthday and who is over age 18?

YES WAIT FOR PERSON TO GET ON LINE

Hello. My name is _____, and I am calling from the Institute for Public Policy and Business Research at the University of Kansas. This is not a sales call. We are doing a study on behalf of the National Institute of Standards and Technology. The study is exploring consumer reactions to some present and future technologies for communicating and providing entertainment. GO TO Q3.

NO When would be a good time to contact him/her?
WRITE DOWN CONTACT INFORMATION:
OK. Thank you very much for your time. We will try to reach him/her later. Good bye. HANG UP.

Q3. We are seeking people who would be interested in participating in a group discussion about current and future technologies for communicating and providing entertainment. High definition television will be one of the topics discussed, and a demonstration of high definition television will be included. The discussion will take place at the KCPT public television studios in Kansas City (125 E. 31st St.). Participants in the group discussion will be paid 50 dollars for their participation.

[INTERVIEWER: READ DATE OF THE GROUP YOU ARE MOST INTERESTED IN RECRUITING. IF THE PERSON SAYS THE DATE DOESN'T WORK, OFFER ALTERNATIVE. INTERVIEWER: CIRCLE CORRECT DATE]

The discussion will take place:

Thursday, January 6, 6:30-8:30 PM.
Tuesday, January 11, 6:30-8:30 PM.

Would you be willing to participate in this group discussion?

YES GO TO Q4.
NO THANK AND TERMINATE CALL.

Q4. Excellent! I would like to confirm your telephone number and ask your name and mailing address so we may send you a confirmation letter and directions to the meeting.
Is your telephone number (_____) _____-_____?
YES GO TO Q6
NO GO TO Q5

Q6. What is your correct telephone number? _____

Q7. May I have your name and mailing address, please?

Great! That's all the information we need.

We look forward to seeing you on: [INTERVIEWER, CIRCLE ONE]

Thursday, January 6, 6:30-8:30 PM.
Tuesday, January 11, 6:30-8:30 PM.

You will be receiving a confirmation letter with directions to the meeting in a few days. If at any time you have questions, you may call Pat Oslund at (785) 864-9108. Thank you very much for your cooperation. HANG UP.

ANSWERS TO POSSIBLE QUESTIONS

What is National Institute of Standards and Technology?
Otherwise known as NIST, this federal agency was established by Congress "to assist industry in the development of technology ... needed to improve product quality, to modernize manufacturing processes, to ensure product reliability ... and to facilitate rapid commercialization ... of products based on new scientific discoveries."

NIST strengthens the U.S. economy and improves the quality of life by working with industry to develop and apply technology, measurements, and standards.

What is High Definition Television?
High definition television, or HDTV, is a new way of broadcasting television. The signals will be much more clear than what you see today. The detail and viewing area will be more like going out to a movie. The picture will have more detail, and it will also be wider.

Where is the KCPT studio?
The address is 125 E. 31st Street in Kansas City. It is located in Midtown, very near the Channel 5 Broadcast Tower. That's the big tower in Midtown that is lighted up for the holiday season. We will send a map with more detailed instructions.

What about handicap accessibility?
The KCPT building is **not** officially designated as wheelchair accessible. However, there is an elevator to the second floor that is big enough for a wheelchair. We will be using the KCPT 2nd floor conference room. We can't change the place of the discussion because that is where the high definition television is available. We will provide any other accommodation that we can. Please let us know what you will need so that we can make arrangements.

Can I bring my (husband, wife, friend, etc.)?
Our recruitment is based on a random selection method, so only the person we recruited is eligible to participate and to receive the $50 compensation. We are sorry that others cannot participate at this time.

APPENDIX 2.2. FOCUS GROUP PROTOCOL

CONSUMER FOCUS GROUP

Participants: Residents of the Kansas City area
Location: Station KCPT, Kansas City MO
Recruitment: Survey lab
General Purpose: To explore consumer reactions to both present and future methods and devices for communicating at a distance and providing entertainment using digital video methods.
Specific goals: to suggest things we haven't thought of:
- ideas for the consumer survey on DV
- ideas on how/why people will use DV

0. DEMO OF HDTV

(Playing as the participants arrive and get refreshments. *Ask for reactions informally*.)

A. OPENERS (5 minutes)

Introduce self and assistant(s).
Explain the idea of a focus group.
Research is being conducted by KU under a grant from the National Institute for Standards and Technology.
Introduce the topic for the session:

> To explore consumer reactions to some present and future methods and devices for communicating at a distance and providing entertainment (don't mention DV yet).

State that the session will be audio-taped.
Assure participants of anonymity of responses. **Be sure that everyone has signed and turned in the consent statement and receipt for payment.**

Guidelines for participation:
Speak one at a time
Speak so that everyone can hear you
Do not hesitate to disagree with others; there are no right or wrong answers
I may need to interrupt from time to time to keep the discussion on track

B. INTRODUCTION OF PARTICIPANTS (5 minutes)

So that we may all know each other a little better, let's begin with each person providing the following:

- First name
- Where do you live?
- Your occupation?
- What do you like to do when you're not working?
- How many people live in your household?

C. WARM-UP: General impressions of entertainment and communications methods (30 minutes)

To get started, let's talk about some of the new entertainment and communications technologies that are being introduced or just being developed.

1. For each of the following please tell us:
[display list]

- Have you heard of it?
- Do you know what it is?
- Have you seen it demonstrated or advertized?
- What did or do you think of it? [explain each item as needed]

a) high definition TV (HDTV) [demonstrated]

b) IMAX or OMNIMAX movies [at the Zoo]
also: 3-D IMAX [at the new science museum]

c) video wall or very large display [e.g., at the Chief's stadium]

d) movies on DVD disks [they used to call it digital video disk]

e) home theater [big screen TV plus surround sound]

f) satellite digital TV [has a small dish antenna, very clear picture, lots of national channels]

g) the Internet - email, world wide web
also broad-band or high-speed Internet access (e.g. Cable MODEM) [very fast Internet WWW pictures]

h) web TV (interactive TV plus Internet access) [click on an ad, get more information]

i) video on demand (VOD) [order up any TV movie in the their catalog whenever you want and get it on cable at home]

j) digital still and video cameras [just like film or VCR except you can send it on the Internet]

D. ENTERTAINMENT/COMMUNICATIONS METHODS (60 minutes)

NEXT, let's talk about different ways you might want to be entertained, or why you might need to communicate at a distance, and how you might accomplish it.

1. For each type of activity:
[display list]

- Think for a minute about if and how you and your family do it.
- Or give me some examples of what you do.
- What are the barriers to using the different methods? [possible prompts in brackets]

For each type, we would also like to know:

- what new methods might you use in the future?
- what techniques do you use now that you might use less?
- what would you like to see happen?
- would you pay extra to get it?
- have you any ideas for additional products?
  [Explain technologies as seems to be needed]

a) keeping in touch with people you care about.
[now: telephone, mail, email]
[future: videophone, videomail {live or canned talking heads}]
also: getting in touch with groups or meeting people at a distance; getting an education at a distance
[Now: webpage/threaded discussion, e-list, snail mailing list, teleconference, telephone; books, mail]
[New: videoconference, distance learning]
{sit in a room with live TV connecting people in several places}
[Future: video bulletin boards/web sites, video discussion list, video chat rooms]

b) keeping and sharing a visual record of your life
[Now: photos, movies, VCR]
[New: digital camera and VCR, digital video editors]
{better pictures than older camcorders}

c) protecting or checking up on your house when you are away
[Now: burglar alarms, surveillance camera, remote dial-in]
also monitoring conditions at a remote location
[New: check on child in daycare, view traffic conditions, etc.]
[Future: Internet surveillance, household management systems]

d) being entertained by sports or drama

[Now: VCR rental, TV, cable, pay-per-view, radio, newspaper/magazine subscription, book club, library; physical presence at event]

[New: VOD, program guides]

[Future improvements in display: immersiveness, 3D, POV control]

{a sense of being surrounded by a real place}

[Continuing improvements in production values: quality of computer graphics and special effects, animation]

e) passively receiving advertisements

[Now: mail, TV, newspapers and magazines, radio, signs]

[Future improvements in display: wall displays, immersiveness, interactive ads

[Continuing improvements in production values: quality of computer graphics and special effects, animation]

f) actively shopping and purchasing goods, and services

[Now: telephone/catalog, mail, non-DV Internet e-shopping, shopping in a physical store]

[New: video e-shopping]

{e.g. create a picture of yourself in a new dress and then turn it around in space}

g) locating information in general

[Now: TV, printed periodicals, books, hot line]

[Future: image searching, personalized news TV]

{e.g. find a web site that shows videos of a hurricane as it occurs}

h) Are there other general types of activities, purposes, or communication technologies we haven't mentioned?

2. What are your ***primary or most important*** activities of this kind?
   - What other major activities?
   - Which 3 types of activity do you spend the most time on?
   - Which 3 types of activity do you spend the most money on?

E. DEVICES AND QUALITY SCALES (20 minutes)

1. For the following types of technologies and devices, what features or characteristics are especially desirable or important to you? What are less important?

   [possible prompts:
   - ease of use
   - image quality
   - sound quality
   - wide variety and choice of programs
   - powerful ways of finding programs, information]

a) TV or video monitors and speakers
[picture quality: definition, 3D, wide screen]
what is more important: sound or picture quality?
what is more important: high definition or more channels?

b) home video cameras

c) recording and playback devices and media (DVCR, DVD)

d) access channels: antenna, satellite, cable, video rental/purchase, telephone

e) access methods: TV guides, Internet search engines, interactive ads

f) real time communication: videophones, video conference

F. WRAP-UP & CONCLUSIONS (4 minutes)

1. Is there anything else you would like to add? Anything we have missed?

Thank you for your time. We appreciate your willingness to participate. Your comments have been very helpful.

3. CONSUMER SURVEY METHODS

Purpose of the consumer survey

The ultimate goal of the DV consumer survey is to evaluate the effects of improved DV technology on consumer satisfaction. For the present baseline study, most of the effects of ATP-supported DV technologies have not yet been actualized. Consequently, consumers are not yet fully aware in concrete terms of what the new DV technologies will mean for them. Any information they provide us now about the value they expect to place on new technologies in the future will surely undergo substantial revision after the fact. Therefore, at this stage of the research our goals are necessarily limited to the following:

- Proof of concept. We will show how data on consumer valuation of DV technology can be captured and analyzed. (This report covers data capture only; a subsequent report will show how it can be analyzed.)
- Naive valuation. We will capture baseline data on how relatively-uninformed consumers see things at this time, keeping in mind that it will change in the future.

Our survey assumes that two different types of consumer models will be used to represent consumers:

- Utility function (especially useful in a general equilibrium approach to valuation), and
- Consumer surplus (which assumes a partial equilibrium approach to valuation).

Each of these techniques has been used widely in the economics literature to estimate changes in consumer satisfaction and are standard methods of applied economics.

Needed characteristics of data

For the data from the survey to be the most useful, it should be able to be used in two ways: it should be able to be merged with data from other sources, and it should be able to be used to estimate consumer preferences.

Merging with other data

The data generated from the survey need to be consistent with consumption data from any other sources that will be used for the statistical analysis of consumer behavior. In our future research, we expect to use two types of additional data (in conjunction with data generated from our survey):

- Consumption of non-DV goods, and
- Use of time.

These data are needed in order to draw the kind of complete picture of household utility that is required for a general equilibrium analysis. The additional data are much less important for the

consumer surplus approach. We think it is especially important to include time-use data, because much of the effect of enhanced consumer video is likely to consist in a change in the pattern of recreational time use. Consequently, expenditures of dollars alone are not an adequate measure of what the consumer "pays" in order to utilize DV goods; the value of changes in time-use must also be taken into account.

Micro data on consumer expenditures and on time-use are gathered in surveys done by others and are made available for public use; hence there is no need for us to repeat their work. However, the data generated by our survey must be able to be linked in some way to the data generated by the other surveys. This means that the basic styles and approaches of the surveys need to be similar. Keeping them similar creates data that are more compatible in the sense that one is measuring similar phenomenon in each survey.

The data from two surveys that are being related to each other need to match in a stronger sense. The surveys need to contain data for the same or closely similar variables so that statistical techniques can be used to merge the results of the surveys with each other. Practically, this means that questions need to be asked on both surveys about demographics and other common variables that help determine proxy consumption and/or time-use patterns.

Ideally, data from the various surveys would be merged at the level of individual sample observations using what is called a "synthetic match" (Pechman and Okner, 1974). In other words, observations from two different data sets are matched using important underlying variables such as income and family composition, which must be common in the two observations being matched. We have designed the consumer survey in such a way that a synthetic match is feasible with microdata such as the 1998 Consumer Expenditure Survey, available from the US Bureau of Labor Statistics (2000) and Robinson's *Americans' Use of Time, 1985* survey, available from ICPSR at the University of Michigan (Robinson, 1993). Chapter 6 sketches an algorithm for performing a synthetic match. Another possible approach, also discussed in Chapter 6, involves integrating the new data with previously-estimated consumption parameters.

Estimating consumer preferences

The data generated by the survey also must be used to estimate consumer preferences for various types and qualities of digital video. In particular, these data will be used in a subsequent report to estimate a representative utility function. Besides providing preference rankings from consumers, the survey also needs to provide value estimates for consumption of digital video that can be used to calculate consumer surplus.

Utility and demand system

Because our goal is to estimate a demand or utility system, we have specified a particular utility function. We have also planned an econometric method for estimating the utility system. Before finalizing the survey instrument, we listed all the variables needed to estimate this system. We then performed a cross check to make sure that all needed variables were included in the survey. The utility system is described in Appendix 3.1. It has the following key features:

- It includes demands for time as well as demands for goods, and the two kinds of demands are interrelated.
- It is in Gorman Polar Form (Gorman, 1959). Consequently, it obeys sufficient conditions for aggregation, meaning that demands can be smoothly integrated with the demands for other goods without violating the assumptions of economic demand theory.
- It is linear in income, so that the translation from utility to money metric is direct.

Focus groups as input to survey design

The focus groups (described in Chapter 2) were intended in part to inform the survey instrument. As it happened, the focus groups did not dramatically change our ideas on what the survey instrument would contain. Instead, they provided a general confirmation of our approach. However, at specific places in the survey, the focus groups did have some effect. Specifically, the information from the focus groups affected the survey instrument writing in two ways described below.

First, the focus groups provided us with some idea of the level of sophistication we should expect to meet when asking people questions about visual electronic entertainment. We did not want to "turn people off" by using language that they were completely unfamiliar with, while at the same time, we did not want to imply that respondents were ignorant of familiar developments in video technology.

Second, the focus groups raised questions which in one form or another found their way into the survey instrument. Put simply, the focus groups broadened our awareness of potential answers to questions and our awareness of interesting questions and answers the respondents may give us. For example:

- The focus groups revealed that not everyone perceives digital as higher quality. For example, some people preferred the sound of music from vinyl records to that from (presumably higher fidelity) digital CDs. Consequently, at certain points in the survey instrument, we asked questions that might seem curious to people who prefer conventionally "better" quality to "worse" quality. For example, we asked what are the disadvantages of DVD players as compared to VCR players.

- The focus groups cast light on why people prefer going to the movies rather than just renting them and watching them at home. Some people prefer the social aspect of watching a movie in a theater, even if the movie is old and available on VCR and DVD.

Needed categories of information

We wanted to ask survey respondents about three categories of information:

- Demographic questions;
- Current household consumption of video technologies and entertainment services; and
- Respondent's preferences and evaluation of potential new video entertainment technologies and services.

Demographic information

We wanted basic demographic information about surveyed households: the size and composition of the household, labor market activity, gender, and income.

Existing and planned household TV hardware and current video entertainment services

We wanted to know what types of video equipment the household currently has available, such as the size of the television screen on their best television set and whether they have a VCR or a DVD. We also wanted know the types of video-related services they were currently receiving, such as cable television, premium channels, or satellite television. The point is not only to establish a baseline level of consumption, but also to establish anchor points so that hypothetical or contingent evaluation responses can be related back to actual behavior. In addition, we asked open-ended questions about the respondent's attitudes toward existing video technologies.

Preferences and values for new video technologies

We wanted to know how much the respondent values the improvements that digital video can provide the consumer. We wanted respondents to evaluate choices between different technological possibilities such as larger screen size and improved picture quality. We also wanted to place dollar values on their willingness to pay for the improved services provided by digital video. In addition to picture quality, we were also interested in the respondents evaluations of DVD players, video on demand, and technologies that provide more accommodating viewing such as "instant replay" of live television.

In general, the survey was designed to focus as far as possible on characteristics of DV goods rather than on specific products (Lancaster, 1971). That is, we assume that much of the contribution to utility from new DV technologies will consist in qualitative improvements in the entertainment experience, and the survey must place values on those qualitative changes. Note however that our survey does not include a comprehensive inventory of all characteristics or attributes of DV consumer goods;[1] rather it constitutes a proof of concept, showing how survey questions can be used to evaluate DV characteristics.

Actually, the survey contains two kinds of questions, and consequently supports a "proof of concept" for two different approaches to valuation.

Binary choice. One series of questions asks for tradeoffs between different bundles of attributes, without any reference to money. This approach is theoretically desirable, and especially so in cases of hypothetical goods, where consumers have not yet had the experience of making choices involving expenditures of real dollars. However, this approach is very expensive, in the sense that a relatively large number of survey questions must be asked in order to define the utility function. We asked

[1] For an initial attempt at an exhaustive list of important characteristics or attributes of DV goods, see Burress *et al.* (1998).

questions of this type to force a comparison between large screen TV sets with conventional picture quality, versus smaller TVs with high definition picture quality.

Willingness to pay. Another series of questions asks for direct evaluation of the characteristics of hardware or services in terms of money. This approach is relatively economical, in the sense of requiring a more limited number of survey questions. However, it also requires simplifying assumptions on the utility system to be estimated. We asked questions of this type on all major DV characteristics that we surveyed.

Survey procedures, testing, and content

The survey was designed to be administered to a random sample of households throughout the US. To reach these households, we generated random phone numbers based on in-service phone exchanges in every state. This procedure is costly in that many of the randomly-generated numbers will be out-of-service numbers or business numbers. At the same time, the procedure includes numbers for households that have their phones unlisted. Administration of the survey began in April, 2000, and is expected to be completed in June, 2000.

We subjected the survey instruments to internal testing among our staff members - those who were not working on the digital video project directly. Their comments led us to revise and simplify several of the questions. We then did a small trial run using the random phone number list. As we made calls to the public, we discovered that a few additional questions needed revision and that the introductory script needed to be simplified. In particular, we needed to make it clear to the public that we were not trying to sell them anything. Some test data are included in Appendix 3.3.

The rest of this chapter describes the detailed content of the survey questions. It follows an outline of the survey instrument, but it is organized by topic rather than exactly following the sequence of questions in the survey instrument. A copy of the survey instrument is provided in Appendix 3.2 and shows the actual sequence of questions.

I. Introductory material

In the beginning of our survey script, the surveyors identify who they are and what organization they are representing. The first step is to identify the person in the household who will supply the information we want about electronic entertainment. When we started making calls for the survey, we asked to speak with “person in your household who knows the most about your household’s electronics purchases and who is over the age of 18.” However, this “scared off” many potential survey respondents and required us to call back many times to reach the desired person. As a consequence, we simplified our protocol to speak with the person who answered the phone, provided the person was over age 18.

II. Demographic information

We included seven different demographic variables in the survey questions:

- Number of people in the household;
- Age of the household residents by category;
- Whether respondent rents or owns dwelling;
- Number of employed persons in the household;
- Hours worked by top two workers in the household;
- Gender of the respondent; and
- Estimate of household income.

The gender of the respondent is surmised by the surveyor rather than asked directly. The income question asks about income only within broad categories and is put at the end of the interview. It has been our past experience that questions on income tend to be sensitive and often cause respondents to hang up the telephone without answering any more questions.

III. Existing and planned household TV hardware and current video entertainment services

We wanted a basic inventory of the entertainment technologies tied to the television and the services received in the household tied to the television. We separated the questions about television technology and services into two basic types of entertainment:

- TV transmission (broadcast, cable, or satellite): the traditional television experience of watching television channels provided by antenna, cable or satellite; and
- Video playback: watching recorded movies at home with either a VCR or a DVD player.

TV transmission

Hardware. The television set is the primary technology for home visual entertainment. As such, we wanted to know about the quantity and quality of the television sets that the respondent's household has. We wanted to know how many working color televisions the household has and the size of the screen of the best television. We also wanted to know the respondent's opinions about television quality. We asked how the respondent would like her or his television improved. We also asked about familiarity with high definition television (HDTV) and, if the respondent was familiar with it, what her or his response was. If the respondent was thinking of buying a new television in the next 12 months, we asked whether he or she was considering purchasing an HDTV.

