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Srinarayan Sharma
*Oakland University*

Xiaodong Deng
*Oakland University*

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**Srinarayan Sharma and Xiaodong Deng**
Department of Decision and Information Sciences
School of Business Administration
Oakland University
srisharm@oakland.edu deng@oakland.edu

**Abstract**

*Portable computing devices with wireless links are new means for computing and communication. PDAs, cell phones, and portable computers are expected to drive mobile commerce. Among them personal digital assistants (PDAs) are considered to have the most potential. While there is strong indication that PDA adoption is increasing, little systematic research has been done to understand the determinants of PDA adoption and use by individuals. In this study we empirically examine PDA adoption using widely employed Technology Acceptance Model (TAM). The findings of the study show that TAM predicts PDA adoption well.*

## Introduction

Portable computing devices with wireless links are seen as a new means for computing and communication (Keen 2001). PDAs, cell phones, and portable computers are expected to drive mobile commerce and increase organizational reach. Among them personal digital assistants (PDAs) are considered to have the most potential (Fortune 2001). A number of recent surveys indicate that PDA adoption is increasing. Unfortunately little systematic research has been done to understand the determinants of PDA adoption and use by individuals. Understanding PDA adoption has direct implications for the study of electronic commerce as it along with wireless technology has the potential to reach any customer anywhere and make personalized, targeted message distribution possible (Coyle 2001).

The remainder of our paper is organized as follows. In the next section, we describe what a PDA is. In the following section, we describe our theoretical framework and research model. We then describe the research methodology used and discuss reliability and validity issues. Following this, we present our findings and discuss the results. Finally, we conclude with implications for practice and research.

## What is PDA?

PDAs are highly portable, easy to use computing and communications devices aimed at the mass market. Basic PDAs enable users to organize schedules and contact information, create to-do lists, play music, record memos, track expenses, and jot down notes in their own handwriting. More sophisticated PDAs can run word processing, spreadsheet, and electronic book reading programs and provide e-mail and Internet access.

PDAs along with other wireless devices bring localization, personalization, and immediacy to the web (Coyle 2001). Localization is the ability to geographically locate wireless devices using either the global positioning system (GPS) or taking advantage of sophisticated cellular triangulation techniques to pinpoint location to within several feet. Wirelessly connected users can enter their street location on a PDA and receive information about nearby shops, restaurants, etc. Another major advantage of PDA is

its ability to immediately deliver or push information to users when they need it rather than when it is requested. Since wireless network providers already track user identity for billing purposes, applications can leverage this information to personalize content based on user preferences and/or patterns of use. These provide businesses new opportunities for building trusted and sustainable relationships with customers and suppliers as well as efficiently utilizing an increasingly mobile workforce.

## Theoretical Framework and Research Model of Individual PDA Adoption

We use TAM to understand the adoption and use of PDA by individuals in this paper (Figure 1). TAM is an application of the Theory of Reasoned Action (TRA) (Fishbein and Ajzen 1975). TAM posits perceived usefulness and perceived ease of use as two beliefs that determine users' attitude towards their intention to use and actual usage (Davis, Bagozzi, and Warshaw 1989). Intention to use is in turn is the sole direct determinant of actual usage. Perceived usefulness is defined as the extent to which a person believes that using the information technology will enhance his/her job performance. Perceived ease of use is defined as the extent to which a person believes that using the IT will be free of effort. Perceived usefulness has a direct impact on adoption intention. Perceived ease of use has both a direct and indirect effect on attitude, defined as the mediating affective response between beliefs and usage intentions.

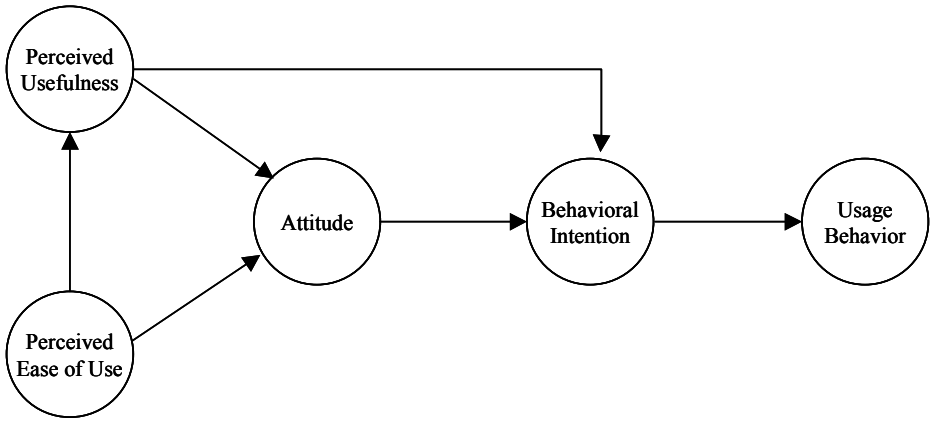


**Figure 1. Model of Individual PDA Adoption**

## Methodology

A survey design was employed to test the hypotheses derived from the TAM model.

