Factors Affecting the Adoption of Production Digital Printing Technologies by Commercial Printers in India

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Certificate of Approval

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Abstract

The global print market has been declining. However, recent studies showed that the US print market is finally growing again (EPICOMM, 2015). A report by Drupa (2014) suggested that this is due to the growth in digital printing and the digitalization of media. This trend has given rise to many opportunities such as variable data printing and on-demand printing. Moreover, a shift toward shorter print runs and tighter deadlines has facilitated companies in the US printing industry to adopt digital printing technologies. Research shows a similar trend in Europe as well (Pira, 2012). However, the penetration of digital printing technologies varies by geographic regions. Research by Drupa (2014) indicates that while US and Europe possess the highest rate of adoption, developing regions such as India have just started to grasp these opportunities. Thus, this thesis aims at examining the factors affecting the adoption of production digital printing (PDP) technologies by commercial printers in India. The increasing value of the Indian print industry (Chander, 2012), along with the growing economy (The World Bank Group, 2015) made India a good region for the study.

Online web surveys were sent to 802 Indian commercial printers, of which 132 were returned giving a response rate of 16.46%. Most (93%) of the responders showed moderate to high awareness on the benefits of PDP technologies. The survey data were analyzed using binary logistic regression, which also presented the odds ratio to rank the factors in their order of importance with respect to the adoption decision. The independent variables included factors from Rogers' (1996) Diffusion

of Innovations as well as two factors from Davis' (1989) Technology Acceptance Model. While Relative advantage was found to be the strongest factor positively affecting the adoption of PDP technologies, complexity had a strong negative effect on adoption. Compatibility, observability, and perceived ease-of-use were other significant factors positively affecting the adoption. Trialability and perceived usefulness were found to be insignificant. These factors were measured using 5-point Likert scales. On the other hand, the dichotomous dependent variable of adoption was measured by the responses to the simple questions, "Do you currently use production digital printing technologies?" and "Do you plan to adopt production digital printing technologies?" This study indicated that 61.36% of the commercial printers surveyed were currently using PDP technologies, with 66.67% of non-adopters planning on adopting the technology in the next 36 months. Dry toner EP was the most widely adopted PDP technology.

This study likely helps suppliers in the Indian printing industry understand commercial printers and their readiness to adopt PDP technologies. As a solutions supplier in the Indian print industry, the author was extremely interested in service providers' receptivity to incorporate new technologies in their companies. Ultimately, the study suggested that both print services providers and suppliers must give utmost priority to education and training related to PDP technologies.

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Chapter 1

Introduction

Background

"Print is dying." This is a phrase nearly everyone in the printing industry has heard since the widespread adoption of digital media. However, research suggests that this claim is only partly true. A survey of over 300 company owners and managers by EPICOMM (2014) revealed that the global print market has declined by 20% in less than 20 years. However, it suggests that the US printing industry is finally growing again in 2014. As seen in Figure 1, the gains have been modest – sales are up an average of 2.5% per quarter over the last four quarters as examined in the 2014 study.

