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The adoption of electronic banking technologies by US consumers

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Abstract *Is there an electronic banking (e-banking) revolution in the USA? Millions of Americans are currently using a variety of e-banking technologies and millions more are expected to come "online." However, millions of others have not or will not. This paper explores factors that affect the of adoption or intention to adopt three e-banking technologies and changes in these factors over time. Using a Federal Reserve Board commissioned data set, the paper finds that relative advantage, complexity/simplicity, compatibility, observability, risk tolerance, and product involvement are associated with adoption. Income, assets, education, gender and marital status, and age also affect adoption. Adoption changed over time, but the impacts of other factors on adoption have not changed. Implications for both the banking industry and public policy are discussed.*

Introduction

Electronic banking (e-banking) technology represents a variety of different services, ranging from the common automatic teller machine (ATM) services and direct deposit to automatic bill payment (ABP), electronic transfer of funds (EFT), and computer banking (PC banking). The use of some e-banking technologies has grown rapidly in the USA, while others have been adopted more slowly[1].

Both theoretical and empirical literature related to the general adoption of technology provides a framework to examine the adoption of e-banking technologies. If the promise of increased efficiency for the banking industry and increased convenience and service for the consumer is to be realized, then understanding the factors that influence the acceptance of new products will allow businesses to create a climate in which technological advances with real advantages can be embraced by a majority instead of just a few techno-savvy consumers.

This paper applies the theories of technology acceptance and the diffusion of innovations to the adoption of three e-banking technologies: automatic bill payment, phone banking, and PC banking. Empirically, we examine whether and how the characteristics that describe the adoption of new innovations are related to consumer adoption of e-banking technologies. Unlike other studies, we include adoption as well as intentions to adopt in our measurement and we explore how these factors have changed over time.

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E-banking in the USA: background

The picture of e-banking in the USA is one of a wide variety of services used by a disparate number of consumers. Approximately 91 percent of US households have a bank account and, of these, 93 percent have one or more EFT features associated with their accounts. In 2003, the number of ATM transactions stood at 902 million per month, up slightly from 2002 (*EFT Data Book*, 2003). In addition, by 2003, the number of point-of-sale debit transactions stood at 495 million per month, up 21 percent from 2002, and the volume of electronic payments in the USA in 2003 exceeded that of checks for the first time. Thanks in part to the US Department of Treasury's EFT '99 initiative, nearly four-fifths of social security recipients now have their benefits deposited directly into their bank accounts and one-half of employees use direct deposit for their paychecks. A total of 32 million Americans view at least one bill each month over the Internet. Of Internet users, 18 percent already use electronic bill paying, while another 41 percent have expressed an interest in using some form of electronic bill presentment and payment (Bills, 2002). To meet consumer demand it was predicted that 87 percent of community banks would offer Internet banking services in 2003 (Pastore, 2001). On the other hand, reports indicate that consumers were less than receptive to using e-signature technology (*Insurance Networking*, 2001), and 90 percent of households were not choosing PC banking (*ABA Banking Journal*, 2001). Others report that while 39 percent of US households had access to online banking, only 18 percent have used it (*Electronic Payments International*, 2001). Projections for the future of PC banking vary considerably, from 18 million to 25 million users by 2004 (Carlson *et al.*, 2001).

Some e-banking services are still in their infancy while others are more mature, and banks are making adjustments in service to meet customer needs. The *American Banker* (2000) reported that one-third of consumers who had signed up for e-banking had stopped using it due to unsatisfactory customer service or the complexity of using the service. While consumers may be willing to adopt e-banking technologies, they also want assurance that problems will be resolved and that some transactions will remain personal (Goldfarb, 2001; *Financial Technology Bulletin*, 2000). Thus, banks are recognizing the importance of customer service and incorporating the "new" while holding on to consumer preferences for the "old." For example, "Check tech" allows consumers to see pictures of their paid checks and to see checking statements online (Marjanovic, 2000). "Check tech" is intended to encourage increased Internet use as well as to provide a marketing tool aimed at those consumers who feel that online banking does not fit well with their current banking preferences and behavior. Consumers have also expressed concerns over the security and privacy of their financial information in online environments (Federal Deposit Insurance Corporation, 2001).

This brief overview of the e-banking marketplace points to mixed results with regard to consumer adoption and success of e-banking products and services. While adoption of some e-banking technologies is widespread, this may be due to the fact that the technology is passive rather than active in nature (for example, once consumers sign up for direct deposit, there is nothing else they need to do). Some technologies are mature, while others are more truly new. For example, ATMs have been in use for 30 years, while PC banking has not yet become mainstream. Other e-banking products, such as electronic bill payment and presentment (EBPP), create a new product that does not alter established usage patterns. EBPP allows consumers to review a bill and

deduct the amount from their account ledger without having to write and mail a check. Some e-banking technologies, such as PC banking, require new behavioral patterns of the consumer.

Literature review

Rogers (1962) proposed a model of the diffusion of innovations that included five product or service characteristics postulated to influence consumer acceptance of new products and services: relative advantage, compatibility, simplicity/complexity, observability, and trialability. Several researchers have incorporated pieces of Rogers' model in empirical work that examined technological innovations (Rogers, 1962; Raju, 1980; Shimp and Beardon, 1982; Price and Ridgeway, 1983; Childers, 1986; Prendergast, 1993; Busch, 1995; Dabholkar, 1996; Lockett and Littler, 1997; Daniel, 1999; Howcroft *et al.*, 2002; Lee *et al.*, 2003).

Trialability refers to the ability of consumers to experiment with a new innovation and evaluate its benefits. The extent to which various financial institutions offer "introductory" e-banking to their customers impacts the trialability and accessibility of the innovation. Empirical studies on the acceptance of technologies have found consistently positive relationships between usefulness and to a lesser extent, ease of use, and the adoption of a variety of specific technologies, ranging from computer software to e-mail (see, for example, Davis, 1989; Karahanna *et al.*, 1999; Chau and Hu, 2001).

Relative advantage is the degree to which consumers perceive a new product or service as different from and better than its substitutes (Rogers, 1962). In the case of e-banking, savings of time, money and convenience have been cited as relative advantages. At the same time, financial management conducted online raises concerns of privacy, a relative disadvantage for some (Abbate, 1999; Snel, 2000; Karjaluoto *et al.*, 2002). Consumers who must supply myriad personal information before being permitted to use the innovation may be inhibited from adopting a given e-banking service.