### *Sample*

The sample comprised of students in undergraduate and graduate courses in information systems at a mid-western university. Of the 214 responses, 37 (17.3%) respondents were less than 21 years old, 145 (67.8%) were between 21 and 30, 20 (9.3%) were between 31 and 40, and 9 (4.2%) were above 40 years old. 107 (59%) respondents were female and 103 (48.6%) were male. 67 (31.3%) respondents worked full time, 119 (55.6%) worked part-time, and 22 (10.3%) didn't work.

### *Measurement Instruments*

Measures of the constructs/variables in TAM were adapted from previous studies (Davis et al. 1989; Moore and Benbasat 1991; Taylor and Todd 1995a, 1995b). Perceived ease of use refers to the degree to which the prospective user expects the target system to be free of effort. Perceived usefulness is defined as the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context (Davis et al. 1989; Moore and Benbasat 1991). For simplicity, this study adopted the short version of Moore and Benbasat's (1991) instruments to measure perceived ease-of-use and perceived usefulness.

Attitude toward usage is the feeling of favorableness or unfavorableness towards using the technology (Davis et al. 1989; Taylor and Todd 1995a, 1995b). The measurement instruments for attitude toward usage and behavioral intention for usage were adopted from Taylor and Todd's (1995a, 1995b) study. Usage behavior has been measured by the frequent use (Thompson et al. 1991) and extent of use (Doll and Torkzadeh 1998) of the technology. Since PDA is a general technology, the measurement items of the usage behavior focus on the use of the PDA for tasks (i.e., job duties) (Igbaria et al. 1995).

### *Data Analysis*

LISREL VIII (Joreskog and Sorbom 1993) was used to evaluate the reliability and validity of the items. It was also used to test the goodness-of-fit of the research model (Figure 1) against the sample of 214 observations. LISREL is a statistical tool for analyzing covariance matrices according to systems of structural equations (Joreskog and Sorbom 1993). Model specification is accomplished by fixing or constraining elements in five matrices that are analogous to the factor pattern matrix, factor correlation matrix, and communalities from a common factor analysis. Chi-square was used to measure the goodness-of-fit of the model. Although the chi-square statistic is a global test of a model's ability to reproduce the sample variance/covariance matrix, it is sensitive to sample size and departures from multivariate normality (Bollen 1989). Thus, the chi-square statistic must be interpreted with caution (Joreskog and Sorbom 1993).

Wheaton (1987) has suggested that it is prudent to report several fit measures. Many fit indexes have been developed in previous studies to assess the degree of congruence between the model and data. This research reports CFI (Bentler 1990) and NNFI (Bentler and Bonett 1980). They were selected because they are generally unaffected by sample size. Medsker, Williams, and Holahan (1994) recommend the CFI index as being the best approximation of the population value for a single model. Marsh, Balla, and McDonald (1988) report that the NNFI is also generally unaffected by sample size; it is useful for situations where a parsimony-type index is needed to account for the number of estimated parameters in a model (Medsker, Williams, and Holahan 1994).

## Results and Discussion

### *Measurement Instruments*

Confirmatory factor analysis was used to confirm the results of the measurement model. Parameter estimates and completely standardized parameter estimates are illustrated in Table 1. The completely standardized item-factor loadings are high (all above .70) and significant, as evidenced by their *t*-values (from 7.54 to 12.30). All items had reliability scores (R-square) above .50 (from .52 to .85), indicating good reliability. Results of the confirmatory factor analysis confirmed the existence of five constructs.

Cronbach's alphas, the correlations between the constructs, the differences between the chi-square values (with one degree of freedom) for the fixed and free solutions, and the descriptive statistics are shown in Table 2. Reliabilities for the five constructs in TAM model were from 0.82 to 0.89 (see the value in the diagonal cells in Table 2), indicating that each construct performs well (i.e. reliable). Table 2 also reports the correlations between the constructs. As shown in the upper portion of the off-diagonal cells, all but one value are greater enough (r ranges from 0.377 to 0.703) to suggest that the constructs are strongly positively correlated. The correlation between perceived ease of use and usage behavior is relatively weak (r = 0.172). However, the correlation is still significant at 0.05 levels.