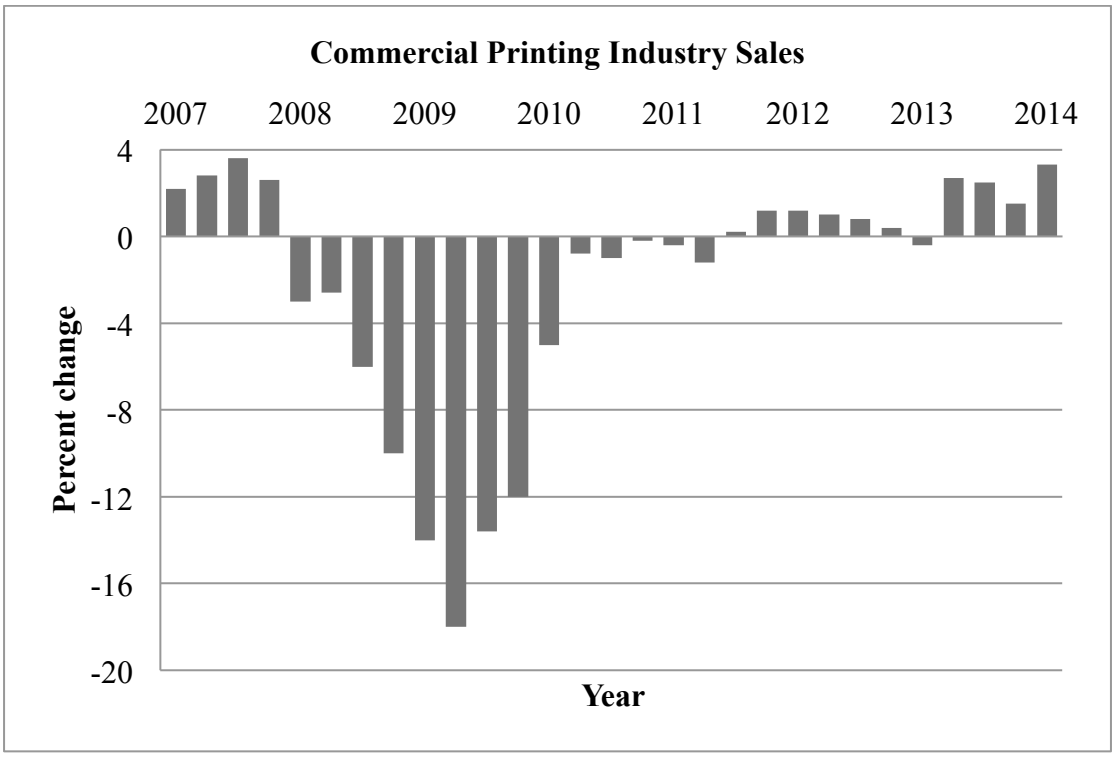

Figure 1. Commercial printing industry sales, percent change by quarter. Reprinted with permission from "Here is your guide to the future," by EPICOMM, 2014, p. 1.

Specifically, industry sales increased 2.7% in the last quarter of 2014. That follows gains of 2.5%, 1.5%, and 3.3% during the previous three quarters and extends print's strongest advance since 2007. EPICOMM (2014) expects growth to continue in 2015.

EPICOMM (2014) described the change in sales distribution from 2013 to 2014 using the data obtained in their survey. Nearly two-thirds (65.4%) of participants reported a sales increase in 2014, up sharply from 47.8% during the same period in 2013. Moreover, for the first time in years, some State of the Industry survey participants in the EPICOMM study described business conditions positively using terms such as "encouraging," "improved," and "very favorable," rather than negatively.

The improving economy also plays a role in this growth. During 2013, new policy initiatives in major developed economies have reduced systemic risks and helped stabilize consumer, business and investor confidence, but with very limited impacts on growth (Drupa, 2014). In the USA, growth is expected to continue. While private sector demand is projected to gradually strengthen, the automatic spending cuts and uncertainties associated with budget issues will continue to have an effect on consumer confidence.

Thus, there is now growth in the industry. Romano (2014) suggests that this is due to the growth in the general commercial printing industry in the following areas:

- Small-format digital printing
- Wide-format, signage, textiles, and other forms of specialty graphics
- Label and packaging

However, as digital printing grows, demand for conventional printing technologies appear to weaken. Drupa (2014) reported a 25% decline in the demand for conventional printing methods such as offset lithography and flexography.

The Digitalization Trend

Digital printing technologies show a great deal of promise. This disruptive technology, supported by the digitalization of all forms of content, has provided opportunities for print providers to use digital technologies to meet the current demands of the consumers by providing extra value-added services such as variable data printing, web-to-print, and on-demand or short-run print (Drupa, 2014). This, in turn, has produced a shift from mass production of static print through offset, gravure and flexography processes to mass customization of small volumes of digital print down to print runs of as small as one.

Digital printing offers new opportunities for businesses to provide customers with only a few copies of the printed product required, which would not have economically been feasible for conventional printing methods to deliver. Moldvay (2012) in a IBISWorld industry report entitled *Printing in the US* indicates that due to this, there has been a shift toward shorter print runs (i.e. fewer than 2,000 copies), faster turnarounds and tighter deadlines (Moldvay, 2012). This has resulted in commercial printers increasingly investing in new technology and equipment to remain competitive. This factor has also increased the amount of revenue generated from digital printing, which is a small but rapidly growing service offering for the industry (Moldvay, 2012). Digitization allows text-based content to be produced for

various media from a single source. Furthermore, it enables printers to produce small print runs economically and offer customized printing, especially for direct mail.

Moldvay (2012) also reports that over the past five years, growth in outsourcing and rising computer usage in the United States has led to an increase in digital printing. However, overall growth has varied among other print market segments. While there has been a strong increase in the value of shipments in the digital printing segment, there has been slow growth or decline in other areas such as the loose-leaf binder-manufacturing segment, commercial and job printing activities comprising of printing invoices and order forms.

New Markets

The technological advancements in printing industry equipment and materials have produced new markets. Online printing portals (web-to-print) provide convenience to some customers and drives demand for industry services. Computer technologies allow printers to provide additional value-added services such as digital asset management (DAM), data analytics and data management. New technologies affecting customers and end markets can also impact demand for some printing services. For example, there has been a decrease in the use of bank checks due to new electronic bill-payment systems. There has also been a decrease in demand for commercially printed business forms due in large part to individuals and businesses printing forms themselves from computers.