Observability is the extent to which an innovation is visible and communicable to consumers. For example, seeing ATMs on the street corners and in grocery stores may make this technology more observable than PC banking conducted inside the home.

Simplicity/complexity is the extent to which consumers perceive a new innovation as easy to understand or use. For consumers without previous computer experience, or for those who believe that e-banking is difficult to use, adoption of these innovations may be thwarted.

Compatibility is the extent to which a new product or service is consistent and compatible with consumers' needs, beliefs, values, experiences, and habits. In the case of e-banking, we must consider the degree to which a given technology fits in with the banking behavior of a consumer, and the way in which they have historically managed their finances. Technological service innovations differ from other commodities insofar as their adoption may require behavior different from consumers' typical routines (Gatignon and Robertson, 1985). This includes "bricks and mortar" issues such as not having a branch bank to visit, as well as "paper" issues including receiving statements electronically and not in the mail.

A further refinement of Rogers' original model added the dimensions of perceived risk as well as product involvement (that is, how involved consumers are in related

product categories; Lockett and Littler, 1997). This study found that risk-averse households were less likely to adopt direct banking and households that used other technologies (ATMs and buying products over the telephone) were more likely to adopt direct banking. The researchers conclude that "perceived innovation attributes appear to be better predictors of adoption behavior than personal characteristics" (Lockett and Littler, 1997, p. 807).

The Technology Acceptance Model (TAM), proposed by Davis (1989), incorporated the characteristics of perceived ease of use and perceived usefulness into a model of technology acceptance. Empirical work related to diffusion of technological innovations has expanded the use of the TAM model to include individual differences (Gattiker, 1992; Gefen and Straub, 1997; Taylor and Todd, 1995; Mick and Fournier, 1998; Jayawardhena and Foley, 2000; Karjaluoto *et al.*, 2002), and attitudes as defined by the Theory of Reasoned Action (Davis *et al.*, 1989; Karahanna *et al.*, 1999; Jayawardhena and Foley, 2000; Venkatesh and Morris, 2000; Karjaluoto *et al.*, 2002).

Explorations of demographic correlates of technology acceptance have produced differing results with respect to significant relationships to adoption. In part, these differences may relate to the sets of variables included in the analysis. Gender has not been found to have a direct effect on adoption of technology in general (Taylor and Todd, 1995; Gefen and Straub, 1997), but men and women appear to have different acceptance rates of specific computer technologies, with men more likely to adopt (Gefen and Straub, 1997). Results with respect to gender may be confounded by marital status. When it comes to bank accounts, married couples may have jointly held accounts; thus at the household level, adoption of e-banking may be related to the combination of marital status and gender, with married couples more likely to adopt than either single males or single females. Research has also linked age and adoption of technologies, with younger persons being more likely to adopt (Zeithaml and Gilly, 1987; Trocchia and Janda, 2000; Karjaluoto *et al.*, 2002; Lee *et al.*, 2002). Race has not often been included in studies of technology adoption. Lee and Lee (2000) did find that for direct bill payment, minorities were less likely to have already adopted the technology. Increases in income and education tend to be positively related to the adoption of an innovation (Donnelly, 1970; Uhl *et al.*, 1970; Labay and Kinnear, 1981; Kennickell and Kwast 1997; Daniel, 1999; Lee and Lee, 2000; Jayawardhena and Foley, 2000; Mattila, 2001; Lee *et al.*, 2002; Karjaluoto *et al.*, 2002).

Hypotheses

Overall, the literature tells us almost unequivocally that the more observable, compatible, simple, and useful a technology is and the more advantages it offers, the more likely consumers are to adopt that technology. Lockett and Littler (1997) found that attributes were better predictors of adoption than personal or socioeconomic characteristics. Others have found that increases in income and education also elicit a positive effect on adoption, while age was found to be negatively related to adoption of innovations. Although the findings are less robust, men may be more likely to adopt new technology, while minorities may be less likely.

Virtually all the previous studies have focused on adoption as a binary variable; that is, consumers either have adopted or have not adopted the innovation under study. In this study, we will focus on the adoption continuum, ranging from those who have

already adopted to those who, in all likelihood, will never adopt selected e-banking services.

Personal characteristics

Based on the literature, we generate the following hypotheses with respect to socioeconomic and demographic characteristics:

H1. Individuals with higher incomes are more likely to adopt e-banking.

H1a. Individuals with higher net worth are more likely to adopt e-banking.

H1b. Individuals with expectations of higher incomes in the future are more likely to adopt e-banking.

H2. Younger individuals are more likely to adopt e-banking.

H3. Married households are more likely to adopt e-banking.

H4. Individuals with higher levels of education are more likely to adopt e-banking.

H5. Minorities are less likely to adopt e-banking.

E-banking characteristics

We expressly want to test the effects of the innovative characteristics of the e-banking technologies on the likelihood of adoption:

H6. The easier e-banking is to try out, the greater the likelihood of adoption.

H7. The more relative advantages e-banking offers, the greater the likelihood of adoption.

H8. The simpler e-banking is to use, the greater the likelihood of adoption.

H9. The more observable e-banking is, the greater the likelihood of adoption.

H10. The more compatible e-banking is with the way consumers manage their finances, the greater the likelihood of adoption.

H11. The less risky e-banking is perceived, the greater the likelihood of adoption.

H12. Individuals who evidence involvement in e-banking by already using ATMs or direct deposit are more likely to adopt other e-banking technologies.

Differences among e-banking technologies

This study focuses on the adoption of three e-banking technologies: ABP, phone banking, and PC banking. These three were chosen to represent different types of e-banking technologies at different stages in their development and that might attract different types of users.

(1) ABP (preauthorized debits), a long-standing e-banking service, represents a passive technology; once a consumer signs up for automatic payment of a particular bill (a mortgage or utility payment, for example), there is little else to do other than ensure that funds are in the account before the debit date.

(2) Phone banking represents an active technology that has undergone an evolution, from calling the bank and talking in person to a customer service representative to calling an automated account management system. Unlike PC banking, however, phone banking requires no equipment or services other than a touch-tone phone line, something that is widely available to US households.

(3) PC banking, the fastest growing e-banking technology, calls for perhaps the most consumer involvement, as it requires the consumer to maintain and regularly interact with additional technology (a computer and an Internet connection).

These different e-banking technologies lead to the following hypothesis, expressed as the null hypothesis:

H13. There are no differences in the characteristics associated with the adoption of ABP, phone banking, and PC banking.