Services. We asked about services provided through the television set, including cable television, premium channels, and satellite television. We also asked the total number of television channels the household receives. We asked what the respondents paid for cable services, satellite television, and premium channels. Besides these services, which are directly tied to traditional television sets, we also asked if the households received Internet services, and if so, how much they paid for these services. Finally, we asked how many hours per week the respondents watch television.

Video playback

Hardware. We asked if the household had a VCR or a DVD player, and, if so, when it was purchased and how much it cost. If the respondent did not have a DVD player, we asked if he or she were thinking of getting one in the next 12 months. If the respondent either had a DVD player or had seen one, we asked him or her some comparison questions: what were the advantages and disadvantages of the DVD player, as compared with a VCR?

Services. We asked respondents to compare their experiences of going to a theater to watch a movie with renting a movie on either VCR or DVD to watch at home. We asked them how often they engaged in each type of activity, how much they spent per person when they go to a movie theater, and what they liked about each type of activity. We then asked which type of activity they preferred. Finally, we asked the respondents how they thought the experience of watching movies at home could best be improved.

IV. Preferences and values for new video technologies

Questions on preferences about new technologies and services are the core of the survey instrument. We tried to extract preferences about two basic aspects of using the television for entertainment:

- The quality of the screen picture, and
- The extent of viewer control of the content and timing of video entertainment.

The survey instrument has three basic groups of questions that elicit respondents preferences on:

- The trade-off between screen size and picture quality;
- Respondents' preferences for different types of viewer control of television content and timing;
- Respondents' evaluation of one big package of viewing entertainment that combines screen size, picture quality, and viewer control of content and timing.

Screen size and picture quality

We wanted respondents to reveal their preferences for improved picture quality. There are two different approaches in the literature. One approach uses the simple willingness-to-pay question; i.e., "How much more would you pay for improved picture quality on your television?" Both common sense and previous research show that this basic question has to be modified in various ways to be effective, but the key idea is to obtain a stated dollar value for a given commodity or service.

The second approach has respondents make a series of binary choices involving trade offs between picture quality and other attributes. The basic question format is: "Which do you prefer, improved picture quality with a low level of other attributes, or the picture quality you currently have on your television with a high level of other attributes?" Again, this basic question must be altered to be effective.

Binary choice. In order to make the binary choice questions effective we needed to bundle picture quality with some other aspect of television technology (1) which is easily describable over the phone, and (2) for which most people can easily agree on what is better and what is worse. We chose screen size as the second characteristic of television-viewing technology. Screen size is easily describable over the phone — we asked respondents to compare 27, 36, and 49 diagonal inch screens (which are fairly standard sizes), and most people can agree which is better — bigger is better, at least up to a point.

Describing picture quality to respondents was a harder problem. Picture quality includes several distinct scales (e.g., spatial and temporal resolution and color accuracy), and has numerous distinguishable gradations within each scale, but for description over the phone we settled on two basic types of picture quality:

- "Picture quality like a conventional color TV," and
- "Picture quality as crisp, clear, and colorful as what you would see in a movie theater."

Again, we used the focus groups to get some idea of what respondents could distinguish in terms of picture quality, and we decided on these two extremes. We originally considered an intermediate level of picture quality between the two extremes, but pretests of this additional level of picture quality indicated that it was too complex to be easily communicated.

The choices of attributes we settled on were: screen size (27, 36, and 49 diagonal inches), and picture quality (conventional color television and movie theater quality). We could give the respondents up to 3x2 = six possible bundles to compare between, for a total of 15 possible comparisons per respondent. However, the innate preference orderings "bigger is better" and "higher picture quality is better" greatly reduce the number of useful comparisons. We could reasonably assume for example that if a consumer preferred a 27 inch screen with movie quality picture, over a 49 inch screen with convention color television, then they would also prefer the 27 inch screen with movie quality picture over a 36 inch screen with conventional color television. This (not especially shrewd) insight allowed us to limit the maximum number of comparisons that we needed to ask each respondent to 3. By randomly sampling which respondents were asked which question, we further reduced the number of comparisons to either one or two per respondent.

We began the binary choice questions with the same question for everyone:

> "Which would you prefer, a 49 inch screen with a conventional color television picture, or a 27 inch screen with movie quality picture?"

If respondent chose the 27 inch screen with movie quality picture, it can be shown that all possible comparisons are determined by the "more is better" rules described above, so the binary questions were terminated.

If respondent chose the 49 inch screen with a conventional color television picture, then he/she was asked one out of two possible follow-on questions, either:

- "Which do you prefer, a 49 inch screen with a conventional color television picture, or a 36 inch screen with movie quality picture?", or
- "Which do you prefer, a 36 inch screen with a conventional color television picture, or a 27 inch screen with movie quality picture?".

A random selection process was used to determine which follow-on question a given respondent was asked.

Willingness to pay. Eliciting the consumer's willingness to pay for picture quality was a simpler problem, in part because we had already introduced the concepts of picture quality in the course of the binary choice questions. We used what is called a "referendum approach," because the literature on contingent valuation and stated preference methodology argue that this approach has the least bias. In other words, the respondent is not asked to provide a definite dollar value for a good; instead, the respondent is asked whether he or she would purchase the good if the price were a stated number of dollars. In order to reveal several points on the demand curve for picture quality, we did not propose the same dollar amount to each respondent. Instead, we randomly varied the amount among four possible values.

We set up the question by putting the respondents into a purchasing frame of mind by asking them to "suppose that they are going to buy a new large TV this month." We identify this large television as 49 inches or larger. Then we give them a binary choice, something they are familiar with by this point in the survey. They have two available picture quality choices: a TV set with a movie quality picture, and a TV set with conventional TV picture quality. Now we introduce the price difference that randomly varies among respondents. The respondents are told that they must pay either $50, $200, $500, or $2000 more for the better quality picture. Then the respondents are asked which they would buy: the television with conventional TV picture quality or the TV with movie quality picture.

Control of content and timing

We wanted the respondents to evaluate three different types of technologies that improved viewer control of the content and timing of video entertainment. The technologies are DVD players, an "instant replay" mechanism, and "video on demand" (or VOD).

The problem with these questions was to describe the new technologies so the respondents could get a feel for how they would alter their television viewing, without making the questions sound too commercial.

In each case we used a willingness-to-pay type of question like the question described above with randomly changing prices for the technology. However, some changes in the basic format had to be made because of each of the technologies. We will discuss these details for each technology.

DVD Player vs. VCR. The question asking respondents to choose between a DVD player and a VCR is the question most similar to the above willingness-to-pay question. We asked the respondents to suppose they were going to buy a "video recorder and player this month." We further asked them to suppose that a new DVD-type machine was available "that combined all of the advantages of today's

DVD players and VCRs, and had none of the disadvantages. We ask the respondents to suppose that this machine costs more than a conventional VCR by one of four values, $50, $100, $250, and $500, randomly selected. Then they were asked which machine would they buy.

The mention of possible disadvantages of the DVD player is included because, in the section just before this question, the respondents had been asked to compare DVD players and VCRs, and one of the questions asked them what they did not like about DVD players.

Instant Replay. "Instant replay" is a device added to the television which will allow "you to stop what you were watching, even if it were a live telecast, and go back and watch part of the telecast again. At the same time as you were using this 'instant replay' feature, the device would record anything you were missing." So, "instant replay" is not exactly what the device is, but the name was as close as we could come to a phrase that described the device and was recognizable to nearly everyone. The introductory descriptive material seemed necessary to support an informed decision.

We also altered what the respondent would hypothetically pay for. We asked if they would rent the device if it cost a certain amount per month to rent. The amounts, randomly selected, were $3, $7, $15, and $30 per month.

Video on Demand. "Video on Demand" (VOD) refers to generic subscription services that make available a "huge library of movies, documentaries and educational programs" that are available within five minutes at any time of day. This service would be like a super video store delivered directly to your television for a fixed fee once a month with no additional charge for each individual order.

Respondents were asked if they would pay a given dollar charge for this service. The stated monthly amount varied randomly across four possible charges: $8, $16, $40, and $80.

A big package

The final set of preference questions is concerned with a combination of all of the characteristics discussed in the previous two sections: the "big package." The "big package" provides large screen size and movie picture quality, and more viewer control of television content and presentation with a DVD player and recorder, "instant replay," and video on demand.

A slightly different willingness-to-pay procedure was used with the "big package". First the respondents were asked if they would pay a certain amount per month for the "big package." As before, the amount for each respondent was randomly chosen from four different values — $16, $40, $80, and $200. If the respondents said either yes or no to this amount, then they were asked another valuation question. (If they said "don't know" or refused to answer, they were not asked a second valuation question.) If the respondents said yes to the initial amount, then they were asked if they would make monthly payments of double the initial amount to get the "big package." If the respondents said no to the initial amount, then they were asked if they would get the "big package" if the cost were reduced to one half the initial amount.

In the contingent valuation and stated preference literature, this procedure is called the double-bound dichotomous choice procedure. Hanemann, Loomis, and Kanninen (1991) have shown that using the double bound procedure is statistically more efficient than using the single bound procedure. From an economic point of view, the advantage of this procedure is that it reveals more of the demand curve for the "big package" without falling into a "bidding marathon" (with the respondent answering repeated questions designed to narrow down his or her valuation) -- a procedure known to create significant bias.

The last three questions act as a check on the reasonableness of the respondent's answers, and also add information about potential changes in viewing habits and time allocation. The first question asks if the respondent did have the "big package," would he or she personally watch more television? If the answer was no, don't know, or refused, then the survey was ended. If the answer was yes, then the respondent was asked to estimate the increased number of hours he or she would watch television with the "big package." The respondent was then asked what would he or she would do less. These answers provide information on the potential changes in use of time by respondent due to the "big package."

APPENDIX 3.1. CONSUMER UTILITY AND DEMAND MODEL

A practical indirect utility function for the demand for video attributes

Overall goal:

We want to use time-use information as well as consumption choice information to help establish the utility of TV attributes, using a tractable demand system derived from utility theory.

Subgoals:

1. Indirect utility should be stated in a direct money metric. Hence it must be linear-affine in income; hence it can be represented in Gorman Polar Form (Gorman, 1959). Consequently, it would be trivial to calculate an exact general equilibrium equivalent to the consumer surplus welfare approximation.

2. We want to have a combined demand for time and goods, with both a dollar budget constraint

(1) $\mathbf{P'X} = W_0 T_0 + Y,$

and also a time budget constraint

(2) $\mathbf{W't} = H = 24\text{hours/day} - T_0^*.$

In the above, **P** is a vector of prices of goods and/or attributes.
X is a vector of quantities of goods and/or attributes.
W_0 is the wage rate.
T_0 is labor hours, which is assumed fixed at T_0^* and is not included in the time budget. (It is empirically reasonable to assume that the labor supply is fixed, provided that housework is included in the definition of labor. As we shall see, there does exist a simple indirect utility representation for the fixed labor supply.)
Y is non-labor income.
T is a vector of time allocations to activities.
W is a purely formal set of time costs. After optimizing, we will set $W_i = 1$ for all $i>0$ so that non-work hours add up to H.[2]

3. In our formalism, indirect utility $V(\mathbf{P}, \mathbf{W}, W_0, Y, H; T_0^*)$ has a dual aspect reflecting the two budget constraints. It turns out that this leads to multiple Roy's identities as follows.

For fixed **P**, W_0, Y we have $T_i = -(\partial V/\partial W_i)/(\partial V/\partial H)$.

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[2] In a more advanced application, **W** could have a practical meaning implying values other than 1, for example, to accommodate independent information on the relative psychic costs of engaging in different activities.

For fixed **W**, W_0, H we have $X_i = -(\partial V/\partial P_i)/(\partial V/\partial Y)$.
For fixed **P**, **W**, H we have $T_0 = T_0^* = -(\partial V/\partial W_0)/(\partial V/\partial Y)$.

(The proof that this setup works is direct -- just define V as the criterion for the overall household optimization problem, then note that it is also the criterion for the separate partial optimization problems for **T** and **X**. These separate problems lead independently to Roy's identity, using the same logic that is explained in texts of microeconomic theory such as Varian (1978).)

4. The TV quality good and TV time expenditure should have these characteristics:

- dollar expenditures falls with TV quality price P_{TV}.
- time expenditure can either fall or rise with TV quality price P_{TV}.
- utility is bounded even when TV quality price P_{TV} equals 0 or ∞. (This is important so that we do not get an unrealistically infinite consumer surplus either for introducing new goods, or for dropping the price to zero.)

We will interpret T_{TV} and X_{TV} as the marginal change in viewing time and TV quality, starting from some fixed reference point.

A solution

A specification for indirect utility V that satisfies all of these constraints is

(3) $V = [(\alpha + F)/(1 + F)](W_0T_0^* + Y)H/[A(\mathbf{P})B(\mathbf{W})] + E(\mathbf{P}, \mathbf{W})$, where

(4) $F = F(\mathbf{P}, \mathbf{W}) = [P_{TV}/C(\mathbf{P})]^{\beta}[W_{TV}/D(\mathbf{W})]^{\gamma}$, and:

A(.), B(.), C(.), and D(.) are positive and homogeneous of degree 1, and
E(.) is homogenous of degree zero separately in **P** and in **W**.
For simplicity we will assume that:

- A(.) and C(.) do not depend on P_{TV};
- B(.) and D(.) do not depend on W_{TV}; and
- $E \equiv 0$.

Then α turns out to be the ratio between utility when TV quality is infinite, and utility when TV quality is zero. Note that linearity in income of V (and hence of demands) implies that this ratio must be independent of income (i.e., demands are homothetic). That restriction should be OK for analyzing cases where income effects are not significant.[3]

[3] However, we could "cheat" in actual applications and let F depend on income and work hours by assuming, for example, that they appear in F as markers for heterogeneous preferences rather than as optimization parameters. Note that under that interpretation, F would not be differentiated with respect to income when using Roy's identity.

From Roy's identity we have:

(5) $X_{TV} = [- \beta F/(P_{TV}(\alpha + F)) + \beta F/(P_{TV}(1+F))](W_0T_0 + Y)$

(6) $T_{TV} = [- \gamma F/(W_{TV}(\alpha + F)) + \gamma F/(W_{TV}(1+F))]H$

Note that the ratio of expenditure budget share to time budget share for TV quality is:

$(P_{TN}X_{TV})/(W_0T_0 + y)]/[(W_{TV}T_{TV})/H] = \beta/\gamma.$

If β were known, this equation could be used to estimate $(W_{TV})\gamma$. However, a better estimation strategy is to use time information equally with quantity information in order to estimate the response of F to the relative price of quality.

We now set **W** to a vector of constants, and assume that C(**P**) = constant (i.e., other prices do not vary or are not observed in our data set). After absorbing various constants into δ and η, the demand equations become

(7) $X_{TV} = [\beta F(\alpha-1)/((\alpha + F)(1+F))](W_0T_0 + y)/P_{TV}$

(8) $T_{TV} = [\delta F(\alpha-1)/((\alpha + F)(1+F))]$, where

(9) $F = \eta P_{TV}^{\beta}$,

and where $\delta = \gamma H/W_{TV}$ and

$$\eta = [1/C(\mathbf{P})]^{\beta}[W_{TV}/D(\mathbf{W})]^{\gamma}.$$

We assume $\beta > 0$ because utility increases with TV quality. However, γ can have either sign, so time usage could potentially decrease as well as increase with TV quality. ($T_{TV} < 0$ is allowed because it measures a marginal time use only.) Hence we require $\alpha>1$, $\beta>0$, $\eta>0$, but δ is unconstrained. Given data on (P_{TV}, X_{TV}, T_{TV}) we can estimate the four parameters α, β, δ, η using a non-linear regression. (We could also generalize the parameters to depend on family size and workforce participation.)

Application

Marginal time use

T_{TV} can be interpreted as the answer to the marginal time use question for the "big package" in the survey.

The price of aggregate video quality

P_{TV} can be interpreted from the willingness-to-pay question for the "big package." However, since P_{TV} is a marginal price, we need to subtract off the amount they would be willing to pay for what they already have. We will estimate that as equal to what they actually do pay now.

To estimate what they actually do pay now, we need a series of assumptions. For example:
Hardware quasi-rents: acquisition cost * 1.5% carrying cost and maintenance per month.
Acquisition cost of best TV is asked on the survey.
Acquisition cost of a DVD and/or VCR - assume $300 each.
Video service rentals: actual payment
Rental for basic cable + advanced cable is asked on the survey.
Rental for movies: ask the number of rentals per month, estimate $2/ video plus time costs.
Estimate time costs at 30 minutes/video * $10/ hour = $5 per video.

Marginal aggregate video quality

But how do we measure X_{TV}? It is an aggregate over quality attributes. For example, we could use trade-off data on screen size and picture quality to estimate an aggregate utility for those two variables, using a logistic regression (see below). In general, that approach is theoretically sound and could be applied for aggregating all quality variables. However, because of survey costs, we will not have extensive-enough trade-off data on most of the variables to use that approach. Therefore, the screen aggregate will have to be aggregated together with other variables using a combination of willingness-to-pay (WTP) and market data. We will define an approximate index of aggregate quality:

(10) $X_{TV} = \Sigma_i \pi_i q_i$, where

π_i = marginal WTP_i, q_i = amount of attribute i.

To find $\boldsymbol{\pi}$, we can regress P_{TV} (i.e., WTP for the whole package) on detailed WTP answers for components of the package (for those components where we asked about WTP), plus data on what component they have now (for components where we did not ask about WTP), forcing all coefficients positive. (We might condition this regression on income, family size, and other variables.)
We would interpret coefficients on what components they have now as π_i for those components. We would interpret coefficients on the WTP responses as correction factors on the WTP responses.

A logistic regression for aggregating picture size and picture quality

We assume a sub-utility function which is Constant Elasticity of Substitution (CES):

(11) $U = [(\text{screen in inches})^{\lambda} + (\text{picture quality scale})^{\lambda}]^{1/\lambda}$.

The picture quality scale could be assumed to be 1 = current, 2 = movie-like, 0 = a nearly useless picture filled with static (an extrapolated reference point).[4]

A nonlinear estimation method is:

Select an arbitrary λ.

Define the binary variable Z = 1 if (consumer chooses case 1 over case 2) else 0.

Estimate Z = logistic function of { (screen size 1)$^{\lambda}$ - (screen size 2)$^{\lambda}$, (picture quality 1)$^{\lambda}$ - (picture quality 2)$^{\lambda}$, income, family size, other variables} + disturbance term.

Repeat, while varying λ to optimize the statistical fit.

[4] This scale arbitrarily assumes that a movement from a zero point of almost nothing to a conventional TV picture leads to the same quality increase as a movement from conventional TV to movie-like quality. However, this assumption is innocuous for two reasons:

- the survey does not include any comparison data that makes use of the zero point;
- the factor λ can absorb any transformation in metric, either for picture size or picture quality, provided that the metrical transformation is of the exponential form, i.e. $x \rightarrow x' = x^{\varphi}$ for some fixed φ.

APPENDIX 3.2. SURVEY PROTOCOL

Begin. Hit enter.

WORDS TYPED IN CAPITAL LETTERS AND/OR LAVENDER BACKGROUND ARE INSTRUCTIONS FOR SURVEYORS AND ARE NOT READ TO THE RESPONDENTS. WHEN YOU REACH A PARTY ON THE PHONE, PLEASE READ THE FOLLOWING INTRODUCTION SLOWLY.

Hello, my name is_____, and I am calling from the University of Kansas. Is this a residence?

YES: CONTINUE TO #1
NO: Ok. Thank you very much for your time. Good bye. HANG UP. ENTER "NO" ON Q0 BELOW.

IF CONTINUING...
#1. We are doing a university research study on people's preferences for different kinds of technology. We are conducting the survey on behalf of the National Institute of Standards and Technology, a branch of the federal government devoted to improving technology in the US.
This is a ten minute survey and the results will be used to develop new technology standards. Your answers are all confidential and this is not a sales call, it is a research study. Your responses will remain confidential, and you may discontinue at any time. The survey should take just under 10 minutes.

Q0. Are you willing to continue at this time? No Yes
NOTE: It is very important to fill out an answer on Q0.

FOR SURVEYORS: A household is a living unit that may be a 1) family or 2) a single person or 3) two or more single people who live together and share their income and purchasing decisions.

Q1. Great. Let's get started. First, we would like some basic information about your household. In your household, how many people including yourself are:

SURVEYOR: Fill in 0 if none.
Age 65 and over_____
Age 45 to 64_____
Age 26 to 44_____
Age 18 to 25_____
Under age 18_____

Q2. And what age group are you in personally? (Age 65 and over, ages 45-64, ages 26 to 44, age 18 to 25, under age 18, refused/NA) NOTE: If under 18, survey terminates. Skip to goodbye section.

Q3. Do you own or do you rent the dwelling you currently live in? (Own, Rent, Other, Refused/NA)

SURVEYOR: If the person says something like living with relatives, check "other."