In today's market, most graphic arts service providers are using cloud computing for not only job submission but also for all their software composition tools such as Adobe Creative Cloud. The graphic communications industry will re-

invent itself under cloud computing architectures because these technologies provide a more cost effective and streamlined business model (Bondy, Peterson, & Webb, 2015). Printers can now create a document in one location, store it in the cloud, and retrieve it in a different location for print, which has reduced storage and transport costs and made more timely delivery possible. Online printing operators offer convenient services and are emerging as significant segments in the short print-run space where small businesses represent the major customer base. Websites can provide design templates and offer customers the ability to design documents interactively. In sum, digital printers are moving into other ancillary services, including data asset management, fulfillment and inventory management, design services and e-commerce services.

Rise of Digital Printing

With digital printing offering opportunities for businesses and customers, the workflow of the printing industry is changing. Moldvay (2012) predicts that over the next five years, improved digital printing devices and more sophisticated workflow software will continue to promote shorter, digitally printed runs in the United States. This is because digital printing has low setup costs and can accommodate shorter runs. This allows for easier document updating, reduced warehousing costs and the management of a greater number of unique documents. Alternative technologies including the Internet and other office printing equipment will have a dampening effect on demand for traditional commercial and job printing activities.

Digital printing is growing in Europe as well. A report by Smithers Pira entitled *The Future of Digital vs Analogue Printing (2015)* states that there was a

7.7% Compound Annual Growth Rate (CAGR) for digital printing technologies during 2010-15 and the growth will continue at 4.1% during 2015-2020 in Europe. This strong growth is largely due to new products and services, from short-run print on-demand to high-value variable-data applications, including direct mail, transactional printing and transpromo[1].

Europe's analogue print market was valued at $150 billion in 2015, down 2.7% from 2008. A further 2.2% decrease is forecasted in 2020 to under $135 billion (Smyth, 2015). This change has been due to the adoption of digital printing technologies. For instance, the industry has enthusiastically adopted wide-format inkjet machines to print posters and point-of-sale displays as part of the graphics sector not as a separate signage sector.

Hence, traditional print is not "dying." The communication needs are changing and the printing industry is adapting to these changes by delivering a different mix of media in print and other digital media channels. Traditional print volumes have declined and some have shifted to alternative media. The crux of the thesis was to examine these trends in a developing country, in this case, India. The primary aim of this research is to assess the factors affecting the adoption of production digital printing[2] (PDP) technologies by commercial printers in India.

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[1] InfoTrends defines transpromo as a cocktail of transactional print, bold design, color, and variable marketing information which is used to deliver a mix of transactional and value added marketing data through business communications.

[2] Production digital printing (PDP) technologies are defined by InfoTrends as greater than 70 pages per minute color production devices using inkjet (IJ) or electrophotographic (EP) technologies. This excludes small office home office (SOHO) printers as the present study considers machines staffed by operators as production-level.

Problem Statement

Breakthrough technologies including digital print, cloud computing, data/digital content management, mobile technology, and cross-media communications are transforming the printing industry in the US and Europe. In this study, the researcher aims to deliver primary market research while presenting the effect of these disruptive technologies and their impact on the traditional print services businesses in India.

Electrophotography and inkjet are the two major production digital printing technologies. The penetration of these technologies varies by geographic regions (Drupa, 2014). While US and Europe possess the highest rate of adoption of production digital printing technologies, developing regions such as Africa and India have just started to grasp these opportunities but it is not known at what rate (Drupa, 2014). Thus, the focus of this thesis was to determine how does India, as a developing nation, compare to mature economies of US and Europe in the adoption of production digital printing technologies.

The research study was designed to determine the technology adoption of commercial printers in India using factors from tested technology adoption models in the literature, such as Rogers' Diffusion of Innovations (DOI) and Davis' Technology Acceptance Model (TAM). This study assessed the factors affecting the adoption of production digital printing technologies by the commercial printers in India, and ranks these factors based on their significance of effects on the adopters. Specifically, factors such as relative advantage, compatibility, complexity, trialability, observability, perceived ease-of-use, and perceived usefulness were studied. This approach is presented in Figure 2.