Finally, we are interested in whether there have been any significant changes over time in the adoption of e-banking technologies. With data available from 1999 and 2003, we pose the final hypothesis, also stated as a null hypothesis:

H14. There is no difference over time in the factors associated with the adoption of e-banking technologies.

Methodology

Data

The Surveys of Consumers were initiated in the late 1940s by the Survey Research Center at the University of Michigan. The purpose of these surveys is to measure changes in consumer attitudes and expectations with regard to consumer finance decisions. Each monthly telephone survey of 500 households includes a set of core questions covering consumer attitudes and expectations along with socioeconomic and demographic characteristics (see Curtin, 2001 for more information). For two months, September and October 1999, and again in June and July, 2003, the Federal Reserve Board commissioned additional questions on the Surveys of Consumers, covering various topics related to e-banking services. The surveys yielded data from 1,000 respondents in 1999 and 1,002 respondents in 2003.

Respondents were asked about their use and expected future use of a variety of e-banking products: ATMs, debit cards, pre-paid (stored-value) cards, EFTs, direct deposit, automatic bill paying (preauthorized debits), phone banking, and PC banking. Virtually all other adoption of innovation studies have used a binary "adopted/have not adopted" dependent variable. In contrast, in this study adoption was measured on a four-point ordinal scale ranging from "will never adopt this technology" to "already have adopted this technology." Respondents were asked if they used each of the technologies listed above. If they had already adopted the technology, they were classified as a "current user." For those who were not current users, a follow-up question asked how likely they were to begin using the technology in the next 12 months. If they responded that they were very likely, somewhat likely, or there were even chances that they would adopt, they were classified as "likely to use." If they responded they were somewhat unlikely or very unlikely to begin using the technology, a second follow-up question asked whether they would ever consider using

the technology. Those who answered "yes" (that is, they would consider using the technology in the future) were classified as "unlikely to use" while those who answered "no" (that is, they would not consider using the technology in the future) were classified as "will never use."

Participants also were asked to respond to a series of statements regarding their perceptions about e-banking in general and factors associated with the diffusion of innovations. These statements were created using the theoretical foundations provided by the Diffusion of Innovations and TAM models (Rogers, 1962; Davis, 1989) and measures found in previous research. The theoretical foundations include trialability, relative advantage, complexity/simplicity, observability, and compatibility. As in previous studies, the statements were adapted to fit with the specific technology being examined (in this case, e-banking; see, for example, Chau and Hu, 2001; Davis *et al.*, 1989; Davis, 1989). A total of 14 statements were developed that specifically relate to e-banking[2]. Responses were on a five-point Likert scale from strongly agree to strongly disagree.

This study focuses on ABP via preauthorized debits, phone banking, and PC banking. In 1999, the questions regarding automatic bill payment did not differentiate preauthorized debits from account aggregation and electronic payments, nor did it differentiate electronic bill presentment and payment within PC banking; these later forms of direct bill paying were just emerging at the time of the 1999 survey. The 2003 survey focused specifically on preauthorized debits. Also, neither the 1999 nor 2003 surveys differentiated dial-up PC banking (that is, a direct modem connection to a bank's computer) from Web-based Internet banking access, although the former was more prevalent in 1999 while the later was prevalent in 2003.

Furthermore, most studies have used a single point in time to study adoption. In contrast, this study includes data from 1999 and 2003, a period of substantial change in the e-banking environment. Year of survey is included as a binary variable (being in the 2003 survey = 1). If the year of survey variable is significant, additional exploration of the effects of this variable can be undertaken.

Description of the sample

We used bi-variate analyses to describe our sample. Table I illustrates the bi-variate relationships between adoption of e-banking technologies and demographic characteristics. In 1999, phone banking was the most widely used of the three technologies in the analysis; however by 2003 equal proportions of households were using ABP and phone banking. PC banking had the fastest growing adoption rates, with adoption tripling from 9 percent in 1999 to 27 percent by 2003. Among users of at least one of these technologies, 52 percent used only one of the three e-banking technologies, 37 percent used two of the three, and 11 percent used all three.

It is interesting to note that the percentage point changes from 1999 to 2003 for the "current user" groups for ABP and PC banking are the same as the proportions of respondents who said in 1999 that they were likely to start using these technologies in the next 12 months – that is, it appears that those who said they were likely to adopt these technologies in 1999 actually seem to have adopted them by 2003. However, there was no similar pattern for phone banking.

In general, current and expected future users had higher incomes, more education, and were younger. Married households were more likely to be current users of ABP

	Automatic bill payment		Phone banking		PC banking	
	1999	2003	1999	2003	1999	2003
Current users, full sample[a]	27	39	34	38	9	27
Number of observations used in the analysis	656	715	656	715	656	715
Overall[b]						
Current users	32	48	44	47	12	34
Likely to use within 12 months	15	10	12	11	22	15
Unlikely to use within 12 months	22	15	17	14	31	18
Will never use	31	27	27	28	35	32
Personal characteristics						
Income (in 2003 dollars)[c]						
Current users	70,414	74,352	69,117	69,552	80,729	77,092
Likely to use within 12 months	58,435	59,223	54,258	49,871	62,676	66,106
Unlikely to use within 12 months	54,478	62,034	56,922	59,582	60,632	72,650
Will never use	50,136	57,751	45,687	71,197	47,423	51,935
All observations	53,343	66,510	53,343	66,510	53,343	66,510
Expect income will rise faster than prices during next five years[d]						
Current users	40	52	61	58	20	50
Likely to use within 12 months	21	12	14	11	26	16
Unlikely to use within 12 months	20	15	13	11	35	16
Will never use	18	21	12	19	19	19
All observations	20	20	20	20	20	20
Own stocks						
Current users	38	54	52	51	16	38
Likely to use within 12 months	15	8	9	10	22	16
Unlikely to use within 12 months	23	14	19	13	35	19
Will never use	24	24	20	26	27	27
All observations	51	64	51	64	51	64
Age (in years)						
Current users	44.4	44.9	40.8	41.9	38.5	39.6
Likely to use within 12 months	41.2	40.1	41.1	40.7	38.1	40.8
Unlikely to use within 12 months	44.5	42.5	47.4	46.5	46.6	47.7
Will never use	45.6	48.0	49.4	50.5	48.1	50.8
All observations	44.3	44.9	44.3	44.9	44.3	44.9
Married						
Current users	35	52	48	51	13	37
Likely to use within 12 months	14	8	11	9	18	13
Unlikely to use within 12 months	19	12	16	13	33	19
Will never use	32	28	25	27	36	31
All observations	58	62	58	62	58	62
Single female						
Current users	30	47	40	41	9	26
Likely to use within 12 months	16	11	14	15	23	19
Unlikely to use within 12 months	22	15	13	15	26	15
Will never use	32	27	33	30	42	41
All observations	24	22	24	22	24	22