Q4. Are you employed, either at a paid job or in your own business? (Yes, No, Refused/NA)

NOTE: If no or refused and more than 1 person in household, skip to Q5. If no or refused and only one household, skip to Q6a.
SURVEYORS: The idea is jobs that make money. Homemaking is work, but it is a job only if the person makes money at it. In other words, we don't count homemakers as employed.

Q4a. In a typical week, about how many hours do you work at your paid job or jobs, or in your own business?

15 or under_____
16 to 34_____
35 to 50_____
more than 50_____
Refused or NA_

NOTE: If there is only one person in the household, skip to question Q6a. 35 to 50 is "full time."

Q5. Not counting yourself, how many people in your household are employed, either at a paid job or in their own business? (zero, 1, 2, 3, 4 or more, refused/NA) NOTE: zero, refused: Skip to Q6a. 2,3,4+: skip to Q5b. 1: continue to next.

Q5a. In a typical week, about how many hours does this other person work at a paid job or in his or her own business? (15 or under, 16 to 34, 35 to 50, more than 50, Refused/NA) NOTE: Skip to Q6a.

Q5b. Consider the person in your household other than yourself who works the most hours. In a typical week, about how many hours does this person work at a paid job or in his or her own business? (15 or under, 16 to 34, 35 to 50, more than 50, Refused/NA)

Q6a. Does anyone in your household receive Internet access at home? (No, Yes, Don't know, Refused/NA) NOTE: No, don't know, refused: skip to Q7.

Q6b.Approximately how much does your household pay for Internet access service per month?

____

Q7. How many working color TV sets does your household have? (zero, 1, 2, 3, 4 or more, at least one but don't know exactly, Don't know, Refused/NA) SURVEYOR: If the respondent does not know, try to prompt him/her. For example, ask "is it at least one?" If zero, don't know or refused, skip to Q14.

Q8a. Does your household receive the following services? First, how about cable television? (No, Yes, Don't know, Refused/NA) NOTE: No, don't know, refused: skip to Q9a.

Q8b. Approximately how much does your household pay for cable service per month? Please include any premium cable TV services such as HBO?_____

Q9a. Does your household receive satellite TV? (No, Yes, Don't know, Refused/NA) NOTE: No, don't know, refused: skip to Q9c.

Q9b. Approximately how much does your household pay for satellite TV service per month?
_____

Q9c. About how many TV channels can you receive with good reception? (under 20, 20 to 49, 50 to 99, 100 or over, Don't know, Refused) NOTE: If Q8a is yes or Q9a is yes, continue to Q9d. Else skip to Q10.

Q9d. Does your household receive premium TV services such as HBO, Showtime, or the Movie Channel? (No, Yes, Don't know, Refused/NA)

Q10. At this point, we would like to ask more detailed questions about entertainment technologies, and about television in particular. How large is the screen on your best color TV? Is it approximately...(21 inches or under, 22 to 27 inches, 28 to 36 inches, 37 to 49 inches, larger than 49 inches, Don't know, Refused/NA) SURVEYOR: TV sets are measured diagonally across the screen, if anyone asks. A small TV is 21 inches or under.

Q11. If you could improve your color television, how would you improve it? SURVEYOR: The list below is not to be read, but only to be checked if mentioned by the respondent. (Bigger screen, Better color, Sharper-clearer image, New wide-screen or letter-box format, Better sound, Easier controls, More reliable, Better stuff to watch, High definition or digital, Cable ready, Don't know, Refused/NA, Other-describe.)
Q12. Approximately when did your household purchase your best color television?
SURVEYOR: Fill in only one of the below.

Q12a. Year of purchase (if answer 1998, etc)_____
Q12b. Years ago (if answer with years ago)_____
Q12c. Don't know- rent or borrow- (fill in X)_____
Q12d. Don't know (fill in X)_____
Q12e. Refused (fill in X)_____

Q13. Approximately what did you pay for your best color television?

Price (in dollars)_____
Don't know (fill in X)_____
Refused (fill in X)_____

Q14. Are you thinking about buying a new color television in the next 12 months?
(No, Yes, Don't know, Refused)

Q15. What features will be important to you in the NEXT color television that you purchase? SURVEYOR: The list below is not to be read, but only be checked off if mentioned by the respondent. (Bigger screen, Better color, Sharper-clearer image, New wide-screen or letter-box format, Better sound, Easier controls, More reliable, Better stuff to watch, High definition or digital, Cable ready, Don't know, Refused/NA, Other-describe)

SURVEYORS: To trigger skip rules for next section. If Q7 is zero, don't know, or refused, skip to Q17. Else continue to 16.

Q16. Do you have one of the new high definition televisions, or HDTVs, that are just starting to be sold in stores? (No, Yes, Don't know, Refused) NOTE: Yes, skip to Q19.

Q17. Are you seriously considering buying one of the new high definition televisions, or HDTV, within the next year? (No, Yes, Don't know, Refused)

Q18. Have you seen one of the new high definitions, or HDTV, in person? (No, Yes, Don't know, Refused) NOTE: No, don't know, refused: skip to Q21.

Q19. How would you rate the picture quality of HDTV, as compared with conventional television? (Much better, Somewhat better, About the same, Worse, Refused/NA)

Q20. What are your general impressions of HDTV?_____

Q21. About how many hours of TV do you personally watch in an average week? (zero, 1 to 5, 6 to 10, 11 to 20, 21 to 30, 31 to 40, over 40, don't know, refused)

22. Now we are going to ask you a few questions about television screen size and picture quality, and which is more important. Which would you prefer as your best television if it were available and there were no other choices- a 49 inch screen TV with picture quality like a conventional color TV, or a 27 inch screen TV with picture quality as crisp, clear, and colorful as what you would see in a movie theater? (49 inch screen with conventional picture quality, 27 inch screen with movie quality, Don't know, Refused/NA)

NOTE: 27 inch movie quality: skip to Q22c. Don't know or refused: skip to 22c. Else skip to Q22a or Q22b, depending on a randomly-generated number RANDOM01.

Q22a. Now suppose that you were given a different choice. Which would you prefer- a 49 inch screen TV with picture quality like a conventional color TV or a 36 inch screen TV with picture quality as crisp, clear and colorful as what you would see in a movie theater? (49 inch screen with conventional picture quality, 36 inch screen with movie quality, Don't know, Refused/NA)
NOTE: Skip to Q22c.

Q22b. Now suppose that you were given a different choice. Which would you prefer- a 36 inch screen TV with picture quality like a conventional color TV, or a 27 inch screen TV with picture

quality as crisp and clear and colorful as what you would see in a movie theater? (36 inch screen with conventional picture quality, 27 inch screen with movie quality, Don't know, Refused/NA)

Q22c. Suppose that you were going to buy a new large TV this month, say 49 inches or larger, and that there were two sets available that were the same size. Suppose that one of the sets had a picture with quality like you would see in a movie theater, while the other had a picture with quality like a conventional TV. Suppose that the TV with movie quality costs_____more than the TV with conventional quality. Which do you think you would buy? (SURVEYOR: Choices are $50, $200, $500, $2000. One should appear automatically. DON'T ENTER)
(Movie quality, Conventional, Don't know, Refused)

Q23. Now we are going to ask some questions about VCRs and DVD video players. Does your household have a DVD player? (No, Yes, Don't know, Refused) NOTE: No, don't know, refused: skip to Q24.

Q23a. Approximately when did you purchase your best DVD player? SURVEYOR: Fill in only one of the below.

Year of purchase (if answer 1998, etc.)_____
Years ago (if answer with years ago)_____
Don't own -they rent or borrow- fill in X_____
Don't know (fill in X)_____
Refused (fill in X)_____

Q23b. Approximately what did you pay for your best DVD player?

Price (in dollars)_____
Don't know (fill in X)_____
Refused (fill in X)_____

Q24. Does your household have a VCR? (No, Yes, Don't know, Refused) NOTE: No, don't know, refused: skip to Q25)

Q24a. Approximately when did you purchase your best VCR? SURVEYOR: Fill in only one of the below.

Year of purchase (if answer 1998, etc.)_____
Years ago (if answer with years ago)_____
Don't own -they rent or borrow- (fill in X)_____
Don't know (fill in X)_____
Refused (fill in X)_____

Q24b. Approximately what did you pay for your best VCR? SURVEYOR: Fill in only one of the below.

Price (in dollars)_____
Bought as part of TV (fill in X)____
Don't know (fill in X)_____
Refused (fill in X)_____

Q25. Are you seriously considering buying a new DVD player in the next 12 months? (No, Yes, Don't know, Refused) NOTE: If Q23 is yes, skip to Q27.

Q26. Have you seen a DVD player in operation? (No, Yes, Don't know, Refused) NOTE: No, don't know, refused: Skip to 30.

Q27. How would you rate the picture quality of a DVD player, as compared with a VCR? (Much better, Somewhat better, About the same, Worse, Refused/NA)

Q28. What do you think are the advantages of a DVD player over a VCR? SURVEYOR: Don't read responses. (Better picture, Greater control over watching picture, More reliable medium-disks can't get tangled, Better value, None, Don't know, Refused, Other-describe)

Q29. What do you think are the disadvantages of a DVD player compared with a VCR? SURVEYOR: Don't read responses. (Machine can't record, Machine too expensive, Not enough disks available, Disks too expensive, None, Don't know, Refused, Other-describe)

Q30. Suppose that you were going to buy a new video recorder and player this month, and that a new DVD-type machine were available that combined all of the advantages of today's DVD players and VCRs, and had none of the disadvantages. Suppose that this machine costs _____ more than the price of a conventional VCR. Which do you think you would buy, the new machine or a conventional VCR? (SURVEYOR: Choices are $50, $100, $250 and $500. One should appear automatically. DON'T ENTER) (New machine, VCR, Don't know, Refused)

Q31. Now we have a few questions about movies and video rentals. In general, which do you prefer most of the time- is it going to watch the movies or watching videos at home? (Movies, Videos, Tied, Don't know, Refused)

Q31b. How often do you go out to the movies? (At least once per week, At least one per month, A few times per year, About once a year, Almost never, Don't know, Refused/NA)

Q32. About how much do you spend per person on movie tickets when you go to the movies?

_____

Q33. What do you like about going out to the movies? SURVEYOR: Don't read responses.
(Good picture quality, Big screen, Good sound quality, Like to have others around to see their reactions, Good social event or date, Like first-run features, Don't like to return videos, Candy and popcorn, Nothing, Don't know, Refused, Other-describe)

Q34. How often do you rent videos to watch at home? (At least once per week, At least once per month, A few times per year, About once per year, Almost never, Don't know, Refused/NA)

Q35. What do you like about renting videos to watch at home, in comparison with going out to the movies? SURVEYOR: Don't read responses.
(Wide selection of videos available, Convenience of watching at home, Privacy, Inexpensive, Can replay video in whole or in part, Can watch at any time, Cheap food and snacks, Can stop in middle, Nothing, Don't know, Refused, Other-describe)

Q36. How do you think that the experience of watching movies at home could best be improved? SURVEYOR: Don't read responses.
(Better picture quality, bigger picture, not having to go out to get and return, easier to use, better sound system, better/added controls such as fast forward and pause, Don't know, Refused, Other-describe)

Q37. Now we are going to describe some technologies that might improve your experience of watching TV and videos at home. We have all had the experience of watching something on television and having our viewing interrupted at a critical point, or missing a few key moments of telecast. Suppose that your television were equipped with a device that allowed you to stop what you were watching, even if it were a live telecast, and go back and watch part of the telecast again. At the same time as you were using this "instant replay" feature, the device would record anything you were missing. Suppose that you could rent this device today, and that it could be added to your current TV. Do you think you probably would rent the device if it cost an extra $_____ per month? SURVEYOR: Choices are $3, $7, $15, $30. One should appear automatically. DON'T ENTER PRICE. (No, Yes, Don't know, Refused)

Q38. Suppose a new "video on demand" subscription service became available in your community. This video on demand service would give you access to a huge library of movies, documentaries and educational programs that you could access at any time. All you would need to do would be to call in your order, and your movie or video would be delivered directly over a cable to your TV with 5 minutes notice. You would never need to go to the store to rent a video. There would be a monthly fee, but you could order as many videos as you wanted with no added charge. Suppose that service cost $_____ per month. Would you probably subscribe to the service? SURVEYOR: Choices are $8, $16, $40, $80. One should appear automatically. DON'T ENTER PRICE. (No, Yes, Don't know, Refused)

The next questions combine all of the advanced equipment and services that we have been talking about. Suppose that you could rent a package deal with all of the following: A TV with a 49-inch screen, a picture as clear as at a movie theater; video on demand service, giving you access to a huge number of videos with 5 minutes notice; instant replay for live TV; ability to record live TV with high picture quality; and at least 100 cable channels. SURVEYOR: Read text above, then ENTER 1 to move to actual questions.

Q39. Suppose that the monthly payments were $_____ and that the package were available without any added installation charge or long-term contracts. Do you think that you would probably

rent the package? SURVEYOR: Choices of $16, $40, $80 or $200 should fill automatically. DON'T ENTER PRICE. (No, Yes, Don't know, Refused) Don't know or refused: Skip to Q41.

Q40. Now suppose that the monthly payments were $_____ instead. Do you think that you probably would rent the package? SURVEYOR: If Q39 is no, (.5 * price in Q39) should be filled automatically. If Q39 is yes, (2* price in Q39) should be filled in automatically. DON'T ENTER PRICE. (No, Yes, Don't know, Refused)

Q41. If you did have all the advanced equipment and services we have been talking about, do you think that you personally would be watching more TV? (No, Yes, Don't know, Refused)
Note: No, don't know, refused: skip to Q44.

Q42. About how many more hours per week?_____

Q43. If you spent more time watching TV, what do you think you would spend less time on? SURVEYOR: Don't read responses. (Other entertainment like going to sporting events and movies, active recreation like participating in sports and hobbies, work, sleep, Don't know, Refused, Other-describe)

Q44. Finally, for statistical purposes only, which best describes your household's income before taxes? (Less than $15,000, $15,000-$30,000, $30,000-$50,000, $50,000-$80,000, over $80,000, Don't know, Refused)

Q45. SURVEYOR: FILL IN GENDER. GUESS IF NECESSARY. (Male, female)

Thank you very much for your time. Have a good (morning, afternoon, evening). Good bye.
Hit enter.

ENTER interviewer ID_____
RESPONDENT ID#_____

APPENDIX 3.3. SURVEY TEST DATA

Survey responses

This appendix presents some results from a very small sample of initial survey interviews.

Number of survey contacts = 33. These are contacts where someone actually answered the phone, was ascertained to be an appropriate respondent, and then either took or refused to take the survey.

Number of telephone numbers dialed = (approximately) 300. This includes cases where someone answered the phone, but was not the respondent with whom we wished to speak.

Number of partial completions = 1. It seems as if, once the survey has started, most respondents follow it through to the end.

Number of full completions = 7 = 21%. The low percentage of completions and the high number of cases in which the person who answered the phone was not "the person in the household who knows the most about electronics purchases" led us to revise the introductory script. In subsequent surveys, we accepted any knowledgeable person. (The revised script is shown in Appendix 3.2.)

Average length of time to fully complete survey = 13 minutes.

Preliminary frequencies

A few preliminary results are presented here to illustrate what the overall survey results might look like. Among our 7 completed cases, only one had a large screen TV. About half the respondents had seen HDTV in person.

Q10. At this point, we would like to ask more detailed questions about entertainment technologies, and about television in particular. How large is the screen on your best color TV? Is it approximately...

		Frequency	Percent
Valid	21 inches or under	3	42.9
	22 to 27 inches	3	42.9
	37 to 49 inches	1	14.3
	Total	7	100.0

Q18. Have you seen one of the new high definition televisions, or HDTV, in person?

		Frequency	Percent
Valid	No	3	42.9
	Yes	3	42.9
	Total	6	85.7
Missing	System	1	14.3
Total		7	100.0

4. PATENT EVENT STUDY METHODS AND FINDINGS

Introduction

Hundreds of studies in finance and economics have made use of information on stock price variations to capture the market values of events that affect a firm or set of firms. For example, researchers may investigate the impacts of a stock split or the impact of changes in corporate management. The underlying assumption in an event study is that the expected current and future impacts of such an event will be reflected in changes in a firm's valuation within a fairly short time window surrounding the date that the event takes place. An overview of the "event study" methodology is provided by MacKinlay (1997). The key elements of an event study are:

- Identification of a set of related events that may affect firm valuations. The events must be associated with a date or range of dates on which they occur.
- Specification of a "window" or time period during which effects of the events are expected to materialize.
- Estimation of "normal" returns (percentage changes in prices) for firms that may be affected by the events. The normal return for a firm is the return that is predicted by an equation relating the firm's return to the market return and other variables, estimated using data from a time period that does not include the chosen window. MacKinlay (1997) discusses alternative forms of the equation to estimate normal returns.
- Estimation of "abnormal" returns during the window. The abnormal return is the difference between the actual stock market return and the predicted normal return.
- Testing of abnormal returns to see if the null hypothesis (no impact) can be rejected.

It seems natural that an event study approach could be used to try to detect the impacts of patents on firm valuations. Patent grants are made public by the US Patent and Trademark Office each Tuesday. Patent announcements contain substantive detailed information about the technical approach pursued by the innovating firm in achieving its outcome. Patents have clear announcement dates, although they may be anticipated in advance of their announcement. The information that a patent has been issued could, in theory, change an investor's willingness to buy or hold shares of a firm. In other words, an event study could, in theory, be used to estimate the value of patents, and, indirectly, of research and development. Such an approach would be complementary to the work of Griliches (1990), who discusses the usefulness of patents as an indicator of innovation.

It also seems plausible to use an event study approach to estimate spillovers from an innovating firm to related firms. Using patents as an indicator of innovation, one could ask "how does the announcement of a patent for a firm affect the valuation of rival firms within the same industry?" On average, does information about the innovation of one firm enhance the value of other firms or decrease their value?

Recently Austin (1993, 1994a, 1994b) used an event study approach to address both of the issues discussed above. Austin estimated the effect of patents on innovating firms in the bio-technology

industry. More importantly, Austin estimated spillover effects across firms in the industry; that is, he estimated the impact patent announcements on firms related to the innovating firms. Austin found significant positive effects of patent grants on innovating firms and small negative effects on rival firms.

We plan to apply Austin's event study approach (although not his exact models of returns) to the digital video industry. In this report, we provide initial results showing that this line of research is promising. In particular, we find a positive effect of DV patents on the market returns of the patenting firm. (If there had been no detectable effect, then we have recommended abandoning this line of research.) In our next report we will examine the spillover effects of DV patents on competing firms.

The patent data set

Following Austin, we use patents as indicators of innovation. We created a database of patents by downloading weekly files of patent information from the US Patent and Trademarks Office web site. The downloaded files span the time period September, 1996 through December, 1999. The information in the files includes the patent number; the title; the application and issue dates; the inventor(s); the entity (person or firm) that owns the patent; the patent class in which the patent has been classified; related patent classes; references and citations; and an abstract describing the patent. We arranged the weekly patent data into a database that can be searched by keyword and by field.

After forming the database, we searched for the keyword phrase "digital video" in any of the fields. The search returned a set of about 5000 patents for the time period under consideration. We grouped these patents by patent class. The patents spanned some 180 classes, but about 65 percent of them were in the top 13 classes. All of the patent classes are fairly broad and contain many patents not obviously related to DV. Depending on the class, patents with the "digital video" string comprise between 5 and 34 percent of the total patents in the class. We then turned to the *Manual of U.S. Patent Classification* (US Patent and Trademark Office, 1999) for verbal descriptions of the top 13 patent classes. The verbal descriptions confirmed that we had chosen an appropriate set of patent classes (Table 4.1).

Once we identified a set of patent classes, we did another keyword search against the database. We identified patents that both:

- were categorized in the 13 identified classes, and
- contained the words "digital" and "video" (not necessarily sequentially) in the abstract or title fields only.

This process eliminated patents that contained "digital video" only in reference or less important fields. It also eliminated patents in all but the 13 classes on which we chose to focus. At the same time, it included patents that contained the strings "digital" and "video," but not the complete string "digital video." This specification for identifying "DV" patents resulted in a set of 1075 patents received by some 300 firms during the 1996-1999 time period.