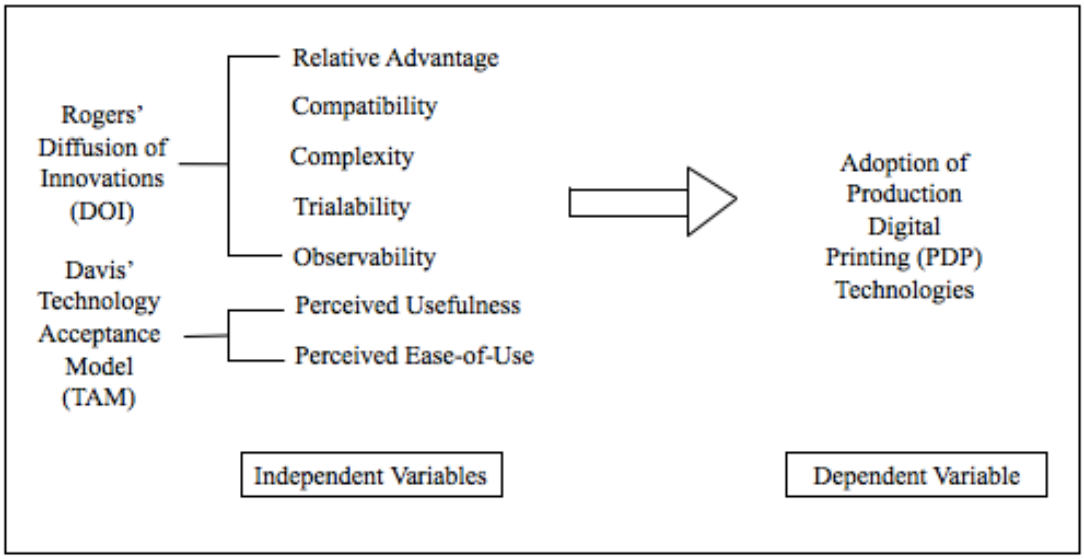

Figure 2. Proposed approach for research

The research was targeted at business owners because it is the CEO's have profound influence on the final decisions in the company. Al-Qirim (2007) found that the greater the CEO's innovativeness and involvement in adoption of a new technology, the more likely the technology is to be adopted.

This research allowed the researcher to comprehend the behavior of the business owners of the commercial printers in India, which in turn will potentially help the suppliers and dealers to better serve the commercial printers to advance their businesses via informed technology adoption. As the global print industry makes the transition from strictly traditional printing to traditional plus digital printing, the study evaluated the position and receptivity of the business owners of the commercial printers in India towards production digital printing technologies. The researcher believes that those suppliers and dealers who can understand and motivate their traditional print service providers to transform into integrated cross-media service

providers to offer new services made available by digital printing as discussed above can in turn potentially help boost their profit margins.

India was chosen because of the size of its printing industry and the growth rate of the economy. Since most businesses in developing countries such as India are small, there is often a lack of adequate resources to invest in new technologies and absorb possible failure (Goode & Stevens, 2000). In addition, the practice of printing on-demand and variable data printing are new technologies for businesses in developing countries. New technology adoption decisions are made if the firm perceives the new technology as useful in meeting market needs. Moreover, adoption depends on these businesses making changes in the organizational structure, product characteristics and business culture of their enterprises (Montealegre, 1996). Thus, the following questions motivated the present research: "What is the readiness of the Indian printing industry to make these changes? Are the perceived risks worth the investment?" This research was designed to study such questions by determining the facilitators and inhibitors of this technology adoption decision.

Significance of Topic

The information from this thesis on the readiness of adoption of new digital technology by the Indian commercial printers contributes to adoption and diffusion of innovative technology research. This will help researchers interested in the adoption of innovations to gain a deeper insight into this dynamic field by adding another example of a technology adoption decision to the already large database of articles in this area.

In addition, printing equipment suppliers are interested in the readiness of print service providers to adopt production digital printing technologies that appear to promise substantial benefits. Understanding the motivation of these print service providers in one developing nation would certainly help suppliers better understand their needs.

Reason for Interest

This study was very helpful to the researcher in his career for practical business reasons. As a graphic communications supplier in India, the researcher was extremely interested in service providers' receptivity and readiness to incorporate new technology in their companies. This research helped the researcher gain a better understanding of the Indian market, the technological adoption trends and the barriers to adoption of technology allowing him to serve the market more efficiently and attain business success via a more well-informed market plan.

With this knowledge, the researcher aspires to help Indian commercial printers "cross-the-chasm" to adopt and use production digital printing technologies to provide print on-demand, web-to-print and variable data printing, and transform into an integrated cross-media service provider to advance locally as well as regionally.

Chapter 2

Theoretical Basis

This chapter provides the theoretical basis to the research study using two technology innovation and adoption models. Empirical research based on these models will be presented in Chapter 3.