(*continued*)

Table I.
Description of the sample (in percentages except where noted)

	Automatic bill payment		Phone banking		PC banking	
	1999	2003	1999	2003	1999	2003
Single male						
Current users	25	35	34	41	11	36
Likely to use within 12 months	19	15	14	12	34	21
Unlikely to use within 12 months	31	27	27	15	33	20
Will never use	24	23	26	31	22	23
All observations	18	16	18	16	18	16
Education (in years)						
Current users	14.3	14.4	14.6	14.5	14.7	14.7
Likely to use within 12 months	13.4	14.2	13.3	13.5	14.3	14.3
Unlikely to use within 12 months	13.7	14.2	13.7	14.1	14.2	14.3
Will never use	13.7	13.7	13.0	13.8	13.0	13.4
All observations	13.9	14.1	13.9	14.1	13.9	14.1
College or more						
Current users	38	52	60	55	15	42
Likely to use within 12 months	13	10	9	8	26	15
Unlikely to use within 12 months	21	15	16	12	35	20
Will never use	28	24	16	25	23	23
All observations	42	46	42	46	42	46
White						
Current users	32	47	43	46	11	34
Likely to use within 12 months	14	9	11	11	21	15
Unlikely to use within 12 months	22	15	18	13	32	17
Will never use	32	29	28	30	35	34
All observations	84	82	84	82	84	82
Minority						
Current users	32	52	46	52	14	33
Likely to use within 12 months	24	15	18	12	27	19
Unlikely to use within 12 months	20	16	13	15	24	23
Will never use	24	17	23	21	35	25
All observations	16	18	16	18	16	18
West						
Current users	33	47	55	50	16	37
Likely to use within 12 months	12	13	8	11	26	15
Unlikely to use within 12 months	23	17	13	14	30	17
Will never use	31	23	24	25	27	31
All observations	23	22	23	22	23	22
Midwest						
Current users	38	45	34	37	8	31
Likely to use within 12 months	15	10	10	15	20	13
Unlikely to use within 12 months	16	14	20	16	30	20
Will never use	32	31	36	32	42	36
All observations	25	26	25	26	25	26
South						
Current users	32	51	45	51	14	39
Likely to use within 12 months	18	9	13	10	19	14
Unlikely to use within 12 months	19	15	15	14	29	17
Will never use	31	26	27	26	38	30
All observations	34	35	34	35	34	35

(*continued*)

Table I.

	Automatic bill payment		Phone banking		PC banking	
	1999	2003	1999	2003	1999	2003
Northeast						
Current users	23	47	41	52	8	26
Likely to use within 12 months	16	9	17	8	26	22
Unlikely to use within 12 months	34	18	22	10	38	19
Will never use	28	26	20	30	28	33
All observations	18	17	18	17	18	17
E-banking characteristics						
Trialability: "I have the opportunity to try various electronic banking services"[e]						
Current users	38	50	52	52	16	40
Likely to use within 12 months	18	10	14	12	26	15
Unlikely to use within 12 months	19	16	11	13	32	18
Will never use	25	24	22	23	26	27
All observations	52	72	52	72	52	72
Relative advantage: "electronic banking is convenient"						
Current users	35	51	48	50	14	41
Likely to use within 12 months	16	11	14	11	25	16
Unlikely to use within 12 months	24	16	17	14	33	18
Will never use	25	22	22	25	28	25
All observations	79	82	79	82	79	82
Complexity/simplicity: "electronic banking is [easy] to use"						
Current users	35	52	51	51	17	44
Likely to use within 12 months	15	11	13	12	26	16
Unlikely to use within 12 months	22	14	14	12	30	15
Will never use	28	22	22	25	27	26
All observations	56	64	56	64	56	64
Compatibility: "It doesn't bother me to use a machine for banking transactions instead of a person"						
Current users	41	55	63	55	21	51
Likely to use within 12 months	19	12	10	13	34	17
Unlikely to use within 12 months	22	15	11	13	30	16
Will never use	18	18	16	19	14	16
All observations	40	44	40	44	40	44
Observability: "I have seen how others use electronic banking"						
Current users	35	49	54	52	15	38
Likely to use within 12 months	16	12	15	11	26	16
Unlikely to use within 12 months	21	16	11	14	28	19
Will never use	28	23	21	24	31	26
All observations	42	64	42	64	42	64
Safety: "When I use electronic banking my money is as safe as when I use other banking services"						
Current users	39	54	50	51	17	43
Likely to use within 12 months	18	12	14	12	28	18
Unlikely to use within 12 months	22	14	16	14	32	18
Will never use	21	20	19	23	23	21
All observations	49	55	49	55	49	55

(*continued*)

Table I.

	Automatic bill payment		Phone banking		PC banking	
	1999	2003	1999	2003	1999	2003
Risk: "I feel comfortable providing my personal information through electronic banking systems"						
Current users	39	58	58	53	22	51
Likely to use within 12 months	23	13	13	13	34	16
Unlikely to use within 12 months	20	12	15	13	29	16
Will never use	17	16	14	21	15	17
All observations	37	43	37	43	37	43
Involvement (use ATM card and/or direct deposit)						
Current users	30	24	24	26	32	29
Likely to use within 12 months	22	14	15	14	32	19
Unlikely to use within 12 months	15	10	12	10	23	15
Will never use	34	52	48	50	13	37
All observations	88	87	88	87	88	87

Notes:

[a] The proportion of current users in the full sample is based upon an *N* of 1,000 for 1999 and 1,002 for 2003; the number of observations used in the analysis is based upon those observations without missing data for the variables of interest. All data were weighted for the descriptive analysis

[b] Numbers in the columns from "current users" to "will never use" sum to 100 percent. Some components may not sum to 100 due to rounding