Table 4.1
Top Patent Classes Related to Digital Video

Patent Class Number	Description	% of Class included in "DV" specification	% of Class Containing String "Digital Video"
369	Dynamic Information Storage or Retrieval	1.2	7.0
360	Dynamic Magnetic Information Storage or Retrieval	1.9	6.8
455	Telecommunications	2.1	7.0
380	Cryptography	2.7	10.6
370	Multiplex Communications	4.0	8.3
364	Electrical Computers and Data Processing Systems	4.4	7.8
382	Image Analysis	4.4	9.8
345	Computer Graphics Processing and Selective Visual Display Systems	4.5	7.4
341	Coded Data Generation or Conversion	5.0	21.2
386	Television Signal Processing for Dynamic Recording or Reproducing	6.0	34.0
375	Pulse or Digital Communications	6.8	12.6
395	Information Processing System Organization	7.8	4.6
348	Television	16.0	23.4

An event study requires that event dates be matched to stock market valuation data. By its nature, the event study is limited to publicly-traded firms only. Thus we needed to match the "owner" names in the patent file to firm names and ID numbers in stock market data. We made use of a file of firm names and ID numbers provided with data from the Center for Research on Stock Prices (CRSP), a data set commonly used for stock market analysis. A first pass through the data allowed us to identify about 100 firm names, corresponding to some 440 of the patents. We then did a Web search for unmatched patent owners, to see if the owner had changed names or was part of a larger firm. This allowed us to identify another 50 firm names and an additional 100 patents. The distribution of selected DV patents for the publicly-traded firms is shown in Table 4.2.

Event study trial runs

Our approach to the event study involved considerable experimentation. For our first experiment, we used about 280 of the patents described above. We removed one large firm from the data set: Sony. Sony had approximately 100 "DV" patents during the time period in question, making it difficult or impossible to distinguish normal from abnormal returns. In addition, we removed patents issued in 1999 because the stock market return data set (the CRSP data) that was available to us extended through December, 1998, only.

Table 4.2
Distribution of "DV" Patent Classes for Publicly Traded Firms

Patent Class Number	Description	Number of Patents	% of Patents
369	Dynamic Information Storage and Retrieval	7	1.3
360	Dynamic Magnetic Information Storage or Retrieval	0	0.0
455	Telecommunications	10	1.8
380	Cryptography	26	4.8
370	Multiplex Communications	24	4.4
364	Electrical Computers and Data Processing Systems	17	3.1
382	Image Analysis	25	4.6
345	Computer Graphics Processing and Selective Visual Display Systems	58	10.7
341	Coded Data Generation or Conversion	5	0.9
386	Television Signal Processing for Dynamic Recording or Reproducing	100	18.5
375	Pulse or Digital Communications	1	0.2
395	Information Processing System Organization	48	8.9
348	Television	221	40.8
Total	Total	535	100.0

In order to carry out the event study, we made use of specialized software called Eventus, licensed by the University of Kansas (Cowan Research, 1998). The Eventus software reads the stock market return files and implements an event study based on options chosen by the user. Options include:

- The model of normal stock market returns. MacKinlay (1997) and Cowan Research (1998) provide a discussion of alternative models.
- The "event window" specifying the number of days before and after the event date that will be included in the analysis.
- The period of time over which the normal return model is estimated.

We experimented with three different models of normal stock market returns:

- The straightforward market model. In this model, an individual firm's returns are estimated as a simple linear relationship to the overall market return. Technically,

  $$R_{jt} = \alpha_j + \beta_j R_{mt} + \varepsilon_{jt},$$

  where R_{jt} is the rate of return for stock j on day t, R_{mt} is the market rate of return for the same day, and ε_{jt} is a homoskedastic random variable with mean zero and no autocorrelation. α_j and β_j are regression parameters.

- The market model with Scholes-Williams adjustments. This model is similar to the market model described above, but it allows one-period autocorrelation of error terms.

- The market model with a GARCH(1,1) error structure. This model assumes that σ^2_{jt}, the conditional variance of ε_{jt} given the information available at time t, is dependent on past values. Technically,

  $$\sigma^2_{jt} = \omega_j + \gamma_j \sigma 2_{jt-1} + \lambda_j \varepsilon_{jt-1}{}^2,$$

  where ω_j, γ_j and λ_j are regression parameters to be estimated.

In all of our experiments, "normal returns" were based exclusively on data prior to the event window (though it is possible to use data after the event window as well). Our first experiments yielded results with a rather low level of statistical and economic significance. The estimated effect of patents on the innovating firms were positive for most events windows in the range: (5 days before event, 5 days event). However, results were rarely significant at p = .10 or better. This low level of significance held across the three market models estimated.

Event study modifications

Upon scrutinizing our patent data, we found that many of the DV patents were issued to very large firms such as Microsoft and Bell Atlantic. This led us to believe that the inclusion of such large firms might account for some of the lack of significance of our results. In most cases individual patent announcements are fairly small-scale events with immediate market values far below $100 million. For a large firm with tens of billions of dollars in capitalization, the impact of such a patent is almost sure to get lost in the usual noise of return fluctuations. Therefore, we conducted another experiment in which we limited the selection of firms to those with a total valuation under $15 billion. The set of patents remaining in the data set fell from 280 to 84. A list in Appendix 4.1 shows the patent dates and firms so identified.

To specify a particular regression model, we needed to make some choices.

- As noted, three different models of "normal" returns are available.
- Many different windows would be acceptable. Based on previous literature, the window should include (at a minimum) either the day of the announcement or the day after, and probably should not exceed 5 days before the event or 10 days after the event. There are more than 30 such windows. (In this context, "days" refers to market trading days rather than calendar days.)

Because we are using a fairly small sample, specifying the exact model raises some statistical issues. In particular, some 90 variant models would appear to be almost equally acceptable. It is possible (and indeed turned out to be the case) that some of the acceptable models may provide results that pass a significance test (e.g. at with p = .10) while other models do not. Of course one might select models based on significance of results (a procedure referred to as a "pretest estimator;" Leamer, 1978)). However, such a procedure constitutes "data mining," which is to say that conventional or "classical" statistical tests based on models selected in this fashion have no useful meaning.

Therefore, we adopted a procedure which is not subject to this criticism. We randomly assigned the 84 patents into one of two groups, one for specifying the "best" model, and the other for estimation

and hypothesis testing. Approximately 40 percent of the patents were used for determining the specification. The most important specification problem turned out to be the choice of the event window. The choice of the error structure for the market model made only a limited difference in the results.

Table 4.3 shows the outcomes of the specification experiments. An event window equal to one day before the event to five days after (-1,5) had the highest level of conventional significance for each of the three market models tested. The event window (-2,5) had the second best results. For a given event window, the GARCH model usually had a slightly higher significance level than the other two models tested.

The three normal return models were then estimated for the two event windows using the remaining 60% of the data. Both windows gave significantly positive results for all three normal return models, with p = .10 or lower. One model was significant at p = .02. Again, the GARCH model provided the most significant estimates. (Note that these results actually tend to understate the significance of the positive returns, in that they are based on only 60% of the data.) These experiments support the hypothesis that the issue of a DV patent by a small- to medium-sized firm has detectable positive effects on that firm's valuation and market return.

Table 4.3
Event Study Results

Model	Event window	Cumulative Average Abnormal Return	t statistic	Significance level (2-tailed test)
Model Specification *Number of events = 32*				
Market Model, no autocorrelation	(-1,+5)	2.76%	1.47	15%
Market Model, Scholes Williams	(-1,+5)	2.65%	1.41	17%
Market Model, GARCH (1,1)	(-1,+5)	3.18%	1.64	11%
Market Model, no autocorrelation	(-2,+5)	2.29%	1.15	25%
Market Model, Scholes Williams	(-2,+5)	2.16%	1.08	29%
Market Model, GARCH (1,1)	(-2,+5)	2.72%	1.35	19%
Estimation and Hypothesis Testing *Number of Events = 52*				
Market Model, no autocorrelation	(-1,+5)	2.77%	1.70	10%
Market Model, Scholes Williams	(-1,+5)	2.83%	1.74	9%
Market Model, GARCH (1,1)	(-1,+5)	3.42%	2.10	4%
Market Model, no autocorrelation	(-2,+5)	3.33%	1.74	9%
Market Model, Scholes Williams	(-2,+5)	3.39%	1.94	6%
Market Model, GARCH (1,1)	(-2,+5)	4.08%	2.33	2%

Additional tests

While we were optimistic after performing the experiments above, we could not conclusively say that the results were due to patent issuances rather than other effects driving stock market prices. In particular, patents are announced on Tuesdays, and the event window (-1,5) contains two Tuesdays. Is it possible that we are simply picking up a "Tuesday effect" or some similar artifact of the statistical design? To test this, we performed a Monte Carlo experiment. We took the universe of all public traded firms and made 250 draws of 50 firms each, to create data sets similar in size to that used for the estimation and testing of the patent impacts. For each firm in each draw, we randomly assigned a Tuesday date in the time period September, 1996, to December, 1998, the same period covered by our patent data. In other words, we created "pseudo-patent" events. We then performed 250 event studies for the pseudo-patent events.

For each of the three models (no autocorrelation, Scholes Williams, and GARCH), the results appeared to be unbiased. That is, the average return over the 250 simulations for the event window (-1,5) was very close to zero (.08%, .09%, .17% for the models respectively). However, the tails of the sampling distribution were "thicker" than would be the case if the test statistics actually had a t distribution. This suggests that a Monte Carlo approach should be used to find exact significance levels.

Future research

The research described above does not address the issue of spillovers. It was our belief that if "own firm" patent effects could not be detected, then any attempt to detect spillover effects would be futile. However, as demonstrated above, it does seem possible to detect the effect of DV patents on innovating firms, provided that the set of firms is limited to those of small or medium size (or a substantially larger sample of patents is generated than we used).

Our next research task is to define a set of patents for which we will look for spillovers. Following Austin (1994a), we will define "important" patents as patents that, in years after issue, receive a high number of citations from other firms applying for related patents. It may also be necessary to expand the sample, for example, by including additional patent classes, or by looking for near synonyms for "digital" or "video" such as "computable' or "image."[5]

[5] Another possible method for increasing the signal to noise ratio would be to specify the model in terms of aggregate dollar gains in the market rather than rates of return, with firms weighted in the sample inversely to their background fluctuation in market capitalization. By hypothesis, patent events have a value distribution that is nearly independent of the firm's market capitalization, while the background fluctuation in capitalization is roughly proportional to capitalization. If so, then the above model is theoretically correct. However, because this model differs substantially from standard models used in event studies, developing it would be a major undertaking.

Conclusion

Digital video patents are positively related to market values of the innovating firms. The detected effects do not seem to be artifacts of stock market price patterns. This leads us to be optimistic that spillover effects on other firms can also be detected.

This measurement technique is of great potential importance. In particular, unlike most other approaches, this approach theoretically sums the effects of *all* spillovers on competing firms. That is to say, it accounts not only for market spillovers (including both negative competitive effects and positive supplier effects), but also for knowledge spillovers and network spillovers. Of course, spillover measures so derived for individual patents are not expected to be very meaningful -- the method will probably produce only an *average* rate of spillovers across many DV patents. However, it will hopefully be possible to infer an average ratio of DV spillovers to own firm effects. Given such a ratio and given a direct measurement of the benefits to owners of a particular DV patent, we will be able to make an empirically-based correction showing the average expected net economic impact on that firm's competitors.

Needless to say, this approach has many other limitations. Most importantly, it measures spillovers as they are *expected* or anticipated by stock market investors at the time the patent is issued, rather than measuring actual outcomes *ex post.* However, according to efficient market theories of stock prices the expected spillovers would be unbiased estimators of the *ex post* spillovers. Future research will need to address the question of whether this is actually the case.

APPENDIX 4.1. FIRMS AND PATENT DATES INCLUDED IN THE EVENT STUDY

Company Name	Date of Patent	Valuation of Firm as of Patent Date ($ mil.)
ADVANCED MICRO DEVICES INC	980324	3,339
ALCATEL ALSTHOM CO GENERAL D E	970617	2,622
ALCATEL ALSTHOM CO GENERAL D E	980922	2,063
ALLIANCE SEMICONDUCTOR CORP	970610	345
AMATI COMMUNICATIONS CORP	970121	276
ANALOG DEVICES INC	980721	3,964
ANALOG DEVICES INC	981201	3,415
ANTEC CORP	970520	405
APPLE COMPUTER INC	970415	2,515
APPLE COMPUTER INC	980825	5,568
ASAHI AMERICA INC	971118	21
AVID TECHNOLOGY INC	970701	600
AVID TECHNOLOGY INC	970805	876
AVID TECHNOLOGY INC	980203	798
AVID TECHNOLOGY INC	981222	545
CHAMPION INTERNATIONAL CORP	981013	2,826
CHIPS & TECHNOLOGIES INC	960910	242
CIRRUS LOGIC INC	961112	1,258
CIRRUS LOGIC INC	961203	1,201
CIRRUS LOGIC INC	970401	705
CIRRUS LOGIC INC	970513	602
CIRRUS LOGIC INC	980331	614
CIRRUS LOGIC INC	980915	443
COGNEX CORP	970617	1,075
DIGITAL EQUIPMENT CORP	970304	4,810
DIGITAL EQUIPMENT CORP	970422	4,165
ELECTROGLAS INC	971230	300
FRANCE TELECOM	980602	141
FUJI PHOTO FILM LTD	980324	202
GATEWAY 2000 INC	970722	6,525
GATEWAY 2000 INC	971007	4,659
GENERAL INSTRUMENT CORP	961015	4,457
GENERAL INSTRUMENT CORP	970401	3,829
GENERAL INSTRUMENT CORP	971216	2,511
GENERAL INSTRUMENT CORP	971230	2,929
GENERAL INSTRUMENT CORP	980210	3,045
HARRIS CORP	970415	6,584
HARRIS CORP	971007	3,542
HONEYWELL INC	970211	9,319
HONEYWELL INC	970610	9,398
HYBRID NETWORKS INC	980421	72
IN FOCUS SYSTEMS INC	980616	161

Company Name	Date of Patent	Valuation of Firm as of Patent Date ($ mil.)
IN FOCUS SYSTEMS INC	980908	83
INFONAUTICS INC	980421	75
INTERGRAPH CORP	981103	306
MACROVISION CORPORATION	970819	126
MACROVISION CORPORATION	981124	306
MEDIA 100 INC	980106	45
MICROWARE SYSTEMS CORP	970408	124
MIKOHN GAMING CORP	970624	43
MOORE CORP LTD	980505	1,410
NATIONAL SEMICONDUCTOR CORP	980616	2,316
OBJECTIVE COMMUNICATIONS INC	970415	36
OBJECTIVE COMMUNICATIONS INC	980728	42
QUESTECH INC	981013	33
RADIUS INC	971028	2
RAYCHEM CORP	980317	3,364
SENSORMATIC ELECTRONICS CORP	981013	290
SENSORMATIC ELECTRONICS CORP	981229	515
SIGMA DESIGNS INC	970325	58
SIGMA DESIGNS INC	981013	15
SONIC SOLUTIONS	980922	18
SUN MICROSYSTEMS INC	970304	11,799
SYBASE INC	980505	718
TEKTRONIX INC	961001	1,940
TEKTRONIX INC	961112	2,135
TEKTRONIX INC	970114	2,443
TEKTRONIX INC	971216	1,842
TEKTRONIX INC	980331	2,117
TEKTRONIX INC	980519	1,866
TEKTRONIX INC	980714	1,712
TEKTRONIX INC	980811	1,298
THOMSON MICROELECTRONICS	970415	9,322
THOMSON MICROELECTRONICS	970819	13,574
THOMSON MICROELECTRONICS	971021	11,313
THOMSON MICROELECTRONICS	980113	7,948
THRUSTMASTER INC	970311	36
TRINITECH SYSTEMS INC	970527	51
UNISYS CORP	980616	6,508
VIDEOSERVER INC	970204	471
VIDEOSERVER INC	981117	169
ZENITH ELECTRONICS CORP	970128	760
ZENITH ELECTRONICS CORP	970610	802
ZENITH ELECTRONICS CORP	970624	827

5. FIRM INTERVIEW METHODS

Purposes of data collection protocols

This chapter describes the protocols developed for collection of primary data relating to projects funded by NIST-ATP as part of its Focused Program on "Digital Video in Information Networks." As detailed in Burress *et al.* (1999b), collection of data on funded projects is a crucial ingredient in the calculation of the economic impacts of NIST-ATP's activities in the Digital Video (DV) area. Data gathered about funded projects are needed to

- Determine the attribution of economic benefits to ATP;
- Measure partial equilibrium effects due to private profits, market spillovers, network spillovers, knowledge spillovers, material spillovers, and fiscal spillovers.

In addition these data also form an important input into the formulation and specification of the general equilibrium model that will be used to aggregate the economic impacts of individual projects into a single comprehensive economy-wide measure.

Description of data collection protocols and instruments

Our primary means of gathering information about NIST-ATP DV projects is through telephone interviews conducted with project personnel associated with each project.

The following list describes the sequence of actions involved in setting up an interview, conducting the interview, and preparing a written report presenting the data gathered:

- *Identify the project contact person*. Find the appropriate person or persons within each organization with whom to speak using information in the funded projects database on the NIST-ATP web site (http://www.atp.nist.gov/www/comps/allbriefs.htm#95-04) or through consultation with the NIST-ATP project supervisor.
- *Make contact by telephone*. Call the contact person to verify that he/she is the correct person to speak with and arrange to send a list of preliminary questions. The script for this initial contact is reproduced as Appendix 5.1.
- *Send pre-interview materials to contact person*. These include a cover letter reiterating project goals and procedures (see Appendix 5.2), and a list of pre-interview questions to the project contact person so that the interviewee(s) could assemble the relevant documents or data sources to provide the information needed in the interview (see Appendix 5.3).
- *Set up the interview.* One to two weeks after sending out the pre-interview materials, make a follow-up telephone or email contact to answer any questions that the contact person might have. Schedule an interview approximately two hours long involving all appropriate project personnel.

- *Conduct the interview*. Follow the interview script (see Appendix 5.4) as a guide. Discretion may be used about the ordering of questions and choice of additional follow-up questions as needed. One or two staff members may conduct the interviews.
- *Draft written report*. Based on interview, fill in information on interview report form (see Appendix 5.5).
- *Follow up questions*. If there are any missing data discovered after the interview or if the interviewee cannot provide all the necessary data available at the time of the interview, obtain these by phone, fax or e-mail as appropriate;
- *Obtain interviewee approval*. Send the written report to the interviewee for his/her approval;
- *Finalize Report*. Make any changes indicated by interviewee responses.

Test Data

To verify the effectiveness of the procedures outlined above, a contact person was identified for each project and initial contact was made to verify willingness to participate in interviews. In the majority of cases, data on the NIST-ATP web site proved to be outdated, and it was necessary in most instances to obtain contact information directly from NIST-ATP personnel.

The remaining steps of the process were tested by actually setting up and conducting one interview. Experience gained in this process was used to refine the instruments developed for this phase of the project. With these modifications all of the data collection instruments appear to be effective. In particular, the time estimate for the interview itself (about 2 hours) proved quite accurate. The results of the interview are reproduced as Appendix 5.6.

Data to support the qualitative attribution model

We developed interview questions for a very detailed qualitative model of ATP's degree of attribution (i.e., causal responsibility) for initiation and success of the client's DV project. (The model itself is described in Burress *et al.* 1999b, Appendix 1). However, we omitted those questions from the interview protocol because of practical limitations on interview time. In particular, we judged that the basic interview for a firm could not much exceed two hours without exhausting the patience of the interviewees. The omitted interview topics are included in Appendix 5.7.

Eliciting and modeling subjective distributional information

In interviewing clients firms, we are faced with the problem of eliciting expected distributional information and then the problem of interpreting the answer. An example is: "How much longer would the innovation have taken to reach market in the absence of ATP?" The desired answer would include a range of possible time differences, with some assumed weighting or density function. But in a brief interview we cannot really ask the informant to map out and parametrize a particular functional form for the distribution of time differences. Instead we need to make some assumptions.

We will assume:

- Conditional on the informant's information, there is a distribution of counterfactual outcomes, say h(t; M, T), where M and T, $0<M<T<\infty$, are parameters to be elicited from the informant. Here M is the estimated median time difference and T is the estimated maximal practical time difference. (If asked, we might define t exceeding T as an event that would happen less than 3 times in a thousand.)

- h is positive on (0,T) and zero elsewhere (i.e., ATP definitely did not increase the time to market, and there is a finite upper bound on the decrease in time to market).

- We are interested mainly in the expected value $G(M, T) = \int th(t; M, T)dt$.

- The most important axioms are: $\partial G/\delta M > 0$ and $\partial G/\partial T > 0$ everywhere.
  It turns out to be surprisingly hard to identify smooth 2-parameter distributions h(t, M, T) with finite support that do not violate $\partial G/\partial T > 0$. The problem is, as the tail T increases with M held constant, the probability mass tends to skew back towards 0. Yet most informants would implicitly assume these axioms.

- It is also assumed that the marginal weight on T declines as T increases.

Then based on the axiomatic model given in Appendix 5.8, we can assume:

$$(1)\ G(M, R) = M\{3/4 + 1/(4\pi) + (R/8)(1 - 1/\pi)(1+2/R^2)\}$$

$$\approx M\{.83 + .085R(1+2/R^2)\}.$$

where $R = T/M$.

The assumed underlying distribution h(t; T, M) is found by solving the axiomatic system. The distribution has 5 terms:

1. a delta distribution at t=M

2,3. uniform distributions on [0, M] and [M, T] with equal probability masses

4,5. sinusoidal distributions on [0, M] and [M, T], each with net probability masses of zero.