Diffusion of Innovations

Rogers' seminal work "Diffusion of Innovations" (DOI) is one of the most cited theories of innovation. Rogers (1996) identified five antecedents that impact the rate of diffusion of technology innovations: relative advantage, complexity, compatibility, observability, and trialability. Rogers' (1996) definitions for these five factors are as follows:

- Relative advantage – "the degree to which an innovation is perceived as being better than the idea it supersedes and is often expressed economically as profits" (p. 213). The degree of relative advantage may be measured in economic terms, but social-prestige factors, convenience, and satisfaction are also often important components.
- Compatibility – "the degree to which an innovation is perceived as consistent with the existing socio-cultural values and beliefs, past experiences, and needs of potential adopters" (p. 223). An idea that is not compatible with the prevalent values and norms of a social system will not be adopted as rapidly as an innovation that is compatible.

- Complexity – “the degree to which an innovation is perceived as relatively difficult to understand and use” (p. 230). Some innovations are readily understood by most members of a social system; others are more complicated and will be adopted more slowly.
- Trialability – “the degree to which an innovation may be experimented with on a limited basis, under one’s own conditions” (p. 231). New ideas that can be tried on the installment plan will generally be adopted more quickly than innovations that are not divisible.
- Observability – “the degree to which the results of an innovation are visible to others” (p. 232). The easier it is for individuals to see the results of an innovation, the more likely they are to adopt.

While these factors provide a framework for understanding the perceptions of individuals with regard to the technology, there are five stages of the innovation-decision process that the business passes through. Rogers (2003) defines the innovation-decision process as “the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision.” The model of innovation-decision process by Rogers (2003) is portrayed in Figure 3.

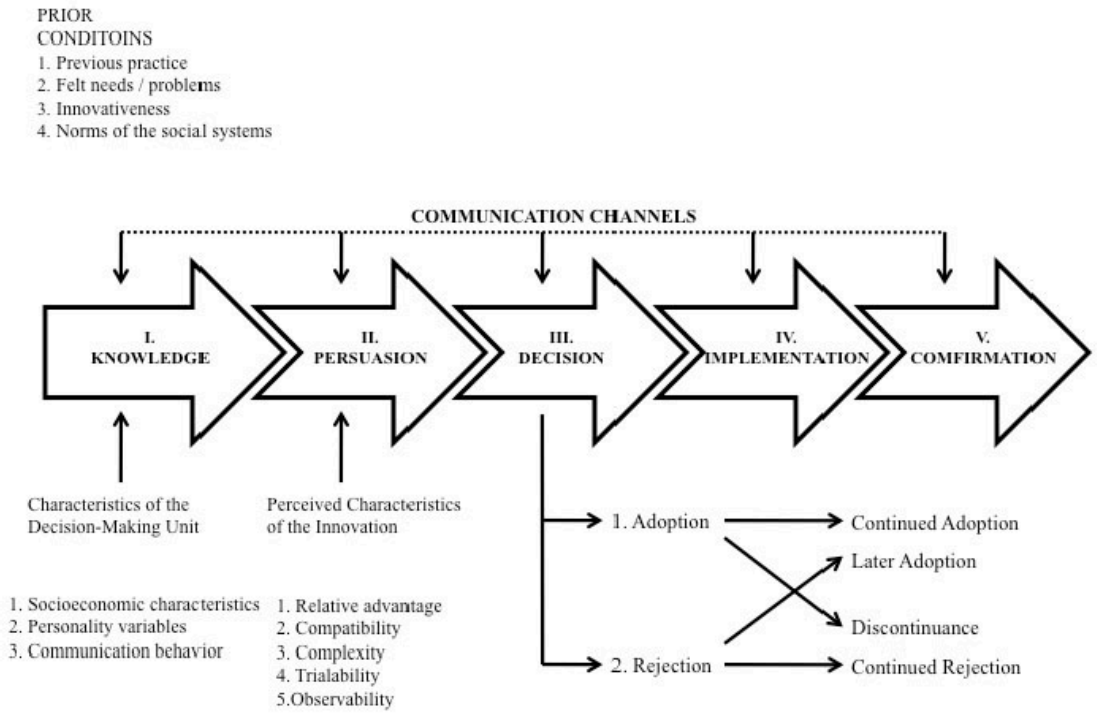

Figure 3. A Model of Five Stages in the Innovation-Decision Process by Rogers, 2003, p. 170.

The present conceptualization consists of five stages:

1. Knowledge occurs when a buyer is exposed to the innovation's existence and gains some understanding of how it functions.
2. Persuasion occurs when a buyer forms a favorable or unfavorable attitude toward the innovation.
3. Decision occurs when a buyer engages in activities that lead to a choice to adopt or reject the innovation.
4. Implementation occurs when a buyer puts an innovation into use.
5. Confirmation occurs a buyer seeks reinforcement of an innovation-decision already made, but he or she may reverse this previous decision if exposed to conflicting messages about the innovation.