[c] The table in this section reads: Among current users of ABP in 1999, the mean income was $70,414 (in 2003 dollars); for those likely to use within 12 months, the mean income was $58,435; for those unlikely to use within 12 months, the mean income was $54,478; and for those who will never use, the mean income was $50,136. Overall, for the entire sample, the mean income in 1999 was $53,343

[d] The table in this section reads: Among those in the sample in 1999 who expected their incomes to rise faster than prices during the next five years, 40 percent were current users of ABP, 21 percent were likely to use it in the next 12 months, 20 percent were unlikely to use it in the next 12 months, and 18 percent will never use it. Overall, for the entire sample, 20 percent expected income to rise faster than prices during the next five years

[e] The table in this section reads: Among those in the sample in 1999 who agreed or strongly agreed with the statement regarding trialability, 38 percent were current ABP users, 18 percent were likely to use in the next 12 months, 19 percent were unlikely to use in the next 12 months and 25 percent will never use ABP. Overall, for the entire sample, 52 percent agreed or strongly agreed with the trialability statement

Table I.

and phone banking in both 1999 and 2003 than single males and single females. Married and single-male headed households were more likely than single-female headed households to use PC banking. As found in other studies, those who had adopted ABP, phone banking, and PC banking had higher educational levels. In 1999, a higher portion of minorities planned to adopt ABP during the next 12 months, but no differences appear in the percent of white and minority individuals who have already adopted the three e-banking technologies.

Factors that affect adoption

Statements representing relative advantage (e-banking is convenient), compatibility (It doesn't bother me to use a machine for a banking transaction instead of talking with a person), simplicity/complexity (e-banking is easy to use), observability (I have seen how others use e-banking), and trialability (I have had the opportunity to try various

e-banking services) were included as a series of binary variables (coded as 1 if the respondent agreed or strongly agreed, and 0 otherwise; see Table I). In addition, one statement associated with risk tolerance (I feel comfortable providing my information through e-banking systems) and one statement on safety perceptions (When I use e-banking, my money is as safe as when I use other banking services) were included using the same coding scheme. Finally our measure of product involvement was a binary variable equal to 1 if the respondent used either ATMs or direct deposit in any form.

Multivariate analysis

In order to determine the effect of the factors theorized to impact adoption, while controlling for additional demographic characteristics, we used ordered probit, regressing consumer demographic characteristics and the hypothesized factors that affect the adoption of technology on the use or planned use of the three types of e-banking products.

The dependent variables were measured using a four-point ordinal scale representing respondents' use or intention to use a given technology (ABP, phone banking, and PC banking). The scale characterized intentions to use as: 0 = would never use the technology; 1 = unlikely to use during the next 12 months; 2 = likely to use during the next 12 months; and 3 = currently use.

By utilizing questions that ask about intended future behavior, we are able to create a continuum of intentions, from those never intending to use each technology to those who have already adopted it.

In this type of multivariate analysis, the ordinal nature of the dependent variable is an important consideration. For discrete, ordinal data, such as the scale used to measure intentions and use, the linear model does not satisfy the requirements that the error term have a mean of zero and constant variance. Others have suggested that ordinal data such as the movement from non-use to use really represent a construct best described as interval (continuous); therefore, to operationalize the model, an ordinal (or ordered) probit model is used (Zavoina and McKelvey, 1975; Winship and Mare, 1984). The model specification is

$$
\begin{aligned}
& y*_i = \beta' xi + e_i, \\
& \varepsilon_i \sim N[0,1], \\
& y_i = 0 \text{ if } y*_i \leq \mu_0, \\
& 1 \text{ if } \mu_0 < y*_i \leq \mu_1, \\
& 2 \text{ if } \mu_1 < y*_i \leq \mu_2, \\
& \cdots \\
& j \text{ if } y*_i > \mu_{j-1}.
\end{aligned}
$$

The observed counterpart to $y*_i$ is y_i. The variance of ε_i is assumed to be 1.0 since as long as y_i, β and ε_i are unobserved, no scaling of the underlying model can be deduced from the observed data. Since the μs are free parameters, there is no significance to the unit distance between the set of observed values of y. They provide the ranking. Estimates may be obtained by maximum likelihood (Greene, 2000). We use Stata to estimate the model.

The technique of ordinal probit not only provides estimates of the impact of the independent variables on the dependent variable of interest, but it also provides additional parameters (Mu_i). The number of the additional parameters is two less than the number of responses coded for the ordinal dependent variable. In our case with a four-level dependent variable, the model provides two Mu_is. These Mu_is provide information as to the location on the implied interval scale measuring the dependent variable, which is not made explicit when the dependent variable is measured using an ordinal scale. The size of these latter coefficients is of less importance than their significance level, as they indicate whether the assumption of a continuous underlying scale is correct.

In addition to the factors theorized to influence adoption, we include a set of economic and demographic descriptors for which we hypothesize a direction of effect on the adoption of e-banking. Household income was converted to 2003 dollars and included as a four-category variable (with under $25,000 as the omitted category). Other economic status measures included whether the individual expects income will increase more than price increases over the next five years (income will not exceed price increases is the omitted category) and a binary variable for whether the household owns any stock (as a proxy for net worth). Demographic variables were age, included as a set of three binary variables (middle age (35-65) and over 65, with under 35 as the omitted category); marital status and gender (single males and single females with married households as the omitted category); college education (included as a binary variable with less than college as the omitted category); and ethnicity (non-minority as the omitted category) (see, for example, Lee and Lee, 2000; Davis, 1989; Chau and Hu, 2001; Karahanna *et al.*, 1999; Donnelly, 1970; Uhl *et al.*, 1970; Labay and Kinnear, 1981; Kennickell and Kwast, 1997 Lee *et al.*, 2002). Region was included as a set of binary control variables to capture households living in the west, midwest, and south (with living in the northeast as the omitted category).

To address the question of differences in adoption for differing technologies, we model adoption for each of the three e-banking technologies separately. In order to study changes over time, we include a binary variable for the year of the survey (with 1999 being the omitted category).

Results

Results are shown in Table II. Both Mu_is were significant for all three models, confirming that our dependent variable, the continuum of adoption, has a continuous underlying scale.

Personal characteristics

Among the socioeconomic variables, those with higher incomes had an increased probability of intent to adopt in the next 12 months or of already using e-banking technologies. Those who expected their incomes to rise faster than prices had an increased probability of intent to adopt in the next 12 months or of already using phone banking and PC banking. Those who own stock (the proxy for net worth) had an increased probability of intent to adopt in the next 12 months or of already using ABP and phone banking. We cannot reject *H1*, *H1a*, and *H1b*.