Since all variables correlate well, discriminant validity analysis was performed to ensure that they are not the same. The lower portion of the off-diagonal cells in Table 2 reported the differences between the chi-square values (with one degree of freedom) for the fixed and free solutions. The values range from 27.8 to 180.15. They are greater than 10.83, the critical value for a significant level at 0.01 level for ten comparisons, suggesting that the variables exhibit acceptable discriminant validity.

### *Structural Model*

Figure 2 displays the results of the structural analysis corresponding to six hypotheses. Overall, the model has a very good model-data fit (Chi-square = 129.68 with 84 degree of freedom, NNFI = 0.94, CFI = 0.95). In addition, the root mean square error of approximation (RMSEA) is only 0.66, which is satisfactory.

**Table 1. Parameter Estimates and t-values for the Variables in the Model (n=214)**

| Items | Factor Loading | t-value | Completely Standardized Factor Loading | Uniqueness/ Error Term | R-Square (Reliability) |
|---|---|---|---|---|---|
| Perceived Ease of Use | | | | | |
| EOU1 | 1.00* | | .73 | .47 | .53 |
| EOU2 | 1.14 | 7.62 | .81 | .34 | .66 |
| EOU3 | 1.10 | 7.54 | .78 | .39 | .61 |
| Perceived Usefulness | | | | | |
| U1 | 1.00* | | .79 | .37 | .63 |
| U2 | 1.08 | 9.90 | .87 | .25 | .75 |
| U3 | 0.91 | 9.25 | .80 | .36 | .64 |
| Attitude | | | | | |
| A1 | 1.00* | | .72 | .48 | .52 |
| A2 | 1.46 | 8.24 | .88 | .23 | .77 |
| A3 | 1.22 | 7.49 | .73 | .46 | .54 |
| Behavioral Intention | | | | | |
| BI1 | 1.00* | | .76 | .42 | .58 |
| BI2 | 0.94 | 8.49 | .76 | .42 | .58 |
| BI3 | 1.14 | 9.23 | .83 | .31 | .69 |
| Usage Behavior | | | | | |
| UB1 | 1.00* | | .92 | .15 | .85 |
| UB2 | 0.85 | 12.30 | .83 | .31 | .69 |
| UB3 | 0.81 | 10.97 | .78 | .40 | .60 |

* Indicates a parameter fixed at 1.00 in the original solution.

**Table 2. The Reliability, Correlation, and Discriminant Validity for the Variables in the Model**

| | Perceived Easy of Use | Perceived Usefulness | Attitude | Behavioral Intention | Usage Behavior |
|---|---|---|---|---|---|
| **Perceived Easy of Use** | .83 | | | | |
| **Perceived Usefulness** | .402**<br>170.43 | .89 | | | |
| **Attitude** | .399**<br>180.15 | .529**<br>170.05 | .86 | | |
| **Behavioral Intention** | .420**<br>166.13 | .584**<br>102.3 | .672**<br>58.19 | .82 | |
| **Usage Behavior** | .172*<br>138.21 | .466**<br>166.9 | .376**<br>124.27 | .703**<br>27.8 | .88 |
| **Mean** | 5.35 | 5.04 | 5.58 | 4.67 | 4.08 |
| **Std. Deviation** | 1.47 | 1.71 | 1.54 | 1.85 | 2.08 |

The results indicate that perceived ease of use has strong, positive, and direct relationships with perceived usefulness and attitude. These relationships are described in hypotheses 1a and 1b, and they have structural coefficients ($\gamma$) of 0.37 (t=3.38) and 0.29 (t=2.64) respectively, which are statistically significant at $p<0.05$. Hypotheses 1a and 1b are supported, indicating that the higher the individual's perceived ease of use of the PDA, the higher the perceived usefulness and the more positive attitude toward the utilization of the PDA. Perceived usefulness is found to have positive and direct relationship with attitude and behavioral intention with structural coefficients ($\beta$) of 0.37 (t=3.34) and 0.47 (t=4.59) respectively. Both relationships are significant at 0.05 and 0.01 level of significance respectively, supporting hypotheses 2a and 2b. The results also indicate that attitude has a strong and positive impact on behavioral intention. The relationship has its structural coefficient ($\beta$) of 0.42 (t=4.47), significant at $p<0.01$, thus supporting hypothesis 3. Finally, hypothesis 4 is also strongly supported with the structural coefficient ($\beta$) of 0.82 (t=8.46), confirming that the higher the behavioral intention of using the PDA, the more the users use the PDA for their work.