This research is mainly concerned with the decision stage of this process, as it will study Indian commercial printers' decision to adopt the production digital printing technologies.

Another model that studies why a business accepts or rejects a technology is the Technology Acceptance Model, which will be reviewed next.

Technology Acceptance Model

Fred Davis (1989) first proposed the Technology Acceptance Model (TAM). TAM is considered an influential extension of theory of reasoned action (TRA) proposed by Ajzen and Fishbein (1980). Davis (1989) and Davis, Bagozzi, and Warshaw (1989) used the TAM to explain why a user accepts or rejects information technology by adapting TRA. Figure 4 depicts the model.

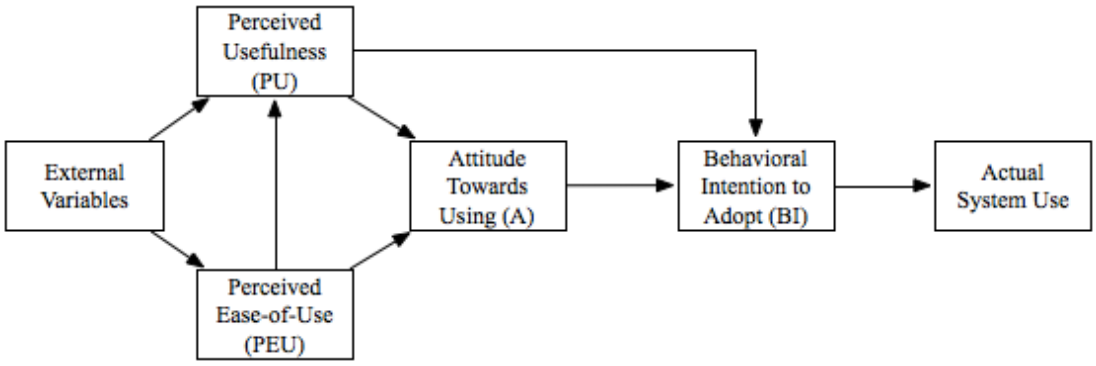

Figure 4. The Technology Acceptance Model (TAM) (adapted from Davis, 1989)

The model describes how external variables influence belief, attitude, and intention to use. According to TAM, one's actual use of a technology system is influenced directly or indirectly by the user's behavioral intentions, attitude,

perceived usefulness, and perceived ease-of-use of the technology. Two cognitive beliefs are posited by TAM: perceived usefulness and perceived ease-of-use. Davis' (1989) definitions of the two key factors are:

- Perceived usefulness (PU) - the degree to which a person believes that using a particular system would enhance his or her job performance.
- Perceived ease-of-use (PEU) - the degree to which a person believes that using a particular system would be free from effort.

These two determinants serve as the basis for attitudes toward using a particular innovative system, which in turn determines the intention to use, which predicts the actual usage behavior.

Conclusion

This chapter reviewed two popular theoretical models relevant to the research study. It discussed Rogers' theory of Diffusion of Innovations, and Davis' Technology Acceptance Model. Together, these theories will help the present research by providing a framework to determine the effect of these factors on Indian commercial printers' decision to adopt production digital printing technologies.

Chapter 3

Literature Review

This chapter starts with an overview of digital printing technology and its global growth trend. The chapter will then summarize studies that have tested technology adoption models discussed in Chapter 2 to describe the factors impacting the adoption of innovations. Lastly, information on the Indian print markets and trends will be presented in the final section of this literature review.

Digital Printing

Digital printing refers to methods of printing from a digitally based image directly to a variety of media (Whitbread, 2009). Digital printing encompasses many technologies. These include various forms of inkjet, thermography, electrophotography and electrostatic printing, ionography, magnetography, and digital photographic imaging and developing. A summary of major digital printing technologies used in the United States is is presented in Figure 5. None of these require a physical master but instead rely on digital data to create images.