The coefficients in (1) were chosen by making minimum information assumptions on the parameters of h(t; M, T)

APPENDIX 5.1. TELEPHONE CONTACT SCRIPT

My name is <fill in name>, I am <fill in position title> at the University of Kansas. I am calling as part of a project being conducted by the University's Institute for Public Policy and Business Research for the National Institute of Standards and Technology's Advanced Technology Program.

According to the NIST-ATP web site you are listed as the contact person for the NIST-ATP supported project on <fill in project title here>.

Is that correct? <If not, can you tell me whom I should contact?>.

As part of a study of the Potential Economic Impacts of Digital Video Technologies we have been authorized by NIST-ATP to gather data on your company's ATP-supported project.

What I would like to do is describe briefly the types of information that we need to gather, and ask you to help me identify the appropriate person or persons to provide this information. Are you in a position to assist me with this?

The information that we need is relatively detailed and includes the following general subject areas:

- The technical characteristics of the project
- The project's relationship to overall R&D efforts at your company
- Expected markets for any goods or services resulting from the project
- The financial aspects of the project—including Expenditures, revenue, and expected future income and expenditure flows
- The identities of important supplies, customers, and producers of complementary and competing goods and services
- The effects of ATP funding on your R&D efforts

Who would be the best people to contact in this regard, and how may I reach them to set up a telephone interview?

If possible, I would like to be able to send them by fax or e-mail a list of questions in advance of our interview so that they can prepare their answers and gather any necessary information. What would be the best way to send this information?

Thank you for your assistance.

APPENDIX 5.2. CONFIRMATION LETTER

The University of Kansas

Institute for Public Policy
and Business Research

<DATE>

<Contact Person name and address>

Dear <Contact Name>;

As I described to you in our phone conversation, the Institute for Public Policy and Business Research at the University of Kansas is studying the economic impacts of Digital Video (DV) technology developments that are being assisted by the National Institute of Standards and Technology's Advanced Technology Program (ATP). I understand that ATP has notified you separately that we are authorized to contact you for this study. In particular, we would like to conduct telephone interviews with you and/or other personnel at your company. If you have any questions about ATP's role in this study, you may contact David Hermreck, Program Manager for ATP's Digital Video Program, at (301)975-4328.

This and similar studies are very important to help Congress and other policymakers understand the real impacts of US technology policy. We realize that these interviews take time away from your work, which is also very important. In return and as a small token of our gratitude, at your request we will share with you some of our recent and unpublished findings related to the economic impacts of several emerging technologies in the DV market place.

To help you gather relevant documentation and identify other knowledgeable personnel, I have attached a preliminary list of interview questions. Our telephone interview will not follow this list precisely, but the list will give you a good idea of the topics we will cover.

We understand that much of this information will be of a confidential nature. We will make every effort to maintain that confidentiality. Our Institute has considerable experience in working with confidential data obtained from individual firms, and we have never had an unauthorized release of data. The data we gather will be included in a complex economic model, and only summary statistical information will be made public. In addition we will consult with you to ensure that whatever we release does not contain any inadvertent data disclosures.

607 Blake Hall • Lawrence, KS 66045-2960• (785) 864-3701• Fax: (785) 864-3683

Once you have had a chance to go over the enclosed list of questions, I will contact you to discuss detailed confidentiality arrangements and set up a mutually convenient time for the interview.

If you wish to contact me for any reason I can be reached by phone at 785-864-2839 or e-mail at jrosenbloom@ukans.edu.

Thank you in advance for your assistance.

Sincerely,

Joshua L. Rosenbloom
Associate Professor, Department of Economics
and Faculty Associate, Institute for Public Policy and Business Research

APPENDIX 5.3. INTERVIEW TOPICS

INTERVIEW TOPICS
(Attachment to letter of confirmation)

1. Project Characteristics

1. What is the purpose of the ATP-funded project on which your company is working? That is, what is the desired end product of this research? What technical innovation(s) does this entail? How does it relate to the primary activity or activities of your company?

2. Are you pursuing this project independently or as part of a partnership? If a partnership, who are the other participants? What is the division of responsibility in the partnership? Who should we contact at other participating companies?

3. How will the resulting innovation(s) be used?

4. By whom will it be used?

5. What benefits will they derive from using it?

6. How does each innovation relate to existing products or services already available on the market? Does it improve on or replace an existing product? Or does it define a new product/service category?

7. How is the usefulness or value of the new or improved product/service related to other products or services? Will it increase or reduce the value of other products? Who are the producers of these other products?

8. Does the usefulness of the innovation you are working on depend on the development of standards of any sort? Is there a danger that the premature emergence of standards could perpetuate an inferior technology? Or that delays in the emergence of standards could delay the commercial introduction of new products?

9. What is the time line for the project you are working on? We would like to know when each of the following events either occurred or is anticipated to occur:
   a) Project initiation
   b) ATP funding secured
   c) Research completed (laboratory verification of concept)
   d) Development completed (demonstration of innovation and product engineering)
   e) Commercial introduction
   f) Extinction/replacement by next generation technology

10. Where on the timeline is the project now?

11. Has the project resulted in any commercial applications to date? For each application have you applied for or been granted a patent?

2. Market Characteristics

1. Who are your major competitors in the market you hope to serve with the innovation on which you are working? Are any of them located outside the United States? What do you know about their progress to date?

2. Will you be able to protect your innovation from imitation once it is introduced? If so, how (i.e., patents, trade secrets, first mover advantages)?

3. Are there likely to be significant first mover advantages in the market for your innovation?
4. Is this market "winner take all" or will there be room for multiple products serving differentiated user needs?

3. Effects of ATP Funding

Note: We understand that these are questions of judgment involving a large degree of uncertainty; we are simply asking for your best understanding of what happened.

1. How has ATP funding of this project affected the progress of research on this innovation? Please be as specific as possible about what aspects of the timing, scope, and conduct of research have been affected.

2. By how much has ATP funding shortened the time needed to develop a commercial application?

3. What are the channels through which ATP funding has affected research progress?

4. Thinking not just about your own company, but also other companies working on similar innovations, by how much do you think ATP funding of your project has accelerated the commercial introduction of the innovation on which you are working? Has ATP support made it more likely that this innovation will be developed in the United States?

5. Has your company's receipt of ATP funding affected the pace of research at other potential competitors (causing them either to accelerate or slow the pace of their own research)?

6. Has receipt of ATP funding assisted in obtaining additional external funding for this project? If so, how much additional funding have you obtained as a result? From what source(s)?

7. Has your firm's internal funding of this project changed as a result of the receipt of ATP funding? If so, how?

4. Costs and Revenues

1. For each project phase listed below please estimate the costs and any offsetting revenues received or anticipated to be received. To the extent that resources such as laboratories and equipment would have been used for other purposes include the rental value of this equipment as well.

Project phase					*Hypothetical*
From:	To:	Total Expenditure	Funds Received from ATP	Revenue from other sources	Expenditure if ATP had not funded project
Initiation	ATP Funding				
ATP funding	Completion of Research				
Completion of research	Completion of development				
Completion of development	First sales				
First sales	Extinction/ replacement				

2. What overhead from uncommercialized R&D does each commercialized project have to support?

3. What is the average anticipated failure rate for projects?

4. What is the payback period that you expect R&D projects to meet? In other words, what internal rate of return is necessary to make a project worthwhile?

5. Market impacts

Note: These questions assume that your company or consortium produces the products that embody the innovation. If you will license the technology to a different company, then we would like your estimates of the effects on that company. We recognize that in some instances your answers will be based on forecasts. We are simply interested in your best estimates of the relevant quantities.

1. For each year of the innovation's expected lifetime what is or is expected to be its
   a) sales volume
   b) price
   c) average unit cost of production
   d) what part of the average costs is fixed overhead due to capital and equipment? what part is attributable to any other overhead costs?

2. What is the likely effect of this innovation on the prices and sales of competing products?

3. How has this innovation affected profits? That is, compared to the case where this innovation was not made, by how much are profits likely to be higher or lower in each year? Be sure to include lost revenues from any existing products displaced by the innovation on which you are working.

4. What (if any) tax consequences has this project had/will have for your company? Consider both tax credits associated with R&D expenditures and additional tax payments due to increased revenues.

6. Spillovers

1. Will your company's R&D efforts on this project produce useful information for other firms?

2. Who is likely to benefit from these knowledge "spillovers"?

3. Are there potential uses of knowledge generated by this project outside the intended scope of products your company will produce?

4. Are there any important knowledge "spill-ins" from which your company has benefitted in regard to this project?

7. Environmental consequences

1. Will the innovation on which you are working have any appreciable environmental consequences, either positive or negative?

APPENDIX 5.4. INTERVIEW SCRIPT

Interview Script for Phone Survey of ATP-DV Firms

Preliminaries

Introduction

Provide the names of all those present. Have each person introduce him/herself and briefly explain his/her role in the project.

Obtain permission to record interview: If it is acceptable to you, we would like to make an audio tape of today's interview. We will be taking notes during the interview but would like to have the tape in the event that we need to check the accuracy of any of our notes.

Explanation of interview purposes

The purpose of this interview is to provide data for a report that we are preparing for the National Institute of Standards and Technology's Advanced Technology Program on the Economic Impacts of its focused program on Digital Video in Information Networks.

At this point in the project we are developing data collection instruments that will be used to monitor ongoing economic impacts in the future, and collecting "baseline" data that can be used as a point of comparison for future measurements. Because different projects are at different stages in their life-cycles some of the questions we ask may not be relevant for your project at this time.

The general topics that we will be covering include the following:

The characteristics of the technology or technologies on which you are working with ATP support. We need this information to identify the market or markets likely to be affected by your research.

The effects that ATP funding has had on your research and development efforts on the funded technology.

The chronology of your project.

Expenditures and revenues associated with the project.

Effects on sales and market prices in affected markets (in cases where this is relevant).

Review of Procedures

We recognize that some of the information we will be asking for is confidential. We have been authorized by ATP to collect this information, and we will take appropriate care to insure that nothing that you wish kept confidential will be released. So if you have concerns about preserving the confidentiality of any information please indicate that fact as we go along.

After completing the interview we will write a report for our files based on our conversation. A copy of this report will be sent to you by e-mail or other means, so that you can correct any errors or omissions that you find.

In addition we will provide you with an opportunity to review the report that we prepare for ATP prior to its submission to ensure that we have not revealed any information that you wish to be kept confidential.

Interview

1. **Technology Description**

We'd like to start by asking you some questions about the technical characteristics of the ATP-funded project on which you are working:

a) First, what is the purpose of the project? That is what are the goals of the research? What will result from it?

Follow up questions

a1) How will the resulting innovation work? What will it do for its users?
a2) Who do you anticipate will be the users of this innovation?
a3) How will they use it? What benefits will they derive from using it?

b) Has this research project resulted in any patents? Is it likely to result in patents in the future?

c) Does this innovation replace or improve upon an existing product or service? Or will it result in an entirely new product or service?

Follow up questions (if yes)

c1) Who makes this existing product?
c2) What is the price of this product?
c3) Does it replace a product produced by your company?
c4) What are the characteristics of the market for the existing product? Is it relatively competitive? Or relatively concentrated?
c5) What factors will influence the rate at which consumers adopt the new product?

d) If it is an entirely new product or service, what was the best available alternative way of accomplishing what it does? And how will the cost/performance trade-off change as a result of this innovation?

2. Commercialization Plans

It may be somewhat premature to discuss at this point, but we'd like to get your sense of how this innovation will be commercialized.

a) does your company or consortium produce the products that embody the innovation on which you are working? Or will it do so in the future?

Follow up questions (if yes)--note that these may be estimates of future effects

a1) What are/will be sales volumes for the innovation in each year of its expected lifetime

a2) At what price has/will the innovation be sold? How will this change over its lifetime?

a3) How has/will this innovation affect the prices and sales of competing products

a4) What is the (anticipated) cost of production?
What is the average unit cost of production?
How much of the cost is fixed overhead cost for capital and equipment? How much is other overhead cost?

a5) What impact will this innovation have on company profits? That is, in comparison to a situation in which this innovation did not exist, how would profits change? Be sure to consider the loss of profits due to other products that will be replaced as a result of the innovation.

b) If you do not (will not) produce the products that embody your innovations but license (will license them to others), estimate if possible:

f1) What are/will be sales volumes for the innovation in each year of its expected lifetime

f2) At what price has/will the innovation be sold? How will this change over its lifetime?

f3) How has/will this innovation affect the prices and sales of competing products?

f4) What is the (anticipated) cost of production? Can you break this down?
What is the average unit cost of production?
How much of the cost is fixed overhead cost for capital and equipment? How much is other overhead cost?

f5) What impact will this innovation have on company profits? That is, in comparison to a situation in which this innovation did not exist, how would profits change? Be sure to consider the loss of profits due to other products that will be replaced as a result of the innovation.

c) What are your expectations about royalties or profits on a per unit basis?

3. Market Characteristics

Before we go on to discuss other aspects of the innovation on which you are working, we would like to get a little background information about the market in which your firm operates.

a) With reference to the innovation your firm is working on, how would you characterize your firm's market position?
   Are there a large number of actual or potential competitors in this market?
   How hard would it be for other firms to enter this market?

b) We are interested in how sensitive you believe sales volume for the innovation your firm is working on is/will be to price variations.
   If you were to raise the price by say 10%, by how much would your firm's sales be likely to decrease?
   If you were to cut the price by say 10%, by how much would your firm's sales be likely to increase?

4. Project Chronology

Next we'd like to discuss the time line of the project.

a) For each of the following events please tell us when they occurred or are expected to occur. For those events forecast to happen in the future, please give us your estimate of: (i) the most likely date for the event to occur,
(ii) the earliest date at which the event might occur, and
(iii) the latest date at which the event might occur.

   Initiation of the project
   ATP funding of project
   Completion of research--laboratory verification of concept
   Completion of development--demonstration of innovation and product engineering
   Commercial introduction--first sales
   Extinction/replacement by next generation technology

5. R&D Competition

a) Are there other companies working on similar technologies?

b) If so:
   who are they?
   are any of them located outside the United States?
   What do you know about their progress to date?

c) This may be a stretch, but I want you to think about what would happen if your company were suddenly to vanish tomorrow. How much would this set back progress on the

innovation you are working on? That is, when would another company produce the same or a functional equivalent of the innovations on which you are working?

d) What will the next generation innovation that replaces this one look like?
Who is likely to develop it?
Will leadership in this innovation convey benefits in developing the next generation innovation?

e) Is this innovation likely to be protectable?
Will patents or secrecy provide protection from imitation by potential competitors?
Are there other means available for your firm to maintain a competitive advantage?

6. Network Effects

Many technologies are characterized by coordination problems involving complementary technologies. For example, in the case of HDTV, transmission is not profitable for broadcasters unless there are sets to receive the picture, and people do not want to buy sets until there is something to watch.

a) Does the value of the innovation you are working on depend significantly on the development of other complementary products?

Follow up questions (if yes)
- a1) what are they?
- a2) who (will) produce them?
- a3) are coordination problems with their producers an obstacle to the successful development of the innovation on which your firm is working?
- a4) is their availability likely to affect the timing of your project?
- a5) is the value of the innovation dependent on innovations that have not yet been made but which you anticipate will be made in the future?
- a6) what are you doing to address any problems of coordination?
- a7) How will the innovation affect the value of other complementary products produced by your company?
- a8) How will the innovation affect the value of other complementary products produced by other companies?

b) Are there any important inputs to your innovation that will be purchased externally? If so, who supplies these inputs?
Are there problems of coordination that might slow or prevent development of your innovation?

c) The value of some technologies depends on the number of other users adopting the technology--this is true for example of telephones or e-mail; until there is a critical mass the technology may not be viable.

Is the value of the innovation on which you are working likely to depend on how many other consumers are using it?

Is there a minimum scale of adoption that must be reached for commercialization to be effective?

d) Are there synergies between the technology on which you are working and other technologies that we haven't discussed yet?

e) In some cases, where standards are important, the premature emergence of an industry standard can result in the perpetuation of an inferior technology. Do you see any danger of that happening in the case of the innovation on which you are working?

7. Effects of ATP Funding on Timing, Location, and R&D Funding

Now we would like to turn to the impact that ATP funding has had on your research. In particular we are interested in identifying the extent to which progress has been accelerated by ATP funding, and the mechanisms through which this acceleration has been accomplished.

a) How has the receipt of ATP funding affected the progress of research on this innovation?

Follow up questions

a1) Without ATP would your company have been likely to develop this innovation? Why?

a2) Without ATP funding would the characteristics or scope of the innovation be different in any respect?

a3) Has any phase of the project been accelerated as the result of ATP funding? If so, how has the chronology of events we discussed earlier have been affected by ATP funding?

b) What are the channels through which ATP funding has affected research progress?

Follow up questions

b1) Are effects primarily through increased funding of R&D?

b2) Has ATP funding increased the availability of finance capital?

b3) Are there organizational effects?

b4) Has collaboration with other firms been affected?

b5) Has ATP funding affected the protectability of the innovation?

b6) Has ATP funding affected the likelihood of commercial success?

b7) Has ATP funding affected the availability of partners or potential partners

b8) Has ATP funding affected bureaucracy within your firm?

b9) Has ATP funding affected business plans?

b10) Are there other channels through which ATP has affected the pace or probability of success of this project?

c) (Asked previously: Are there other companies that have the capacity to develop this innovation? Who are they?) Follow up questions (if yes)

c1) When would they be likely to develop it?
c2) Have other firms altered the pace or emphasis of their R&D because your company has received ATP funding for its research? If so, how?

d) Thinking not just about your own company, but also other companies working on similar innovations, by how much do you think ATP funding of your project has accelerated the commercial introduction of the innovation on which you are working? Has ATP support made it more likely that this innovation will be developed in the United States?

e) How has your receipt of ATP funding affected the pace of research at firms that:
- supply inputs used in the innovation?
- produce complementary goods or services used in conjunction with the innovation?
- are likely to use the innovation?

f) Are there other comparable projects being conducted by your company without ATP funds? If so:
Has ATP funding of this project affected these other projects?

8. R&D and Commercialization Costs

Now we would like to consider costs and revenues associated with the innovation. Where items are purchased externally, the cost simply means the purchase price. But many of the inputs may be resources from within the organization, such as laboratory space, or personnel. If possible please try to estimate the rental value of these facilities.

a) For each of the following project phases what have been (or are predicted to be) your total expenditures, the amount received from ATP, and revenue from other sources (that is excluding funds received from ATP? In addition we would like you to offer your best estimate of the expenditures your firm would have made if ATP had not supported this project.

Project phase		*Actual or predicted*			*Hypothetical*
From:	To:	Total Expenditure	Funds Received from ATP	Revenue from other sources	Expenditure if ATP had not funded project
Initiation	ATP Funding				
ATP funding	Completion of Research				
Completion of research	Completion of development				
Completion of development	First sales				
First sales	Extinction/ replacement				

b) What overhead from uncommercialized R&D does each commercialized project have to support?

c) What is the average anticipated failure rate for projects in your firm?

d) What is the payback period that you expect R&D projects to meet? That is what internal rate of return is necessary to make a project worthwhile?

9. Knowledge Spillovers (not covered elsewhere)

a) Will the project produce information useful to other firms? This can include both positive results, such as the proof of particular concepts, or negative results that show that certain approaches are unlikely to be successful.

b) Who is likely to benefit from these knowledge spillovers?

c) Are there other uses to which the knowledge generated by this project might be useful that are outside the intended scope of products that your company will produce?

d) Have there been important sources of knowledge “spill-ins” that have affected the pace, or direction of research on this project? Where have they come from?

e) Are there other technologies that you consider to be underlying foundations of the work you are doing? If so:
What are these technologies?
Who developed them?

10. Material Spillovers

a) Will this innovation have any impacts either favorable or adverse on the environment? If so, what are they?

11. Additional Contacts

a) Are there other people within your company with whom we should speak about any of the topics we have discussed? If so, who are they?

Concluding Remarks

Thank you for your help. Goodbye.

APPENDIX 5.5. FIRM INTERVIEW REPORT FORM

CONFIDENTIAL REPORT ON IMPACTS FOR DIGITAL TV
Note: confidential or proprietary information is indicated with curly brackets, { }.

0. Interview description[6]
Respondent(s):
Title/occupation:
Organization:
Email address:
Telephone:
FAX:
Date of interview:
ID of interviewers:
Referrals to additional interviewees in firm or elsewhere:

1. Technology description
Name of ATP project:

Technology name or description:

Technology goal(s):

Technology technique:

Current developmental status (stage, timeline, risk):

Related, broader technologies:

Related, narrower technologies:

Cross-references:

[6] Create a separate section 0 for each interview related to a given technology.