Among the other demographic variables, respondents over the age of 65 were less likely to adopt phone banking and PC banking. Those in their middle age were less

Variable	Automatic bill payment	Phone banking	PC banking
Constant	−0.83 (0.16)	−0.24 (0.17)	−1.06 (0.17)
Mu(1)	0.53*** (0.03)	0.47*** (0.03)	0.82*** (0.04)
Mu(2)	0.86*** (0.04)	0.81*** (0.04)	1.49*** (0.05)
Personal characteristics			
Income (< $25,000 omitted category)			
$25,000-$49,999	0.18* (0.10)	0.19* (0.11)	0.17 (0.11)
$50,000-$74,999	0.21* (0.11)	0.08 (0.11)	0.19* (0.11)
$75,000 and over	0.37*** (0.12)	0.09 (0.12)	0.32*** (0.12)
Expect income will rise faster than prices during next five years	0.08 (0.08)	0.16* (0.08)	0.14* (0.08)
Own stock	0.18** (0.07)	0.15* (0.08)	0.12 (0.07)
Age (≤ 35 omitted category)			
Age 36-65	0.02 (0.07)	−0.11 (0.08)	−0.35*** (0.07)
Over 65	0.06 (0.12)	−0.79*** (0.12)	−0.93*** (0.12)
Marital status and gender (married omitted category)			
Single male	−0.07 (0.09)	−0.33*** (0.09)	0.13 (0.09)
Single female	0.06 (0.08)	−0.06 (0.09)	−0.12 (0.08)
College education	−0.01 (0.07)	0.25*** (0.07)	0.18*** (0.07)
Minority	0.27*** (0.09)	0.12 (0.09)	0.03 (0.09)
Region (Northeast omitted category)			
West	0.09 (0.10)	0.07 (0.11)	0.16 (0.10)
Midwest	0.17* (0.10)	−0.20** (0.10)	−0.01 (0.10)
South	0.11 (0.09)	−0.01 (0.10)	0.09 (0.09)
E-banking characteristics			
Trialability: "I have the opportunity to try various electronic banking services"	0.09 (0.07)	0.11 (0.08)	0.11 (0.07)
Relative advantage: "electronic banking is convenient"	0.42*** (0.09)	0.20** (0.09)	0.69*** (0.09)
Complexity/simplicity: "electronic banking is [easy] to use"	−0.02 (0.07)	−0.01 (0.07)	0.19*** (0.07)
Compatibility: "It [doesn't] bother me to use a machine for banking transactions instead of a person"	0.19*** (0.07)	0.26*** (0.08)	0.41*** (0.07)
Observability: "I have seen how others use electronic banking"	−0.04 (0.07)	0.21*** (0.07)	−0.05 (0.07)
Safety: "When I use electronic banking, my money is as safe as when I use other banking services"	0.08 (0.07)	0.08 (0.07)	0.20*** (0.07)
Risk: "I feel comfortable providing my personal information through electronic banking systems"	0.25*** (0.08)	0.12 (0.08)	0.42*** (0.07)
Involvement (use ATM card and/or direct deposit)	0.31*** 0.09)	0.43*** (0.10)	0.22** (0.10)
Year = 2003	0.17*** (0.06)	−0.15** (0.07)	0.31*** (0.06)
N	1,371	1,371	1,371
Reject null hypothesis of no difference between 1999 and 2003?	$\chi^2 = 26.63$ ($p = 0.22$)	$\chi^2 = 20.8$ ($p = 0.53$)	$\chi^2 = 20.78$ ($p = 0.53$)

Notes: Standard errors in brackets; * sig. ≤ 0.10; ** sig. ≤ 0.05; *** sig. ≤ 0.01

Table II.
Results of ordinal probit analysis (regression coefficients)

likely to adopt PC banking than the youngest group of consumers, aged 35 and below. We cannot reject *H2*. Single-male headed households were less likely to adopt phone banking than married couple households; no other gender and marital status relationships were significant. We can partially reject *H3*. College educated individuals were more likely to adopt phone banking and PC banking than those with less education; there was no significant effect for ABP. We partially reject *H4*. Minorities were more likely to adopt or intend to adopt ABP than whites; there was no significant relationship for phone banking or PC banking. We partially reject *H5*. Region was included as a control variable with no formal hypothesis testing. Households living in the midwest were less likely than those in the northeast to have adopted or to intend to adopt phone banking or ABP; region was not significant for PC banking.

E-banking characteristics

Trialability was not significant for any of the three e-banking technologies; we reject *H6*. Both relative advantage and compatibility were significant across all e-banking technologies. Respondents who had more positive perceptions about the relative advantage and compatibility of e-banking technologies had a higher probability of adopting automatic bill payment, phone banking, and PC banking. We do not reject *H7* and *H10*. Simplicity was significant and positive only for PC banking. We partially reject *H8*. Observability was positively associated only with an increased probability of adopting phone banking. We partially reject *H9*. Respondents who were less risk-averse toward e-banking technologies were significantly more likely to adopt ABP and PC banking; those who considered e-banking safe were more likely to adopt PC banking. Thus, we partially reject *H11*. Finally, respondents who were involved with other electronic banking technologies (using ATMs or direct deposit) were significantly more likely to use each of the three e-banking technologies in this study; we do not reject *H12*.

Differences among e-banking technologies

Next we turn to the question of whether different characteristics are associated with adoption of different e-banking technologies. As is apparent from the regression results, different sets of variables were significant in the three different models. Some measure of income (income category, net worth, or expectations about future income) was significant for all e-banking technologies. Age was significant only for phone and PC banking. Marital status and gender were significant only for phone banking while education was significant only for phone and PC banking. Being a minority was significant only for ABP.

Among the measures of diffusion of innovation, simplicity/complexity was significant for PC banking, but not for ABP or phone banking, which is as expected given that these are older and relatively simple e-banking services to understand. Observability was significant only for phone banking. Looking at the risk-tolerance variables, safety and risk were significant for PC banking, while risk was significant for ABP but not for phone banking. Given that different characteristics were associated with adoption of different e-banking technologies, we reject the null hypothesis for *H13*.