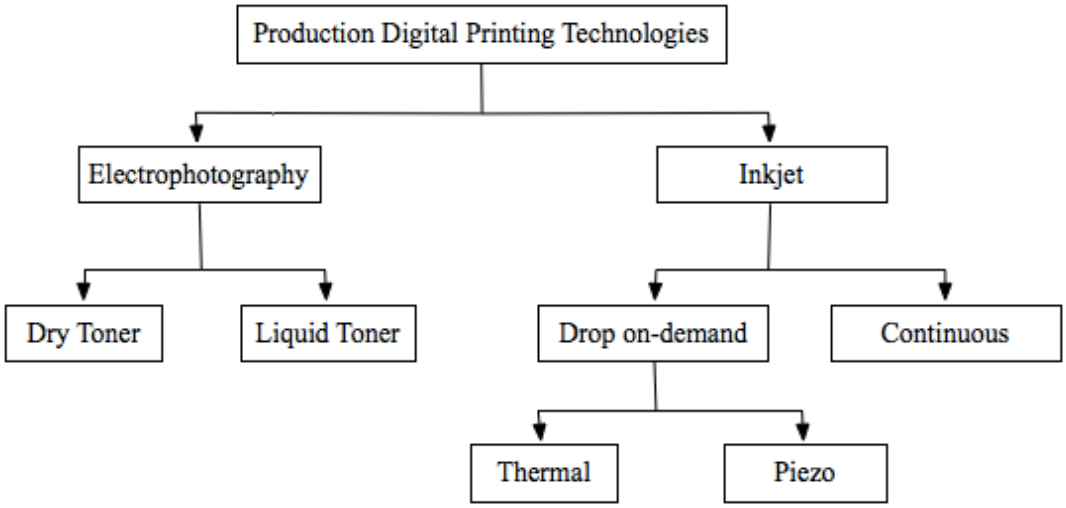

Figure 5. Major digital printing technologies [PDF Document]. Retrieved from a keynote by Prof. Chris Bondy (2014) during CMIC Summit, RIT.

Digital printing often refers to professional printing where small-run jobs from desktop publishing and other digital sources are printed using large-format and/or high-volume electrophotography or inkjet printers. Digital printing generally has a higher cost per page than conventional offset printing methods. But this higher cost is offset by avoiding the cost of making printing plates and the ability to print on-demand to avoid inventory storage cost. Furthermore, it also allows for shorter turnaround times and the possibility of the customization of the image used for each impression (Kasdorf, 2002). The savings in labor and the ever-increasing capability of digital presses means that digital printing is reaching the point where it can match or supersede offset printing technology's ability to produce larger print runs of several thousand sheets at a low price (Hörlesberger, El-Nawawi, & Khalil, 2007). Other advantages over conventional printing methods include:

- Digital presses require minimal press setup and have multicolor registration built-in to its system;
- Digital presses can print proofing, sample and short runs more cost effectively than conventional methods;
- Digital files are usually easier to edit and modify than analog photographic images on plates;
- Digital printing technologies allow the printer to add new services such as variable data printing, personalization, print on-demand, and web-to-print;
- Electronic collation provides greater flexibility where full book blocks can be delivered in an automated in-line process; and
- Workflow automation allows just one operator to operate a production color inkjet system and handle tasks that are typically the responsibility of multiple operates in an offset environment (platemaking, press operation, and finishing).

As color digital presses came to market, the initial reasons for adoption were lower costs for short runs and quick turnarounds (Smyth, 2015). As more companies used the technology, new applications and business models developed for print-on-demand and short-run books, and for inkjet printed signage. Pira (2015) presents a cost comparator model to compare digital and analog printing systems for several categories of output in various applications. For instance, one model shows that the two-page duplexing digital cut sheet machines deliver the lowest cost for very short runs, up to some 700 prints. Longer runs, over 3,500 sheets, are cheaper for straight

litho presses running in sheetwork mode to deliver a four-page product.

Consider Figure 6. The figure depicts a generalized cost model adapted from the Pira (2015) study to compare analog vs digital printing. As seen, digital printing has a flat cost structure whereas the cost per piece declines with longer runs in offset printing. The run length crossover point is around 1,500 (Smyth, 2015). However, with higher productivity and speed of inkjet printers, this run length crossover point is increasing and competing with offset printing. As their cost per page continues to decline, digital presses will supplant offset presses for more and more print jobs.

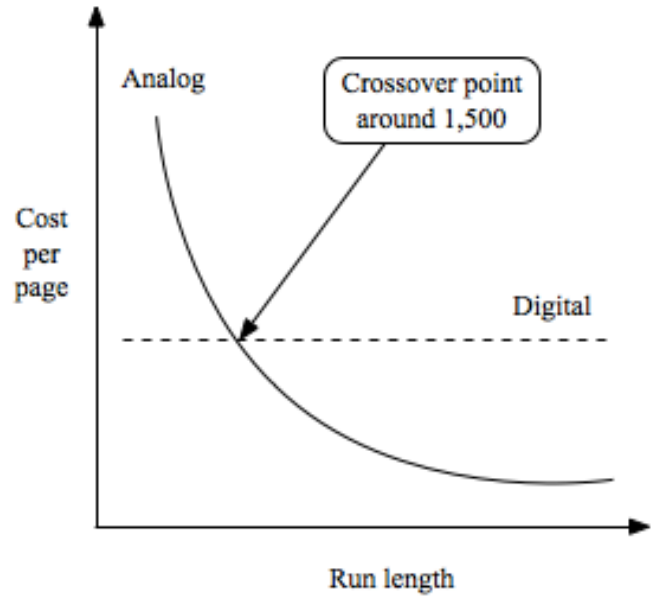

Figure 6. Analog vs Digital run-length crossover point

Having examined digital printing technologies, the review will now turn to studies that have used the innovation adoption models discussed.