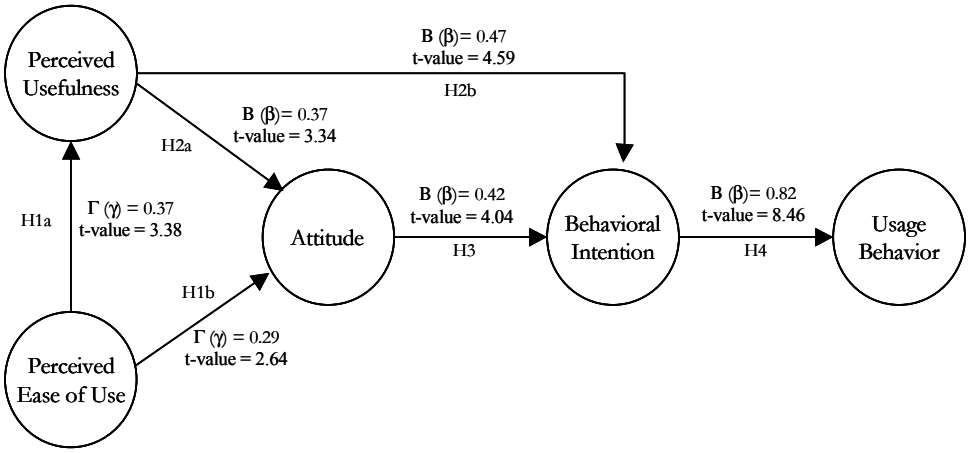


**Figure 2. Structural Coefficients and t-Values for TAM**

## Conclusions

This study examined the adoption of PDAs by individuals. PDAs along with cell phones and portable computers are expected to drive mobile commerce. PDAs with wireless connection are being touted to make the ideal of "information availability, anywhere, anytime" possible. The study showed that PDA adoption could be well predicted by TAM.

As any study it has limitations. The study's sample was limited to students willing to participate in the survey. Because of the use of a convenient cross-sectional sample, the findings of this study should be carefully used. The research needs to be replicated to examine the robustness of the findings across a wide range of contexts and samples. The future efforts at examining the determinants of individual adoption of PDA should attempt to both broaden the sample base and utilize richer and multiple methodologies.

Personal digital assistants (PDAs) is a new information technology, which provides its users the convenience of portability along with the access to the Internet along with horde of information available on it. It combines the features of traditional day planner, calculator, and cell phone which makes available a wealth of information to the users at their fingertips. PDAs are being used in disparate fields from downloading drug and disease databases by physicians and clinicians in medical field for coordination, to helping consumers in their shopping by retailers in supermarket to increase customer loyalty, to helping sailors work more effectively. As with a new information technology, it is important to examine why PDA is being adopted. Using TAM we try to answer this question in this paper.

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# Appendix: Measurement Items

**Perceived Ease of Use**

| | |
|---|---|
| ICEOU1 | I believe that it is easy to get the PDA to do what I want it to do. |
| ICEOU2 | I believe that the PDA is easy to use. |
| ICEOU4 | I believe that it is not difficult to use the PDA. |
| *ICEOU3* | *I believe that learning to operate the PDA is easy for me. (crossing loading)* |

**Perceived Usefulness**

| | |
|---|---|
| ICRA2 | Using the PDA would improve the quality of my work. |
| ICRA3 | Using the PDA would make it easier to do my job. |
| ICRA5 | Using the PDA would give me greater control over my work. |
| *ICRA1* | *Using the PDA would enable me to accomplish tasks more quickly. (low CITC)* |
| ICRA4 | Using the PDA would enhance my effectiveness on the job. (crossing loading) |

**Attitude toward Usage**

| | |
|---|---|
| BIATD2 | Using the PDA is a wise idea. |
| BIATD3 | I like the idea of using the PDA. |
| BIATD4 | Using the PDA would be pleasant. |
| *BIATD1* | *Using the PDA is a good idea. (low Corrected Item-Total Correlation)* |

**Behavioral Intention for Usage**

| | |
|---|---|
| INTUS1 | I intend to use the PDA soon. |
| INTUS2 | I intend to use the PDA for my work. |
| INTUS3 | I intend to use the PDA frequently. |

**Usage Behavior (i.e., Job Duties)**

| | |
|---|---|
| DMJOB1 | I use the PDA to perform a variety of tasks. |
| DMJOB2 | I use the PDA to accomplish similar tasks in a typical day. |
| DMJOB3 | I use the PDA to conduct tasks that are repetitive. |