The year of survey variable was significant for all models; consumers in 2003 were significantly more likely to use ABP and PC banking and significantly less likely to use

phone banking than their counterparts in 1999. We reject *H14*. Given the significance of the year of survey variable, the question arises as to whether there are differential effects of the individual variables in the model by year – that is, does the year of survey variable function as an intercept-shifter or a slope-shifter? To test for these effects, we estimated a fully interactive model (a vector of the year = 2003 variable interacted with each independent variable) and tested the null hypothesis that the coefficients on all the interaction variables are equal to zero. None of the Chi-square statistics between the restricted and unrestricted models were significant, an indication that the year of survey variable is acting as an intercept-shifter rather than as a slope-shifter in all three models.

Marginal effects in the models

The ordered probit coefficients cannot be interpreted in the usual manner of regression coefficients; they do not represent the impact of a one-unit change in the independent variable on the ordered dependent variable (that is, moving from 0 to 1 or 1 to 2). Rather, the coefficients relate to an index number, which in turn can be transformed into a probability of being in each of the four levels. By definition, these four probabilities sum to 1.0. The ordered probit procedure produces a set of marginal effects for each value of the dependent variable, providing an estimate of the magnitude of the effects that each independent variable has on each level of the independent variable, compared with the other groups (again, by definition, these marginal effects across the four levels sum to 0)[3].

These marginal values are presented in Table III, and give insight into the characteristics that are most important in the adoption of e-banking technologies. For example, respondents who agreed about the relative advantage of e-banking had a probability of already using PC banking 15 points higher compared with the other three adoption groups. The probability that they would use PC banking in the next 12 months was 10 points higher and the probability they would never use PC banking was 25 points lower compared with other adoption groups. Similarly, respondents who agreed about relative advantage of e-banking technologies had a probability of already using ABP that was 16 points higher than others and a probability of using phone banking that was 8 points higher than others.

Although the marginal effects of compatibility are smaller than those for relative advantage, they are larger than those for the other measures of the diffusion of innovation suggested by Rogers (1962). Households who were less risk-averse had a probability of adopting ABP that was ten points higher than other groups and a probability of adopting PC banking that was 12 points higher than others. Product involvement played a substantial role in the adoption of ABP and phone banking; households who used ATMs or direct deposit had a probability of adopting ABP that was 12 points higher than others and a probability of adopting phone banking that was 17 points higher than others.

Income, age, gender and marital status, education, and minority status also impart relatively large changes in the probabilities of adoption across all three e-banking technologies. The probability of higher income households ($75,000 or more) being current users of ABP was 15 points higher than that for low income households (under $25,000). The probability of respondents over 65 never using phone banking or PC banking was 29 points and 35 points, respectively, higher than that for respondents 35

Table III.
Estimated marginal effects of the ordered probit analysis

Variable	Automatic bill payment				Phone banking				Computer banking			
	Never use	Unlikely to use	Likely to use	Current users	Never use	Unlikely to use	Likely to use	Current users	Never use	Unlikely to use	Likely to use	Current users
Actual distribution	0.29	0.19	0.13	0.40	0.28	0.15	0.11	0.45	0.33	0.24	0.19	0.23
Predicted distribution	0.26	0.19	0.13	0.41	0.24	0.17	0.13	0.46	0.28	0.31	0.23	0.18
Personal characteristics												
Income (< $25,000 omitted category)												
$25,000-$49,999	−0.06*	−0.01*	0.00*	0.07*	−0.06*	−0.02*	0.00*	0.08*	−0.06	−0.01	0.02	0.05
$50,000-$74,999	−0.07*	−0.02*	0.00*	0.08*	−0.03	−0.01	0.00	0.03	−0.06*	−0.01*	0.02*	0.05*
$75,000 and over	−0.11***	−0.03***	0.00***	0.15***	−0.03	−0.01	0.00	0.04	−0.10***	−0.02***	0.04***	0.09***
Expect income will rise faster than prices during next five years	−0.03	−0.01	0.00	0.03	−0.05*	−0.01*	0.00*	0.06*	−0.05*	−0.01*	0.02*	0.04*
Own stock	−0.06**	−0.01**	0.00**	0.07**	−0.05*	−0.01*	0.00*	0.06*	−0.04	−0.01	0.01	0.03
Age (≤ 35 omitted category)												
Age 36-65	−0.01	0.00	0.00	0.01	0.03	0.01	0.00	−0.04	0.11***	0.02***	−0.0***4	−0.09***
Over 65	−0.02	0.00	0.00	0.02	0.29***	0.02***	−0.02***	−0.28***	0.35***	−0.05***	−0.1***3	−0.17***
Marital status and gender (married omitted category)												
Single male	0.02	0.00	0.00	−0.03	0.11***	0.02***	0.00***	−0.13***	−0.04	−0.01	0.02	0.04
Single female	−0.02	0.00	0.00	0.02	0.02	0.00	0.00	−0.02	0.04	0.00	−0.02	−0.03
College education	0.00	0.00	0.00	0.00	−0.08***	−0.02***	0.00***	0.10***	−0.06***	−0.01***	0.02***	0.05***
Minority	−0.08***	−0.02***	0.00***	0.11***	−0.04	−0.01	0.00	0.05	−0.01	0.00	0.00	0.01
Region (Northeast omitted category)												
West	−0.03	−0.01	0.00	0.04	−0.02	−0.01	0.00	0.03	−0.05	−0.01	0.02	0.04
Midwest	−0.05*	−0.01*	0.00*	0.07*	0.06**	0.01**	0.00**	−0.08**	0.00	0.00	0.00	0.00
South	−0.03	−0.01	0.00	0.04	0.00	0.00	0.00	0.00	−0.03	−0.01	0.01	0.02
E-banking characteristics												
Trialability	−0.03	−0.01	0.00	0.04	−0.03	−0.01	0.00	0.04	−0.04	−0.01	0.01	0.03
Relative advantage	−0.15***	−0.02***	0.01***	0.16***	−0.06**	−0.01**	0.00**	0.08**	−0.25***	0.01***	0.10***	0.15***
Complexity/simplicity	0.01	0.00	0.00	−0.01	0.00	0.00	0.00	0.00	−0.07***	−0.01***	0.02***	0.05***
Compatibility	−0.06***	−0.01***	0.00***	0.07***	−0.08***	−0.02***	0.00***	0.10***	−0.14***	−0.02***	0.05***	0.11***
Observability	0.01	0.00	0.00	−0.02	−0.07***	−0.02***	0.00***	0.08***	0.02	0.00	−0.01	−0.01
Safety	−0.03	−0.01	0.00	0.03	−0.03	−0.01	0.00	0.03	−0.07***	−0.01***	0.02***	0.05***
Risk	−0.08***	−0.02***	0.00***	0.10***	−0.04	−0.01	0.00	0.05	−0.14***	−0.03***	0.05***	0.12***
Involvement	−0.11***	−0.02***	0.01***	0.12***	−0.15***	−0.02***	0.01***	0.17***	−0.08**	−0.01**	0.03**	0.05**
Year = 2003	−0.06***	−0.01***	0.00***	0.07***	0.05**	0.01**	0.00**	−0.06**	−0.10***	−0.02***	0.04***	0.08***

Notes: * sig ≤0.1; ** sig. ≤0.05; *** sig. ≤ 0.01

and under. The probability of single males being current users of phone banking was 13 points less than that for married couples. The probability of already using phone banking was ten points higher for someone with a college education. Minorities had a probability of using ABP that was 11 points higher than that of whites. Other marginal effects, while significant, were small in magnitude.