2. Actual/anticipated effects in immediate markets
Intended initial markets:

Other possible markets:

Planned/actual business model:

Existing substitutes (negatively impacted):

Nature of gain(s) to user (as compared with existing substitutes):

Likely limitations of technology in short-term:

Additional desirable features:

Potential for "inventing around":

Other future substitutes:

Other factors on monopolization potential:[7]

Other factors on intellectual property protection: none identified.

3. Actual/anticipated effects in related markets
Complementary products:

Potential for forced "tie-ins" of this product:

Potential for forced "tie-ins" to this product:[8]

Upstream products (inputs to production of this product): none identified

Downstream products (uses this product as input to production):

---

[7] In addition to those identified in Section 5 below. Also, nearly all DV products have significant monopolization potential because of IRTS (see footnotes 13 and 14 below).

[8] In addition to those implied by complementary markets.

Antagonistic products:[9]

4. Knowledge spillovers[10]
Potential/actual spill-outs:

Potential/actual spill-ins:

5. Network spillovers[11]
Investment coordination problems:[12]

Standards problems:

Hardware-software coordination:

Software-software coordination:

Previous installed base (as a barrier):

Future installed base (as a source of lockin and monopolization):

Other sources of premature lockin:

Economies of scale in production:[13]

---

[9] In addition to substitute products.

[10] In addition to knowledge spillovers implied by previous items.

[11] In addition to network spillovers implied by previous items.

[12] Problems of investment coordination will almost always be present in DV R&D (e.g., over- or under-investment under free competition or monopoly; wasteful or redundant secret research; and problems of government agencies in "picking a winner"). These issues will not be listed unless there are technology-specific considerations.

[13] Nearly all household-oriented applications of DV, as well as some business-oriented applications, will exhibit economically significant increasing returns to scale (IRTS), in the sense that ongoing R&D and commercialization costs can be spread over a large number of consumers.

Direct interactions between consumers (economies of consumption):[14]

Synergies with other technologies (and economies of scope):

Need for development of specialized uses:[15]

Other specialized use networks using this product:

Specialized use networks to which this product belongs:

6. Barriers to development or commercialization[16]
Capital availability:[17]

Other special barriers:

7. Description of this firm

8. Effects of ATP
Effect of ATP on this organization's R&D investment (this and other projects):

Effect of ATP on qualitative characteristics of innovation:

---

[14] Software media costs other than printed manuals are negligible in comparison to marketing, transaction costs, and technical support, especially when using Internet distribution. Hence producer's marginal cost of disseminating software is nearly always less than any positive market price, a form of IRTS leading to an innate social inefficiency.

[15] In addition to the identified complementary markets.

[16] In addition to barriers implied by previous items.

We will not attempt to evaluate technical engineering risk per se, so that will not be listed as a barrier. However item 1 may contain relevant information.

Also, commercialization risk is always present; we will not list it unless there are known problems specific to this technology and not identified elsewhere.

[17] Capital availability will almost always be a potential source of market failure in R&D in general and hence DV R&D (e.g., differences in private and social risk aversion and skewness aversion; differences in private and social discount rates; private information available to researchers but not to investors; transaction costs; asymmetric risk due to existence of bankruptcy). We will mention only special factors or particular evidence specific to this technology. See also discussion of ATP effects below.

Effect of ATP on organization, strategy, partnering, business plan:

Other factors on timing of innovation:

Effect of ATP on other organizations' R&D investment on competitive projects:

Leading competitors in field (experts, firms, laboratories):

Effect of ATP on national location:

Foreign government action:

Likely scenarios absent ATP intervention:

Actual/expected dates:

event	point estimate	lower bound	upper bound
Initiation of the project			
ATP funding of project			
Completion of research laboratory/ verification of concept			
Completion of development /demonstration of innovation and product engineering			
Commercial introduction/first sales			
Extinction/ replacement by next generation technology			

Counterfactual dates (point estimate, LB, UB):[18]

event	point estimate	lower bound	upper bound
Initiation of the project			
Stage comparable to ATP funding of project			
Completion of research laboratory/ verification of concept			
Completion of development /demonstration of innovation and product engineering			
Commercial introduction/first sales			
Extinction/ replacement by next generation technology			

[18] Relative time indicated as in the following: A+48 means actual event plus 48 months

9. Market impacts

Size of potential (market or markets)

Actual/potential sales of products embodying innovation

Revenue per unit earned by innovating firm

Cost saving or monetary benefit to users per unit purchased

APPENDIX 5.6. FIRM INTERVIEW TEST DATA

REPORT ON IMPACTS FOR DIGITAL TV

note: confidential or proprietary information is omitted.

0. Interview description[19]

Respondent(s):	David Waring, Director
Title/occupation:	
Organization:	Telcordia (formerly Bellcore)
Email address:	DLW@research.Telcordia.com
Telephone:	973-829-4850
FAX:	
Date of interview:	11 April 2000
ID of interviewers:	Joshua Rosenbloom
Referrals to additional interviewees in firm or elsewhere:	None identified

1. Technology description

Name of ATP project: Interoperability Tools for Digital Video Systems

Technology name or description:

Software reference implementations of standards for DV access and distribution across ATM-based networks.

Technology goal(s):

The project was tightly coupled to the process of standards development undertaken by the Digital Audio Video International Council (DAVIC) in the mid-1990s. International discussions within DAVIC were focused on developing standards for Digital Storage Media Command and Control (DSMCC) for the interchange of DV content across networks. These standards would specify, for example, how file servers would be located and accessed remotely. The project's goal was to develop a set of software implementations of these standards that would be licensed to two groups: (1) network operators–i.e., telecom firms; and (2) equipment producers –e.g., makers of file servers, ATM switches, set-top box manufacturers.

The DAVIC standards-setting process, which was focused on ATM-based networks, was essentially derailed in late 1997 by the emergence of a competing network architecture centered around IP-based networks. The growth of the Internet substantially undermined interest in ATM

[19] Create a separate section 0 for each interview related to a given technology.

based networks, as did the abandonment at this time by several phone companies of pilot projects distributing DV content over ATM networks.

ATM networks are better for quality of service but are a much more expensive alternative to IP-based networks.

Technology technique:
Develop software tools in conjunction with participation in international standards-setting body.

Current developmental status (stage, timeline, risk):
Project has terminated due to collapse of standards-setting process and the loss of interest in ATM networks as a mechanism of distributing DV content.

Related, broader technologies:
Information Network protocols.

Related, narrower technologies:

Cross-references:

2. Actual/anticipated effects in immediate markets

Intended initial markets:
1) telecommunications companies in major advanced economies (approximately 20 of these world wide, all are well known), and
2) suppliers of components for these networks (approximately 200-300 companies are in these markets).

Other possible markets:
Corporate intranets.

Planned/actual business model:
Software would be licensed to users who would implement it on their networks or embed it in their components. Licenses would typically involve an up-front fee and a negotiated payment presumably reflecting the volume of business that different clients did.

Existing substitutes (negatively impacted):
None identified. The alternative is for users to write their own implementation of the standards.

Nature of gain(s) to user (as compared with existing substitutes):
Up front cost savings from not having to create their own implementations.

Likely limitations of technology in short-term: None identified

Additional desirable features: None identified

Potential for "inventing around":
Large: once standards are adopted they are readily known to all. Being the first to market and establishing market share is the primary source of competitive advantage in this market.

Other future substitutes:
Revised standards could lead to the replacement of existing protocols.

Other factors on monopolization potential:[20] None identified

Other factors on intellectual property protection: None identified.

3. Actual/anticipated effects in related markets
Complementary products:
DV content
Display devices for viewing DV content
Broadband networks connecting final consumers to fiber backbones.

Potential for forced "tie-ins" of this product:
Software tools would be integrated into a variety of products, including relays, file servers, switches, and set top boxes.

Potential for forced "tie-ins" to this product:[21]

Upstream products (inputs to production of this product):
Standards

[20] In addition to those identified in Section 5 below. Also, nearly all DV products have significant monopolization potential because of IRTS (see footnotes 26 and 27 below).

[21] In addition to those implied by complementary markets.

Downstream products (uses this product as input to production):

Delivery of DV content of all sorts to consumers

Distribution of Broadcast or other DV content between producers

Video conferencing.

Antagonistic products:[22]

4. Knowledge spillovers[23]

Potential/actual spill-outs:

Knowledge about ATM networks

Additional skills developed by team working on the project. Now diffused to other electronics companies working in the DV field.

Potential/actual spill-ins:

Knowledge of telephone system networks

Knowledge of ATM networks

Knowledge about DV uses and distribution

Bellcore had prior experience developing reference standard software tools for signaling and control of voice switching on broadband networks.

5. Network spillovers[24]

Investment coordination problems:[25]

Industry adoption of standards was crucial (in this case the failure to adopt standards aligned with the product brought the project to an end).

Standards problems:

Establishing standards was essential.

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[22] In addition to substitute products.

[23] In addition to knowledge spillovers implied by previous items.

[24] In addition to network spillovers implied by previous items.

[25] Problems of investment coordination will almost always be present in DV R&D (e.g., over- or under-investment under free competition or monopoly; wasteful or redundant secret research; and problems of government agencies in "picking a winner"). These issues will not be listed unless there are technology-specific considerations.

Hardware-software coordination:
Important

Software-software coordination:
Important

Previous installed base (as a barrier): Not a significant problem

Future installed base (as a source of lockin and monopolization):
Possibly important as a means of capturing the market.

Other sources of premature lockin: None identified.

Economies of scale in production:[26]
Significant, since most of the costs of producing software are up-front costs.

Direct interactions between consumers (economies of consumption):[27] None identified

Synergies with other technologies (and economies of scope): None identified

Need for development of specialized uses:[28] none identified.

Other specialized use networks using this product: none identified.

Specialized use networks to which this product belongs: none identified.

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[26] Nearly all household-oriented applications of DV, as well as some business-oriented applications, will exhibit economically significant increasing returns to scale (IRTS), in the sense that ongoing R&D and commercialization costs can be spread over a large number of consumers.

[27] Software media costs other than printed manuals are negligible in comparison to marketing, transaction costs, and technical support, especially when using Internet distribution. Hence producer's marginal cost of disseminating software is nearly always less than any positive market price, a form of IRTS leading to an innate social inefficiency.

[28] In addition to the identified complementary markets.

6. Barriers to development or commercialization[29]

Capital availability:[30]

Problems of financing the project were important. The project was viewed as too risky to gain internal financing without ATP support.

Other special barriers: None identified.

7. Description of this firm

8. Effects of ATP

Other factors on timing of innovation:

The standards-setting process determined the timing. The project was undertaken in conjunction with DAVIC-sponsored discussion of standards

Leading competitors in field (experts, firms, laboratories):

Lucent, Alcatel, Erickson, other major telecom.

Columbia University was engaged in research in related fields but was not judged likely to develop a commercially-viable product.

Foreign government action: None identified

Likely scenarios absent ATP intervention:

Bellcore would not have undertaken to develop these software tools in the absence of ATP funding.

If standards had been established, Lucent or another major telecommunications company would probably have developed software implementing the standards. These might have been used

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[29] In addition to barriers implied by previous items.

We will not attempt to evaluate technical engineering risk per se, so that will not be listed as a barrier. However item 1 may contain relevant information.

Also, commercialization risk is always present; we will not list it unless there are known problems specific to this technology and not identified elsewhere.

[30] Capital availability will almost always be a potential source of market failure in R&D in general and hence DV R&D (e.g., differences in private and social risk aversion and skewness aversion; differences in private and social discount rates; private information available to researchers but not to investors; transaction costs; asymmetric risk due to existence of bankruptcy). We will mention only special factors or particular evidence specific to this technology. See also discussion of ATP effects below.

internally without ever being marketed more widely. Thus there were potential cost savings/efficiency gains from a project committed to widespread licensing of the resulting software tools.

Effect of ATP on national location:

Small: Lucent judged the most likely competitor to develop this technology.

Effect of ATP on qualitative characteristics of innovation: None identified

Effect of ATP on organization, strategy, partnering, business plan:

Access to NIST labs was helpful in developing project and would have helped in commercialization.

Effect of ATP on this organization's R&D investment (this and other projects):

Organization would not have devoted resources to this project absent ATP fund

Effect of ATP on other organizations' R&D investment on competitive projects:

Lucent's investments in this area appear to have been unaffected by ATP

Actual/expected dates:

event	**point estimate**	**lower bound**	**upper bound**
Initiation of the project	1995		
ATP funding of project	1995		
Completion of research laboratory /verification of concept	1997		
Completion of development /demonstration of innovation and product engineering	NA		
Commercial introduction/first sales	NA		
Extinction/replacement by next generation technology	NA		

Counterfactual dates (point estimate, LB, UB):[31]

Discussion suggests that ATP funding did not substantially accelerate potential introduction of software tools.

event	point estimate	lower bound	upper bound
Initiation of the project			
Stage comparable to ATP funding of project			
Completion of research laboratory /verification of concept			
Completion of development /demonstration of innovation and product engineering			
Commercial introduction/first sales			
Extinction/replacement by next generation technology			

9. Market impacts

Size of potential (market or markets)	Not applicable
Actual/potential sales of products embodying innovation	Not applicable
Revenue per unit earned by innovating firm	Not applicable
Cost saving or monetary benefit to users per unit purchased	Not applicable

[31] Relative time indicated as in the following: A+48 means actual event plus 48 months

APPENDIX 5.7. QUALITATIVE ATTRIBUTION INTERVIEW TOPICS

The following question topics would support the qualitative attribution model described in Burress *et al.* (1999b, Appendix 1). This line of questions was omitted from the firm interview protocol to economize on interview time. However, some of these topics were covered for more general reasons.

Has ATP funding affected the answer to any of the following questions? How?

- Is the innovation protectable?
- Is commercial success likely?
- Will other companies profit significantly from this innovation?
- Is sufficient finance capital available to your company?
- Is sufficient entrepreneurial capital available to your company?
- Are there other barriers to technical or commercial success?

Has ATP funding affected any of these underlying factors? How?

- What is the nature of the firm and its niche?
  - market power
  - US, world market share
  - size of firm
  - nature of its co-specialized assets
  - length of product cycle
  - cross-industry innovation (outsider)?
  - amount of experience
  - economies of scope and scale
  - ownership of competing technologies
  - degree of dynamism
  - degree of bureaucratization
  - level of technical skills
  - level of business skills
- What is the nature of the industry and market?
  - level of downstream expertise
  - need for regulatory approvals
  - need for reputation
  - degree of competition
  - speed of technical change

size of producers (market concentration)
rate of technical change
incumbent monopoly or oligopoly
level of R&D capability
availability of potential partners
level of infratechnology

APPENDIX 5.8. AXIOMATIC MODEL FOR SUBJECTIVE DISTRIBUTIONAL INFORMATION[32]

Our goal is to elicit from interviewees a subjective distribution of changes in timing of counterfactual events, especially the time at which an innovation would have occurred in the absence of ATP intervention. The problem is to ask a very small number of questions and then infer a quantitative distribution. We assume that the respondent can estimate a median time difference M and a maximal time difference T, and that the minimal time difference is 0. We also assume that the main goal is to calculate the expected value of the distribution, say G(M, T).

Assumptions

G(M, T) should represent the expectation of the time difference over a 2-parameter distribution h(t; M, T). We assume that the following axioms are reasonable and minimal prior constraints on the function G.

(1) $G(M, T) = \int_0^T h(t; M, T)x dx.$

(2) the distribution function h(.;.,.) is non-negative and reasonably smooth.

(3) $h(t; M, T) = 0$ if $t \leq 0$.

(4) $h(t; M, T) = 0$ if $t \geq T$.

(5) $.5 = \int_0^M h(t; M, T)dx.$

(6) $.5 = \int_M^T h(x; M, T)dx.$

(7) $\partial G(M, T)/\partial M > 0$.

[32] An earlier version of this model appeared in Burress (1992)

(8) $\partial G(M, T)/\partial T > 0$.

(9) $\partial^2 G(M, T)/\partial T \partial (M/T) > 0$ (i.e. the relative weight on T should decrease for extreme values of T).

(10) $\partial^2 G(M, T)/\partial M \partial (M/T) < 0$ (conversely, the relative weight on M should increase).

(11) $G(aM, aT) = aG(M, T)$ (scale invariance).

A simplified set-up

Note that from (11) we can conclude

(11') $G(M, T) = g(m)T$ where $m = M/T$; $0<m<1$.

(We should probably also assume the distribution is skewed, leading to $0<m<.5$.) Then defining $k(y; m) = h(t; M, T)/T$, axioms (1) through (10) can be rewritten as

(1') $g(m) = \int_0^1 k(y; m)ydy$, where $y = x/T$.

(2') the distribution function $k(.;.)$ is non-negative and reasonably smooth.

(3') $k(y; m) = 0$ if $y \leq 0$.

(4') $k(y; m) = 0$ if $y \geq 1$.

(5') $.5 = \int_0^m k(y; m)dy$.

(6') $.5 = \int_m^1 k(y; m)dy$.

(7') $g'(m) > 0$.

(8') $g(m) > 0$

(9') $g'(m) > 0$.

(10') $g''(m) < 0$.

Note however that equation (9') adds no new information to equation (7'). Also note that from (1'-6') we can prove

(12) $0 < g(m) < 1$ for $0 < m < 1$.

Solutions

There are very many solutions to this system. First, note that if we replace (10') with

(10*) $g''(m) = 0$

then a solution is given in the distribution sense by

(13a) $k(y; m) = \alpha\delta(y-m) + [(1-\alpha)/2m][1 - \Theta(y-m)(1-2m)/(1-m)]$
(13b) $g(m) = \alpha m + (1-\alpha)(1+2m)/4$
(13c) $G(M, T) = (\alpha+1)M/2 + (1-\alpha)T/4$

where $\alpha>0$ is a constant, $\delta(.)$ is the Dirac delta distribution, and $\Theta(.)$ is the Heaviside step function. If g(.) is continuous then this solution to the modified problem is unique.

Next, consider a class of solutions to the original problem written in the form

(14) $k(y; m) = \alpha\delta(y-m) +[(1-\alpha)/2m][1 + \Theta(y-m)(2m-1)/(1-m)] + l(y; m)$.

Then l(.,.) must be subject to

(5") $0 = \int_0^m l(y; m)dy$, and

$$(6'')\quad 0 = \int_m^1 l(y; m)dy.$$

Also, g(.) is defined by

$$(1'')\quad g(m) = \int_0^1 l(y; m)ydy + m\ .$$

Hence (9') and (10') lead to the conditions

$$(9'')\quad \int_0^1 l_m(y; m)ydy + 1 > 0$$

$$(10'')\quad \int_0^1 l_{mm}(y; m)ydy < 0.$$

There are an unlimited number of smooth functions l(y; m) which satisfy (5''), (6''), (9''), and (10''). As an example, for $\beta>0$ consider the family of solutions generated from

$$(15)\quad l(y; m) = \begin{cases} -\beta\sin[2\pi y/m], & 0<y<m; \\ -\beta\sin[2\pi(y-m)/(1-m)], & m<y<1. \end{cases}$$

We still need to impose (2') on (15); i.e., k(y; m) should be nonnegative; but from (14) and (15), non-negativity can be assured by requiring $0\le\beta\le(1-\alpha)/2m$. Since this must hold for all m, $0<m<.5$, we require

$$(2'')\quad 0\le\beta\le(1-\alpha).$$

(Note this implies $\alpha\le 1$.) Then working back through these equations one can show we have satisfied the original system for any positive α, β satisfying (2''). This system can easily be integrated to give an explicit solution for g(m) and G(M, T):

$$(16a)\quad g(m) = \alpha m + (1-\alpha)(1+2m)/4 - \beta/(2\pi)[m^2 + (1-m)^2]$$

$$(16b)\quad G(M, T) = (\alpha+1)M/2 + (1-\alpha)T/4 - \beta/(2\pi)[2M^2-2MT+T^2]/T$$

Implications

1. Equations (9'), (10'), (11'), and (12) give a consistent but not quite complete prior characterization of G(M, T).

2. Equations (16b) and (2") give a reasonably flexible parametrization of G(M, T).

3. Using this parametrization, the choice of α on $0<\alpha<1$ seems fairly arbitrary. From (16b), $(1-\alpha)/4$ can be interpreted as the relative linear weight to be placed on T (as opposed to M) in computing G. So $\alpha=.5$ is not an unreasonable choice and seems like a minimum information solution.

For choosing β, one reasonable approach is to try to force g(0) to approach 0 and/or g(1) to approach 1 as nearly as possible. The first condition would lead to a maximal $\beta = (1-\alpha)$; while the second would lead to a minimal $\beta=0$. $\beta=0$ violates (10'), so the first condition seems better. However, $\beta=.5(1-\alpha)$ seems like a minimum information solution.

With $\alpha=.5$ and $\beta = (1-\alpha)/2$ we would have

(17a) $g(m) = m/2 + 1/4 -(1/8\pi)[m^2 + (1-m)^2]$.

(17b) $G(M, T) = 3M/4 + T/8 - 1/(8\pi)[2M^2-2MT+T^2]/T$

let $R = 1/m = T/M$, $R>2$; then (17b) becomes

(18) $G(M, R) = M\{3/4 + 1/(4\pi) + (R/8)(1 - 1/\pi)(1+2/R^2)\}$

$\approx M\{.83 + .085R(1+2/R^2)\}$.

6. CGE MODELING METHODS

Purpose

The firm-level and consumer-level data described in previous chapters are intended to support analysis of the impacts of ATP's DV program on US economic welfare. The data will be analyzed in two different ways:

- Using partial equilibrium approaches based on cost saving and consumers surplus, and
- Using a Computable General Equilibrium (CGE) model of the US economy, along the lines described in Burress *et al.* (1999a).

The CGE approach is more complicated and requires the use of much additional data from published sources. The advantage of using a CGE model is that it can handle complicated intersectoral interactions for which partial equilibrium approaches are ill suited. At this stage of the research, however, few of the ATP-supported DV projects have led to commercialized innovations. Consequently, complex intersectoral interactions are not yet ripe for analysis. Therefore, the particular CGE model developed for our next report will constitute a proof-of-concept only. For that reason we will use a small number of sectors, rather than a large scale model with many sectors.

This chapter addresses some new techniques or particular modeling decisions that will be needed to specify and parametrize the CGE models (both small and large). In particular we will address:

- An aggregation scheme for the small model;
- Methods for combining original survey data with other data on household behavior;
- Estimates of income and price demand elasticities for recreation goods.

Issues involving more standard techniques will be deferred until the next report.

The aggregation scheme

For a large scale model, the aggregation scheme would be based on US input-output accounts, which can support upwards of 500 sectors. In addition, new sectors would have to be broken out for DV-related services, both before and after the innovations came on line. For the small scale model, we propose the following sectoral scheme:

B: Private business goods except R&D;
R: R&D;

G: Government except R&D;

H: Households and investment except R&D (capital income aggregated with labor income);

T: Foreign trade.

A highly simplified social accounting matrix is given by:

Table 6.1
A 5-Sector Social Accounting Matrix

	B	R	G	H	T	Total
B	C_b	C_r	C_g	C_h	E	X_b
R	0	0	R_g	R_h	0	X_r
G	0	0	0	T	0	X_g
H	Y_b	Y_r	Y_g	0	0	Y
T	M	0	D	0	0	M+D
Total	X_b	X_r	X_g	Y	E=M+D	

Our current plan is to aggregate digital video sectors with all other business output because our preliminary interviews with firms have revealed that products are just now starting to be commercialized. That is, ATP's DV program has not yet had a great impact on sales or production. If, in the course of our additional firm interviews, we find some products or services well into commercialization, we will break out additional digital video sectors. We will disaggregate the R&D sector because there have been R&D impacts.

Estimating the household behavioral model

Chapter 3 addressed data on consumer demands specifically for DV-related goods and time consumption. In the large-scale CGE model we will need a complete picture showing demands in all sectors, as well as labor supply. That leads to a problem of integrating information on consumption from different sources. Chapter 3 suggests two different ways this can be accomplished:

- By estimating specific demands for DV goods and then integrating them into demand systems already estimated by other researchers; or
- By integrating micro-data from various sources (whether using a synthetic match or by other means), and then estimating a compete household demand system from microdata.

The first approach is simpler and is likely to be used initially when *ex post* market data on ATP-supported DV innovations become available. However, the second approach is theoretically superior and is likely to be used eventually if project resources permit. Much of the work in Chapter 3 was aimed at preserving both approaches as possibilities. In this chapter we show that how these two approaches can be accomplished using the planned data.

In particular, Appendix 6.1 describes a synthetic match algorithm. The next section discusses how DV consumption elasticities can be integrated with price and income elasticities estimated by others.

Integrating price and income elasticities of demand from multiple sources

A possible strategy for building a complete consumption system is to find separate published estimates of own-price and income elasticities for various aggregate goods (and perhaps cross-price elasticities as well, if they are available), as well as average budget shares, and then find the consumption system that "most closely" reproduces those elasticities and average budget shares.

There is a significant obstacle to this approach: a system of demands such that all income and own-price elasticities are constant is not consistent with utility maximization under a given budget constraint (not a new result, but shown in Appendix 6.2). So the problem is to find a system that approximates constant demand elasticity behavior in a given region. In other words, we want a demand system such that, for a fixed vector of prices and a fixed income, all price and income elasticities can be set arbitrarily. (Of course there could be limits on the ranges of allowed elasticities.) Away from that point, elasticities should vary slowly as needed to maintain the hypothesis of utility maximization.

Appendix 6.2 develops a system of this type. It has independent parameters for each income elasticity and each own-price elasticity. It is limited, however, by having only a single parameter that represents all cross-price elasticities for a given good.

Because of parallelism between consumption and production theory, similar models are available for the input demand elasticities of production sectors.

Income and price elasticities for recreation

Most household uses of video are associated with recreation and leisure time. The same is likely to be true in the foreseeable future. It would seem, therefore, that the most important demand elasticities used in the CGE model would be those associated with recreation.

Appendix 6.3 summarizes a review of empirical studies on income and price elasticities for recreation. Here are some proposed interpretations.

Income elasticities of demand

The elasticity of demand for recreation in the US is probably between1.2 and 1.5. In almost all studies in all times and countries, the measured elasticity exceeds one. The elasticity is clearly higher in underdeveloped countries than in developed countries and appears to fall over time within a country. It appears to be approximately constant across countries at the same level of income. There is a very strong implication that the income elasticity of recreation falls as income increases.

Own-price elasticities of demand

The price elasticity of demand for recreation in the US is probably between -.6 and -1.0. The price elasticity appears approximately constant across most countries but is substantially more negative in very poor countries.

Cross-price elasticities of demand

No studies were available that used cross-section data, and only one study looked at goods other than food (and that was not for the US). Time series studies appear to show that the cross-price elasticity of recreation and food ranges from around -.2 or -.3 for rich countries like the US down to -1. for very poor countries.

APPENDIX 6.1. SYNTHETIC MATCH ALGORITHM

A synthetic match is a method of artificially merging two microsample data sets over the same universe for the purpose of combining two sets of variables. The match is performed by putting together records that agree or "are close" on values for a set of variables (say **x**, **X**) that are (at least approximately) the same in meaning and measurement in the two data sets. Then new sample weights are created for the combined records that, as far as possible, are consistent with separate sampling weights of the two records that were joined.

Assumptions and notation

Sampling units are the same for the two datasets (e.g., households, consumption units, persons).

Each dataset has a set of sample weights that are estimators of the number of elements in the universe represented by each observation; say w_i, W_j.

The "common" variables are x_i, X_j.

The goal is to match and reweight observations in such a manner that the matching:

- Completely covers both data sets;
- Treats the two datasets equally;
- Maintains total sample weight; and
- Reflects sample weights of the original individual records as far as possible.

We do *not* assume a 1-to-1 match between records. Individual records in general may have multiple partners, with each partnership creating a new combined observation.

Algorithm

1. Reweight the two sets of weights proportionately to add up to the same total. (Most likely, the new total will be the mean of the two sample totals.)

The weights are now reconciled so that

$$\Sigma_i w_i = \Sigma_j W_j.$$

2. Define a distance function over the common variables; e.g. define

$$D_{ij} = \Sigma_k \alpha^k (x_i^k - X_j^k)^2, \text{ where } \alpha^k \geq 0 \text{ for all k.}$$

In general, the $\boldsymbol{\alpha}$ represent subjective judgements about the relative importance of each of the common variables. (The implicit goals are objective -- e.g., to find optimal predictors for the covariances between pairs of variables that cross the two data sets and appear jointly in regressions planned for the research design -- but it is very hard to model or estimate $\boldsymbol{\alpha}$ formally. See below for further discussion.)

3. For each observation i find the set $j \varepsilon J_i$ that minimizes D_{ij}. Let N_i = size(J_i) = number of ties (in a multiple minimum).
Similarly, for each observation j find the set $i \varepsilon I_j$ that minimizes D_{ij}. Let N_j size(I_j).

4. Create a (sparse) matrix showing all cases of minimum distance, weighted inversely by the number of ties. In particular, define:

$m_{ij} = 1/N_i$, $j \varepsilon J_i$;
$m_{ij} = 0$ otherwise.

$M_{ij} = 1/N_j$, $i \varepsilon I_j$;
$M_{ij} = 0$ otherwise.

$\mu_{ij} = .5(m_{ij} + M_{ij}.)$

5. Perform the RAS algorithm on $\boldsymbol{\mu}$ (as explained below). In other words, find the matrix $\boldsymbol{\mu}^*$ nearest to $\boldsymbol{\mu}$ that has row totals w_i and column totals W_j. Nearness is defined in an entropy or minimum information sense (MacGill, 1977).

Then μ^*_{ij} is the weight for the merged observation i, j.

Some problems

Large matrix problems

The matrix $\boldsymbol{\mu}$ is of dimension nxN, where n and N are the numbers of observations in the two datasets. This could be very large. The RAS algorithm on a very large matrix cannoy be performed using ordinary matrix software. However, the RAS algorithm is still practical. We need to set up records [i, j, μ_{ij}] (e.g., in SAS) for each nonzero μ_{ij}, and then run through the file up to four times for each iteration of RAS. Alternatively, RAS could be implemented using sparse matrix software.

The RAS algorithm is:

- Collect column totals;
- Adjust all matrix entries in each column proportionately to reconcile to that column total;
- Collect row totals;
- Adjust all matrix entries in each row to reconcile to that row total;
- Iterate until all changes in column totals and row totals between iterations are "small enough."

Distance function problems

Missing data. One problem occurs when there are missing data in **x** or **X**. Some possible approaches are:

- Substitute mean values for missing variables.
- Create a distribution for "missing" data and choose randomly from that distribution. This can be as sophisticated as desired.
- In particular, calculate the distributions of non-missing values from the two data sets. Partition it into the difference of two distributions with non-negative densities and totals corresponding to the missing weights in the two samples. Select randomly from the two distributions.
- Do the same, but then look at correlations between that variable and other variables in **x** and/or **X**. Require the new distribution to maintain observed correlations when reweighted by the new distribution function.

Selecting a distance function. Another problem is setting the distance function. Euclidean (squared) weighting makes intuitive sense, but how do we choose $\boldsymbol{\alpha}$?

Conceptually, α^k should depend on the (inverse) variance of x^k or X^k (or their average). However, it should also depend on subjective and objective beliefs about the importance of the individual variable, k. One piece of objective information is: how well does the k variable predict the most important variables that are being merged? In effect we are regressing Y on **X** and then **x** on **z**, as a device for regressing Y on **z**. So conceptually, the goal is to maximize the R^2 of the two regressions. However, there may be many such regressions, so we would also need weights on the relative importance of individual regressions.

Time differences between the two samples could lead to a need to inflate dollar figures. Other adjustments in weights are possible using outside data sources.

APPENDIX 6.2. QUASI-CONSTANT DEMAND ELASTICITY UTILITY SYSTEM

Problem statement

For welfare analysis using CGE models, it is desirable to:

d) Parametrize a consumption system using income and price demand elasticities from a variety of published sources;

e) Infer a specific utility function; and

f) Infer welfare changes in money metric from changes in household prices faced and/or quantities consumed.

Unfortunately, strictly constant price and income elasticities of demand are not consistent with utility maximization under an ordinary budget constraint (not a new finding, but demonstrated in Section 2 below). This appendix develops an approximation to constant elasticities that is based on an exact indirect utility function.

A heuristic analysis

Suppose we have indirect utility from a demand system that assumes constant income and own price elasticities. Let

x_i = demand for ith good

p_i = price of ith good

y = income

V = V(**p**, y) = (pseudo) indirect utility

V_i and V_y = partial derivatives of V

η_i = (-1 times) own-price elasticity of ith good (so η_i is ordinarily positive)

η_y = income elasticity of all goods

Consider the pseudo indirect utility function

$$(1) \quad V = \Sigma_i \mu_i (1/p_i)^{\eta i - 1} + y^{\eta y + 1},$$

where **μ** is a vector of parameters. We can see immediately that (1) is not a valid indirect utility function because it is not homogenous of degree 0 in prices and income. Nevertheless, proceeding as if it were valid, and recalling Roy's identity

(2) $x_i = -V_i / V_y$,

we immediately recover a constant elasticity demand system:

(3) $x_i = \mu_i(\eta_i - 1)(\eta_y + 1)y^{\eta y} / p_i^{\eta i}$, or

(4) $\log x_i = \log [\mu_i(\eta_i - 1)(\eta_y + 1)] - \eta_i \log p_i + \eta_y \log y$.

Conversely, (1) is the solution to the partial differential system (2,3) (and it is unique, up to any monotone transform on V). Note however that the system (3) does not obey the budget constraint $\mathbf{p'x} = y$. Thus, if an indirect utility function did lead to the exact CES system, then working backwards using integrability conditions, we can show that it must have the form (1). Hence exact CES demands are not consistent with utility maximization.

An exact consumption system

Nevertheless, the pseudo indirect utility function (1) must be "close" to some indirect utility functions which are exact and globally valid, and lead to approximately constant elasticities within some region in ($\mathbf{p}$, y) space. So let us look for a function which *does* have the correct homogeneity. In particular, consider

(5) $v(\mathbf{p}, y) = [\Sigma_i \ K_i(y/p_i)^{\alpha i}]\exp[y^{\beta}/\Pi_i p_i^{\gamma i}]$,

where $\boldsymbol{\alpha}$, β, and $\boldsymbol{\gamma}$ are parameters and $\Sigma_i \gamma_i = \beta$. Note that the system is homogenous of degree 1 in prices and income y. Since utility must be increasing in income we must have $\beta > 0$. We intend to interpret y as non-labor income and use the same system to explain the labor supply; consequently, the signs of K_i and α_i are a bit more complicated. For goods that the household purchases, utility must decline with prices, so $K_i\alpha_i > 0$. For goods such as labor that the household sells, utility increases with price and we must have $K_i\alpha_i < 0$. The values of K_i and α_i must also be such that utility is everywhere increasing in y. Setting $K_i\alpha_i > 0$ for purchased goods ensures that the corresponding terms are increasing in y. However, the terms for labor income are problematical - since $K_i\alpha_i < 0$, those terms are decreasing in y. Hence they must dominated by some other terms that are increasing in y. One way to do this is to require that v be everywhere positive. Then note that

(6) $v_y(\mathbf{p}, y) = (v(\mathbf{p}, y)/y)[\Sigma_i \ K_i\alpha_i(y/p_i)^{\alpha i}/\Sigma_i \ K_i(y/p_i)^{\alpha i} + \beta y^{\beta}/\Pi_i p_i^{\gamma i}]$.

Assuming v is positive, the only problem occurs for j with $K_j\alpha_j < 0$ and for that case only when p_j gets small. In that case, the first term inside the brackets is always greater than $-|\alpha_j|$. If we have $\gamma_j > 0$, for small p_j the second term inside the brackets blows up and dominates the first term. Then from (5), requiring all $K_i > 0$ is sufficient for v to be everywhere positive.

To summarize: for globally valid utility it is sufficient to have all $K_i>0$, $\alpha_i>0$ for purchased goods, $\alpha_i < 0$ for labor, $\gamma_i > 0$ for labor, $\beta>0$, and $\Sigma_i \gamma_i = \beta$. (In some cases we can relax these conditions and still have a locally valid indirect utility.)

Using Roy's identity, we can calculate the exact demand system:

$$(7) \quad x_i(\mathbf{p}, y) = (y/p_i)[K_i\alpha_i(y/p_i)^{\alpha i} + \gamma_i \Sigma_j K_j(y/p_j)^{\alpha j} y^{\beta}/\Pi_j p_j^{\gamma j}]/ [\Sigma_j K_j\alpha_j(y/p_j)^{\alpha j} + \beta \Sigma_j K_j(y/p_j)^{\alpha j} y^{\beta}/\Pi_j p_j^{\gamma j}].$$

A constant demand elasticity approximation

We now seek a region of ($\mathbf{p}$, y) such that (7) approximates constant demand elasticities. (We may need additional restrictions on the parameters as well.) The trick is to have

$$(8a) \quad K_i\alpha_i(y/p_i)^{\alpha i} >> \gamma_i \Sigma_j K_j(y/p_j)^{\alpha j} y^{\beta}/\Pi_j p_j^{\gamma j}, \text{ and}$$

$$(8b) \quad \Sigma_j K_j\alpha_j(y/p_j)^{\alpha j} << \beta \Sigma_j K_j(y/p_j)^{\alpha j} y^{\beta}/\Pi_j p_j^{\gamma j}, \text{ so that}$$

$$(9) \quad x_i(\mathbf{p}, y) \sim (y/p_i)[K_i\alpha_i(y/p_i)^{\alpha i}]/ [\beta \Sigma_j K_j(y/p_j)^{\alpha j} y^{\beta}/\Pi_j p_j^{\gamma j}].$$

For simplicity assume we are in a region where (and have chosen units such that) y/p_i is near 1 for all i, and hence $y^{\beta}/\Pi_j p_j^{\gamma j}$ is near 1 as well). Then (8a,b) hold if

$$(10a) \quad |K_i\alpha_i| >> |\gamma_i \Sigma_j K_j| \text{ and}$$

$$(10b) \quad |\Sigma_j K_j\alpha_j| << \beta \Sigma_j K_j.$$

Since the K_i are all positive, (10a) is satisfied for i if and only if γ_i is small with respect to α_i. As we can see from (11) below, this implies either that the cross-price elasticities corresponding to that price are small, or that there is a large (negative) own-price elasticity.

(10b) can be guaranteed by choosing β sufficiently large with respect to $\boldsymbol{\alpha}$, but, as we can see from (11), that would imply small income elasticities. Note however that (10b) also tends to hold because the negative terms on the LHS offset its positive terms.

Under conditions for which (9) is a valid approximation, we have

$$(11)\quad \log x_i(\mathbf{p}, y) \sim \log [K_i\alpha_i / \beta] + [-1 - \alpha_i + \gamma_i] \log p_i + [1 + \alpha_i - \beta] \log y + \Sigma_j [\gamma_i] \log p_j + [-1] \log \Sigma_j K_j(y/p_j)^{\alpha j}.$$

(For labor, x_i is negative and should be replaced with $-x_i$ in the above expression; at the same time, K_i should be replaced with $-K_i$.) The last term keeps this expression from having exact constant elasticities, but it is slowly varying. For example we have

$$(12)\quad d \log x_i(\mathbf{p}, y)/ d \log p_i \sim [-1 - \alpha_i - \gamma_i] + K_i \alpha_i (y/p_i)^{\alpha i} / \Sigma_j K_j(y/p_j)^{\alpha j}.$$

The last term is negligible to the extent that

$$(13)\quad |K_i\alpha_i| << \Sigma_j K_j.$$

Based on the stylized fact that most goods are very roughly Cobb-Douglas, we generally do have α_i, γ_i β small with respect to 1, and hence (13) tends to hold.

The intended application is as follows:
We will assume that the utility function (5) and the demand system (7) hold. We will parametrize it based on the approximation (11).