Discussion and conclusions

This study examined the continuum of consumers' adoption of three different e-banking products. It focused on how socioeconomic and demographic characteristics and consumer perceptions of the relative advantage, compatibility, complexity/simplicity, trialability, observability, risk and product involvement affect adoption. It also explored how changes over time have affected adoption. In an "other things held constant" framework, measures of diffusion of innovation are significant determinants of the likelihood of adoption, but so are measures of personal characteristics. Furthermore, it appears that a rising tide lifts all boats – changes over time are significant but they appear to affect all individuals and families across the board. We also find differences in the characteristics associated with the adoption of different e-banking technologies.

Relative advantage and compatibility were significant and positive for all e-banking products. However, it is important to note that this study shows that e-banking technologies can not be aggregated into a single category – and thus a "one size fits all" marketing approach will not work across various e-banking products and services. We expected that seeing an advantage in using a new technology would lead to an increase in the likelihood of adopting it. This was the case for all e-banking technologies we examined. These technologies are often marketed as being advantageous in that their use can result in time savings and convenience, and in decreasing the likelihood of errors such as checks lost in the mail, dates missed, and inaccurate accounting of monies available.

The positive impacts that income and education have on the likelihood of adoption of the products continue to confirm that income and education levels play a strong role in the adoption of a variety of technologies, as found in other studies. However, these results also point to the existence of a large, untapped target market which may be left behind as the e-banking revolution moves ahead. This is not a new assertion and has been discussed widely in the literature about the "digital divide" (US Department of Commerce, 1999; Foley, 2001; Porter, 2001; Holmes, 2002). With educational marketing efforts, this market segment can represent an opportunity. In addition, a tandem approach by industry and government may help increase the adoption rate among those of lower socioeconomic status. For example, the US Treasury's design for the electronic transfer account (ETA) is an all-electronic account, as the name implies; consumers have no option to use non-electronic features with this account. Other government policies also encourage consumers to migrate toward e-banking. One of the provisions of the Debt Collection and Improvement Act of 1996 required federal benefit recipients to receive their benefits electronically instead of via a paper check. While Congress withdrew the strict requirement for direct deposit, there is still strong encouragement to move toward an all-electronic Treasury. Similarly, the Personal Responsibility and Work Opportunity Act has provisions for electronic delivery of both welfare and food stamp benefits. Consumers who previously have not used ATMs

or electronic benefits payments will be brought into the e-banking market through policies and programs such as these. We are also beginning to see other changes in governmental policies, such as the E-Sign Act, that should aid consumers in using e-banking products.

The significant age differences for phone banking and PC banking are likewise interesting. If electronic access to financial management tools is the wave of the future, marketers need to find ways to make all persons comfortable with these tools. Demonstrations and opportunities to "test drive" new technologies may help consumers gain the comfort and confidence they need. Banks and other industries that support e-banking technologies can help consumers work through the pros and cons of adopting these new technologies. E-banking products and services may provide opportunities for simplified financial management (for example, aggregating expenses in one place for payments) and may be lower cost if firms pass along cost savings to consumers. According to industry analysts, Internet banking costs about $.01 per transaction compared with $1.07 for the same transaction via a teller at a bank branch (Cuevas, 1998).

On the other hand, it is likely that consumers will continue to weigh these advantages against issues of security and privacy, the need to obtain cash and deposit checks and currency, and the desire for personal service. Corporate policies are important components of helping to make e-banking services deliver on their promise of offering relative advantages and compatibility for consumers. Firms recognize that customer service is important regardless of the means by which a transaction is made. Aspects of customer service that cut across personal versus electronic services include accuracy, prompt correction of errors and being able to talk to a real person (Pronsati, 2000). By providing consumers with more satisfactory experiences, banks can make these services more compatible with consumers' beliefs and habits.

This study provides the banking industry with some insight into factors that will likely affect consumer acceptance of e-banking technology and highlights areas of special consideration in the adoption of these new technologies. Relative advantage and compatibility jump to the top of the list of characteristics of e-banking technologies to highlight for consumers. And, while trialability, simplicity, observability, risk, and safety were not significant across all the technologies we examined, including these characteristics in a marketing campaign certainly would not hurt the chances of consumers adopting e-banking. Both the financial services marketplace and the available technologies are evolving quickly – and although it appears that a broad range of consumers are adopting these technologies, and that a rising tide does indeed lift all boats, monitoring these changes and their implications for consumers will be an ongoing challenge.

Notes

1. Adoption of some technologies has been much more rapid outside the USA. For example, in 2001, only 20 percent of US households used computer banking compared with 27 percent in Europe (*Bank Technology News*, 2001). Finland had 2.3 million online customers making 6.9 million online transactions per month; Bank of America, in comparison, had 3.2 million online customers but they made only 3.1 million online transactions per month (*BusinessWeek Online*, 2001).

2. The 2003 survey included three additional attitudinal statements on security and privacy and excluded five attitudinal statements on receipt of electronic disclosures. Only those statements common to both surveys were used in this analysis.
3. As noted in Greene (2000, p. 878), "without a fair amount of extra calculation, it is quite unclear how the coefficients in the ordered probit model should be interpreted." For dummy variables, the marginal effects are calculated by allowing the dummy to take on values of 0 and 1, holding all other variables at the mean. Marginal effects for continuous variables are calculated with a one unit increment. The marginal effects sum to zero, which follows from the requirement that the probabilities across all four categories sum to 1 (Greene, 2000, p. 876-9).

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