APPENDIX 6.3.
REVIEW OF DEMAND ELASTICITIES FOR RECREATION

Country	Good	Income elasticity or expenditure elasticity	Own price elasticity	Cross price elasticity	Number of other goods	Time period	Type of data	Ref
Argentina	Recreation	1.36 (I)	F: -0.98 S: -0.91 CO: -0.98	-	10	1980	Cross sectional	2)
Australia	Recreation	1.30(I)	F: -0.69 S: -0.63 CO:-0.71	-	10	1975	Cross sectional	7)
Australia	Recreation	0.22 (E))	U: -0.09	food: -0.06	7	1955-68	Time series	1)
Austria	Recreation	1.28 (I)	F: -0.93 S: -0.85 CO:-0.93	-	10	1980	Cross sectional	2)
Belgium	Recreation	1.28 (I)	F: -0.92 S: -0.85 CO: -0.93	-	10	1980	Cross sectional	2)
Belgium	Recreation	1.30(I)	F: -0.69 S: -0.63 CO: -0.71	-	10	1975	Cross sectional	7)
Belgium	Recreation and education	1.20(I)	-	-	7	1970	Cross sectional	8)
Bolivia	Recreation	1.53 (I)	F: -1.11 S: -1.05 CO: -1.10	-	10	1980	Cross sectional	2)
Botswana	Recreation	1.64 (I)	F: -1.18 S: -1.13 CO: -1.17	-	10	1980	Cross sectional	2)
Brazil	Recreation	1.35 (I)	F:-0.98 S: -0.91 CO: -0.98	-	10	1980	Cross sectional	2)
Brazil	Recreation	1.46 (I)	F:-0.77 S: -0.72 CO: -0.78	-	10	1975	Cross sectional	7)
Canada	Recreation	1.26 (I)	F: -0.91 S: -0.83 CO:-0.92	-	10	1980	Cross sectional	2)
Chile	Recreation	1.37 (I)	F:-0.99 S: -0.93 CO: -0.99	-	10	1980	Cross sectional	2)
Colombia	Recreation	1.41 (I)	F: -1.02 S: -0.95 CO: -1.02	-	10	1980	Cross sectional	2)
Colombia	Recreation	1.45 (I)	F: -0.76 S: -0.72 CO: -0.78	-	10	1975	Cross sectional	7)

Colombia	Recreation and education	1.26(I)	-	-	7	1970	Cross sectional	8)
Costa Rica	Recreation	1.38 (I)	F: -1.00 S: -0.93 CO: -1.00	-	10	1980	Cross sectional	2)
Denmark	Recreation	1.28 (I)	F: -0.92 S: -0.85 CO: -0.93	-	10	1980	Cross sectional	2)
Denmark	Recreation	1.30(I)	F: -0.68 S: -0.63 CO: -0.71	-	10	1975	Cross sectional	7)
Dominican Republic	Recreation	1.45 (I)	F: -1.05 S: -0.99 CO: -1.05	-	10	1980	Cross sectional	2)
Ecuador	Recreation	1.45 (I)	F: -1.05 S: -0.99 CO: -1.04	-	10	1980	Cross sectional	2)
El Salvador	Recreation	1.51 (I)	F: -1.09 S: -1.03 CO: -1.09	-	10	1980	Cross sectional	2)
Finland	Recreation	1.30 (I)	F: -0.94 S: -0.87 CO: -0.95	-	10	1980	Cross sectional	2)
France	Recreation	1.28 (I)	F: -0.92 S: -0.85 CO: -0.93	-	10	1980	Cross sectional	2)
France	Recreation	1.30(I)	F: -0.69 S: -0.63 CO: -0.71	-	10	1975	Cross sectional	7)
France	Recreation and education	1.20(I)	-	-	7	1970	Cross sectional	8)
Germany	Recreation	1.27 (I)	F: -0.92 S: -0.84 C: -0.93	-	10	1980	Cross sectional	2)
Germany	Recreation	1.30(I)	F: -0.69 S: -0.63 C: -0.71	-	10	1975	Cross sectional	7)
Germany	Recreation and education	1.20(I)	-	-	7	1970	Cross sectional	8)
Greece	Recreation	1.34 (I)	F: -0.97 S: -0.90 CO: -0.97	-	10	1980	Cross sectional	2)
Greece	Recreation and entertainment	1.622(E)	C:-1.427 U:-1.474	Food: +1.497(C), -0.9081(U) Alcoholic beverages: -0.038(C), -0.09(U) Tobacco: -0.224(C), -0.274(U) Clothing: -0.497(C), -0.667(U) Housing: + 0.471(C), +0.304(U) Heating and lighting:	12	1958-86	Time series	5)

				+ 0.341(C), + 0.3(U) Furniture: + 0.826(C), +0.695(U) Health: + 0.281(C), +0.227(U) Transportation: -2.019(C), -2.16(U) Communication: +0.134(C),+0.113(U) Education: +0.284(C),+ 0.252(U) Others: + 0.372(C), +0.245(U)			
Greece	Recreation	0.73 (E)	U: -0.82	food: -0.37	7	1955-68	Time series	1)
Hong Kong	Recreation	1.29 (I)	F: -0.93 S: -0.86 CO: -0.94	-	10	1980	Cross sectional	2)
Hungary	Recreation	1.35 (I)	F: -0.98 S: -0.91 CO: -0.98	-	10	1980	Cross sectional	2)
Hungary	Recreation	1.36 (I)	F: -0.71 S: -0.66 CO: -0.73	-	10	1975	Cross sectional	7)
Hungary	Recreation and education	1.22(I)	-	-	7	1970	Cross sectional	8)
India	Recreation	2.16 (I)	F: -1.56 S: -1.51 CO: -1.54	-	10	1980	Cross sectional	2)
India	Recreation	2.12 (I)	F: -1.12 S: -1.07 CO: -1.11	-	10	1975	Cross sectional	7)
Indonesia	Recreation	1.7 (I)	F: -1.23 S: -1.17 CO: -1.22	-	10	1980	Cross sectional	2)
Iran	Recreation	1.44(I)	F: -0.76 S: -0.71 CO: -0.77	-	10	1975	Cross sectional	7)
Iran	Recreation and education	1.26(I)	-	-	7	1970	Cross sectional	8)
Ireland	Recreation	1.33 (I)	F: -0.96 S: -0.89 CO: -0.97	-	10	1980	Cross sectional	2)
Ireland	Recreation	1.36 (I)	F: -0.71 S: -0.66 CO: -0.73	-	10	1975	Cross sectional	7)
Ireland	Recreation	0.64 (E)	U: -0.38	food: -0.37	7	1955-68	Time series	1)
Israel	Recreation	1.33(I)	F: -0.96 S: -0.89 CO: -0.96	-	10	1980	Cross sectional	2)

Israel	Recreation	1.44 (E)	U: -0.36	food: -0.40	7	1955-68	Time series	1)
Italy	Recreation	1.29 (I)	F: -0.93 S: -0.86 CO: -0.94	-	10	1980	Cross sectional	2)
Italy	Recreation	1.34(I)	F: -0.70 S: -0.65 CO: -0.73	-	10	1975	Cross sectional	7)
Italy	Recreation and education	1.21(I)	-	-	7	1970	Cross sectional	8)
Italy	Recreation	0.93 (E))	U: -0.56	food: -0.21	7	1955-68	Time series	1)
Jamaica	Recreation	2.03(E)	U: -1.05	food: -0.62	7	1955-68	Time series	1)
Japan	Recreation	1.30 (I)	F: -0.94 S: -0.87 CO: -0.95	-	10	1980	Cross sectional	2)
Japan	Recreation	1.33 (I)	F: -0.70 S: -0.64 CO: -0.72	-	10	1975	Cross sectional	7)
Japan	Recreation and education	1.21(I)	-	-	7	1970	Cross sectional	8)
Korea	Receation	1.50 (I)	F: -0.79 S: -0.74 CO: -0.80	-	10	1975	Cross sectional	7)
Korea	Receation	1.45 (I)	F: -1.05 S: -0.99 CO: -1.05	-	10	1980	Cross sectional	2)
Korea	Receation and education	1.29(I)	-	-	7	1970	Cross sectional	8)
Korea	Recreation	1.78(E)	U: -0.24	food: -0.99	7	1955-68	Time series	1)
Luxembourg	Recreation	1.28 (I)	F: -0.92 S: -0.85 CO: -0.93	-	10	1980	Cross sectional	2)
Luxembourg	Recreation	1.30 (I)	F: -0.68 S: -0.63 CO: -0.71	-	10	1975	Cross sectional	7)
Madagascar	Recreation	1.92 (I)	F: -1.39 S: -1.34 CO: -1.38	-	10	1980	Cross sectional	2)
Malaysia	Receation	1.52 (I)	F: -0.80 S: -0.76 CO: -0.81	-	10	1975	Cross sectional	7)
Malaysia	Receation and education	1.26(I)	-	-	7	1970	Cross sectional	8)
Mexico	Recreation	1.39(I)	F: -0.73 S: -0.68 CO: -0.75	-	10	1975	Cross sectional	7)
Morocco	Recreation	1.61 (I)	F: -0.91 S: -0.83 CO: -0.92	-	10	1980	Cross sectional	2)
Netherlands	Recreation	1.28 (I)	F: -0.93	-	10	1980	Cross	2)

			S: -0.85				sectional	
Netherlands	Recreation	1.31 (I)	CO: -0.93 F: -0.69 S: -0.63	-	10	1975	Cross sectional	7)
Netherlands	Recreation and education	1.20(I)	CO: -0.72 -	-	7	1970	Cross sectional	8)
Nigeria	Recreation	1.9 (I)	F: -1.37 S: -1.32	-	10	1980	Cross sectional	2)
Norway	Recreation	1.29 (I)	CO: -1.36 F: -0.93 S: -0.86	-	10	1980	Cross sectional	2)
Pakistan	Recreation	1.60 (I)	CO: -0.94 F: -1.15 S: -1.10	-	10	1980	Cross sectional	2)
Pakistan	Recreation	1.86 (I)	CO: -1.15 F: -0.98 S: -0.93	-	10	1975	Cross sectional	7)
Panama	Recreation	1.43 (I)	CO: -0.98 F: -1.03 S: -0.97	-	10	1980	Cross sectional	2)
Panama	Recreation	1.69 (E)	CO: -1.03 U: -0.92	food: -0.39	7	1955-68	Time series	1)
Paraguay	Recreation	1.46 (I)	F: -1.05 S: -0.99	-	10	1980	Cross sectional	2)
Peru	Recreation	1.43 (I)	CO: -1.05 F: -1.03 S: -0.97	-	10	1980	Cross sectional	2)
Philippines	Recreation	1.62 (I)	CO: -1.03 F: -0.85 S: -0.81	-	10	1975	Cross sectional	7)
Philippines	Recreation and education	1.29(I)	CO: -0.86 -	-	7	1970	Cross sectional	8)
Philippines	Recreation	1.69 (E)	U: -0.19	food: -0.96	7	1955-68	Time series	1)
Poland	Recreation	1.36 (I)	F: -0.99 S: -0.92	-	10	1980	Cross sectional	2)
Poland	Recreation	1.36 (I)	CO: -0.99 F: -0.72 S: -0.67	-	10	1975	Cross sectional	7)
Portugal	Recreation	1.31 (I)	CO: -0.74 F: -0.97 S: -0.90	-	10	1980	Cross sectional	2)
Puerto Rico	Recreation	0.49 (E))	CO: -0.98 U: -0.21	food: -0.34	7	1955-68	Time series	1)
Romania	Recreation	1.43(I)	F: -0.75 S: -0.70	-	10	1975	Cross sectional	7)
Senegal	Recreation	1.79 (I)	CO: -0.77 F: -1.29 S: -1.24 CO: -1.28	-	10	1980	Cross sectional	2)

South Africa	Recreation	0.98 (E)	U: -0.19	food: -0.32	7	1955-68	Time series	1)
Spain	Recreation	1.31 (I)	F: -0.95 S: -0.87 CO: -0.95	-	10	1980	Cross sectional	2)
Spain	Recreation	1.32 (I)	F: -0.70 S: -0.64 CO: -0.72	-	10	1975	Cross sectional	7)
Sri Lanka	Recreation	1.56 (I)	F: -1.13 S: -1.07 CO: -1.12	-	10	1980	Cross sectional	2)
Sri Lanka	Recreation	1.77 (I)	F: -0.93 S: -0.89 CO: -0.93	-	10	1975	Cross sectional	7)
Sweden	Recreation	1.09(E)	U: -0.73	food: -0.20	7	1955-68	Time series	1)
Syria	Recreation	1.45(I)	F: -0.76 S: -0.71 CO: -0.78	-	10	1975	Cross sectional	7)
Taiwan	Recreation	1.76(E)	U: -0.45	food: -0.85	7	1955-68	Time series	1)
Tanzania	Recreation	3.46 (I)	F: -2.52 S: -2.45 CO: -2.48	-	10	1980	Cross sectional	2)
Thailand	Recreation	1.62(I)	F: -0.85 S: -0.81 CO: -0.86	-	10	1980	Cross sectional	2)
Thailand	Recreation	1.99(E)	U: -0.94	food: -0.70	7	1955-68	Time series	1)
Tunisia	Recreation	1.49 (I)	F: -1.07 S: -1.01 CO: -1.05	-	10	1980	Cross sectional	2)
U.S	Recreation	1.28 (I)	F: -0.67 S: -0.61 CO: -0.70	-	10	1975	Cross sectional	7)
U.S	Recreation	1.26 (I)	F: -0.91 S: -0.83 CO: -0.92	-	10	1980	Cross sectional	2)
U.S	Recreation	1.18 (E)	U: -0.66	food: -0.26	7	1955-68	Time series	1)
U.S	Recreation	2.15 (E):1888-1890 1.76 (E):1917-1919 1.46(E): 1935-1936 1.40(E): 1972-1973 1.25(E) :1991	-	-	10	1888-1890, 1917-1919, 1935-1936, 1972-73, and 1991	Time series	3)
U.S.	Recreation	1.55 (E)	C: -1.12	-	14	1973	Cross sectional	4)
U.S.	Entertainment	1.345 (E)	-	-	8	1987	Cross sectional	6)
U.S.	Recreation and education	1.18(I)	-	-	7	1970	Cross sectional	8)
U.S.	i) Reading	1.00(E): 1972-1973 1.00 (E): 1991	-	-	10	1972-73, and 1991	Time series	3)
U.S.	ii) movies and live entertainment	1.260(E): 1972-1973 1.15 (E): 1991	-	-	10	1972-73, and 1991	Time series	3)

U.S.	iii) home entertainment	0.86(E): 1972-1973 0.7 (E): 1991	-	-	10	1972-73, and 1991	Time series	3)
U.S.	iv) sporting equipment	1.16(E): 1972-1973 1.29 (E): 1991	-	-	10	1972-73, and 1991	Time series	3)
UK	Recreation	1.29 (I)	F: -0.93 S: -0.86 CO: -0.94	-	10	1980	Cross sectional	2)
UK	Recreation	1.30 (I)	F: -0.69 S: -0.64 CO: -0.72	-	10	1975	Cross sectional	7)
UK	Recreation and education	1.20(I)	-	-	7	1970	Cross sectional	8)
UK	Recreation	0.89 (E)	U: -0.54	food: -0.29	7	1955-68	Time series	1)
Uruguay	Recreation	1.34 (I)	F: -0.97 S: -0.90 CO: -0.97	-	10	1980	Cross sectional	2)
Uruguay	Recreation	1.36 (I)	F: -0.72 S: -0.66 CO: -0.74	-	10	1975	Cross sectional	7)
Venezuela	Recreation	1.34 (I)	F: -0.97 S: -0.90 CO: -0.97	-	10	1980	Cross sectional	2)
West Germany	Recreation	1.12 (E)	U: -0.8	food: -0.22	7	1955-68	Time series	1)
Yugoslavia	Recreation	1.37 (I)	F: -0.99 S: -0.92 CO: -0.99	-	10	1980	Cross sectional	2)
Yugoslavia	Recreation	1.40 (I)	F: -0.74 S: -0.69 CO: -0.75	-	10	1975	Cross sectional	7)
Zambia	Recreation	2.53 (I)	F: -1.83 S: -1.78 CO: -1.81	-	10	1980	Cross sectional	2)

Notation:

E: Expenditure elasticity of demand for recreation or entertainment

I: Income elasticity of demand for recreation or entertainment

U: Uncompensated price elasticity

C: Compensated price elasticity

F: Frisch price elasticity: The elasticity with respect to the Frisch-deflated price of good I. This is equivalent to the own-price elasticity when there is an income compensation that keeps the marginal utility of income constant.

S: Slutsky price elasticity: It refers to the situation in which income remains constant.

CO: Cournot price elasticity: When income effect of the change in the jth price is included in the ith price elasticity, the ith price elasticity is called the Cournot price elasticity.

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7. CONCLUSION

The primary purpose of this report is to provide protocols for gathering data that will be useful for measuring economic impacts of digital video (DV). These data fall into four main categories:

- Data on DV-related consumer demands and time use;
- Data on R&D investment and production of DV-related firms;
- Data on DV-related patents and stock market prices;
- Data to support development of a Computable General Equilibrium (CGE) model as an accounting and aggregation frame for keeping track of many different DV-related effects.

However, this report also includes some preliminary findings and some new modeling methods that are interesting in their own right.

Some substantive findings

From the focus groups: Not all members of our consumers focus groups agreed with the "natural" quality scales ordinarily assumed by DV technology developers. Some consumers continue to feel that analog vinyl recordings of music have a "warmer" and "more alive" sound than digital CD recordings. Some photographers who develop their own film prefer editing conventional film over editing digital still images, not so much because conventional editing methods give more control over the image, but rather because the method of control has a different feel. Working with film is more tactile than working with digital images. And some consumers may even like the sound of AM car radios.

From the event study: For firms below a certain size, we found that DV patent announcements have a significant and permanent positive effect on prices of stock in the firm that owns the patent. The effect could be present for larger firms as well, but it is too small relative to the normal background noise in stock prices to be detected using the limited sample of firms and DV patents that was available. The effect appears during a "window" that extends from 1 working day prior to the announcement through 5 working days after the announcement. This "own-firm" effect is sufficiently strong that we think it will be useful to look for "cross-firm" effects in the next phase of research. These predicted effects consist in the influence of one firm's patent announcement on the market value of another firm that makes or uses the same technologies. If they can be measured, these effects would show the expected net present value of all spillovers from the first firm's patent onto the second firm, from the point of view of stock market participants.

New models

This report includes four new models that may play supporting roles for analyzing the economic impacts of digital video.

- One model shows how to measure the utility placed by consumers on a bundle of video attributes, making use of time use data as well as consumer expenditure data. This model will be used to analyze consumer survey data that is now being gathered.
- One model describes a very general approach for integrating consumer data at the level of individual observations from different surveys, using what Pechman and Okner (1974) called a "synthetic match." This approach could be used in subsequent research to form a highly disaggregated picture of consumer demands for both video and non-video goods.
- One model shows how to integrate income and price elasticities of demands from various published sources into a coherent utility model. This model provides an alternative way to disaggregate consumer demands.
- One model addresses the problem of interpreting the responses when interviewees are asked to give a range of likely times for an innovation to have appeared in the market place, in the absence of ATP intervention. In particular, the model gives an axiomatic approach for gathering and analyzing data on the subjective probability distributions of timing for a counterfactual event.

Uses of these protocols

The main product documented in this report is methods and protocols for gathering baseline data on the economics of digital video and on ATP's Digital Video Focused Program Area. These methods have been successfully tested. They will be applied to gather original data and the results will be analyzed in the next report in this series. These two reports are intended to support a retrospective evaluation of ATP's DV program, but they will not actually constitute that evaluation. Instead, this work has three main purposes:

- Gathering "transitory"or "volatile" data (as defined in Burress *et al.*, 1999b) – that is, needed data that will become hard or impossible to obtain at some later time, whether because of memory loss on the part of the participants or because of data loss or dispersal over time.
- Project planning – that is, laying out an evaluation research program that can be accomplished in the future, both while the results of the DV program are working their way through the economy, and after those results have become apparent.
- Proof of concept – that is, showing (to the extent possible using existing data) that the proposed methods are capable of being implemented, and will produce usable results.

Ongoing research

It follows that the methods developed here are not "finished" – they are prototypes that would be expected to undergo further development in the course of ongoing research. There are a number of reasons why this is the case. For example:

- The data gathering and analysis undertaken for subsequent reports will undoubtedly uncover many details of these protocols that could be improved.
- Much of the data that will ultimately be needed for an *ex post* impact study is of a type not yet ripe to be gathered. Most significantly, few of the ATP DV projects have yet led to any significant sales to end users, although several are on the brink of commercialization. We anticipate that some of these projects will be successfully commercialized in the future, and at that time it will possible to test the types of data gathering that are appropriate to commercialization. Similarly, most of the knowledge and network spillovers from the ATP DV project are still latent.
- Most of the data gathering is heavily constrained by the amount of time that informants (especially project participants) can reasonably be expected to make available to the evaluation team. Most importantly, because of time constraints the protocols in Chapter 5 do not ask ATP clients about the detailed antecedents of their decision to invest. These details would be necessary to implement the Qualitative Attribution Model described in Burress *et al.* (1996b, Appendix 1). However, it may be possible to gather data in a series of interviews over the course of the evaluation research that could not be gathered at a single point in time. Thus it might be possible to gather some portion of the investment antecedent data in the future.
- Much of the future data gathering would be concerned with data that are not covered in this baseline research at all, especially data classified as "semi-permanent" or "permanent" (Burress *et al.*, 1999b). For example, we are not concerned here with data that would be needed to parametrize non-DV-related sectors of a CGE model.
- To demonstrate feasibility of a concept, it is not necessary to gather test data for all members of a given class of variables. For example, the prototype consumer survey developed in Chapter 2 demonstrates two separate techniques for estimating the consumer's tradeoffs between attributes or characteristics of DV-related goods (i.e., direct comparisons between bundles of attributes, and also marginal willingness-to-pay for one particular attribute). However, we have made no attempt to consider all of the important DV attributes that will eventually need to be studied. (For an initial attempt at compiling an exhaustive list of potentially relevant attributes, see Burress *et al.*, 1998.) Moreover, data on these consumer tradeoffs are of only limited relevance at this time, because consumers are not yet fully informed about the utility of emerging DV technologies.

What the present report does describe is the bare-bones data gathering tools that are needed to implement the research proposed in Burress *et al.*, (1999b). We have shown that these tools do succeed in gathering a substantial body of information relevant to the DV project. Our next report will examine the sense that can be made out of this information.

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