Empirical Research on Technology Adoption

This section reviews research on the adoption of technological innovations. Adoption models have been utilized in this research to provide a concrete framework by examining various factors that impact innovation trends. It will begin with a review of research that has used Rogers' theory and Davis' model, and then will include other models that have been developed.

Diffusion of Innovations

Innovation adoption has been examined over many decades in a variety of academic disciplines such as marketing, economics, communication, sociology, information systems (IS), education and organizational research (Fichman and Carroll, 1999). Particularly, Rogers' theory has been tested in many studies to predict the technology adoption in developing countries (e.g., Al-Gahtani, 2003; He, Duan, Fu & Li, 2006; Al-Jabri & Sohail, 2012). In 2003, Al-Gahtani used Rogers' theory of Diffusion of Innovations to study the computer technology adoption in Saudi Arabia, a developing country. The data was collected using a survey questionnaire sent to fifty-six organizations distributed across the major provinces of the country.

Al-Gahtani measure the five attributes of Rogers' theory (relative advantage, compatibility, observability, trialability and complexity) using multiple scales and were then used for testing the hypotheses. The hypotheses included:

- H_1: Relative advantage will be positively associated with computer adoption,
- H_2: Compatibility will be positively associated with computer adoption,

- H_3: Complexity will be negatively associated with computer adoption,
- H_4: Observability will be positively associated with computer adoption, and
- H_5: Trialability will be positively associated with computer adoption.

The data analysis strongly confirmed all the five hypotheses and the hypothesized directions of relationships. However, inconsistent with earlier studies, Al-Gahtani found that compatibility (0.340 at $p < 0.01$) had a stronger effect than the relative advantage (0.27 at $p < 0.01$) on the adoption rate. Thus, this study concluded that the innovation diffusion research developed in technologically advanced societies is just as applicable in less technologically developed countries.

In a similar study, He, Duan, Fu, & Li (2006) tested Rogers' theory to assess the adoption of online e-payment in Chinese companies. He et al. (2006) used multiple logistic regression analysis to test the significance of Rogers' factors on technology adoption. The model chi-square of 30.269 (df=5) suggested that the logistic model was fit for the data.

Agresti (1996) suggested that the logistic regression model is the most appropriate model for binary data, and has been used in many studies involving a dichotomous variable. For instance, Daud, Haron, & Ibrahim (2011) used binary logistic regression to examine the factors associated with the adoption of Enterprise Risk Management among public listed companies in Malaysia. Moreover, Askar, Usluel, & Mumcu (2006) successfully used the binary logistic regression to predict task-related information and communication technologies use in teaching in correspondence to Rogers' five factors. This research will use multiple logistic

regression, since the adoption of production digital printing technologies is measured by binary choices of respondents.

Rogers' theory was used in many studies testing technology adoption in developed regions as well (e.g., Medlin, 2001; Isleem, 2003; Less, 2003). However, Al-Qirim (2007) argued that if Rogers' model were expanded to include more factors, it would provide a more complete model. In his study of eCommerce adoption in New Zealand, he included new factors such as:

- Organizational – measured by firm size
- Individual – CEO's innovativeness and involvement
- Environmental – competition, buyer/supplier pressure and support from technology vendors.

Al-Qirim used a survey questionnaire to obtain primary data from a random sample of 324 small and medium enterprises covering North Auckland. The results revealed that all factors were statistically significant predictors of adoption except for the new variables tested of 1) size of the organization, 2) support from technology vendors and 3) pressure from suppliers or buyers. CEO's innovativeness was the most significant factor affecting eCommerce adoption in this study.

This research introduced new potential determinants of innovation adoption in small and medium enterprises in New Zealand and represented an important extension of Rogers' theory. A second theory that has received a lot of attention is the Technology Acceptance Model.

Technology Acceptance Model

The Technology Acceptance Model (TAM) introduced perceived usefulness and perceived ease-of-use as two important factors influencing the acceptance and use of a technology. First, the importance of perceived usefulness is reviewed. One reason why a majority of innovation initiatives fail is the lack of proper understanding of the creativity needed by the ultimate users who are struggling to use the newly developed products (Tanev & Frederiksen, 2014). The perception of the technology usefulness lies in the eyes of the user. If the user does not perceive it as useful, the actual innovativeness of the product or service is lost. Consider Figure 7.

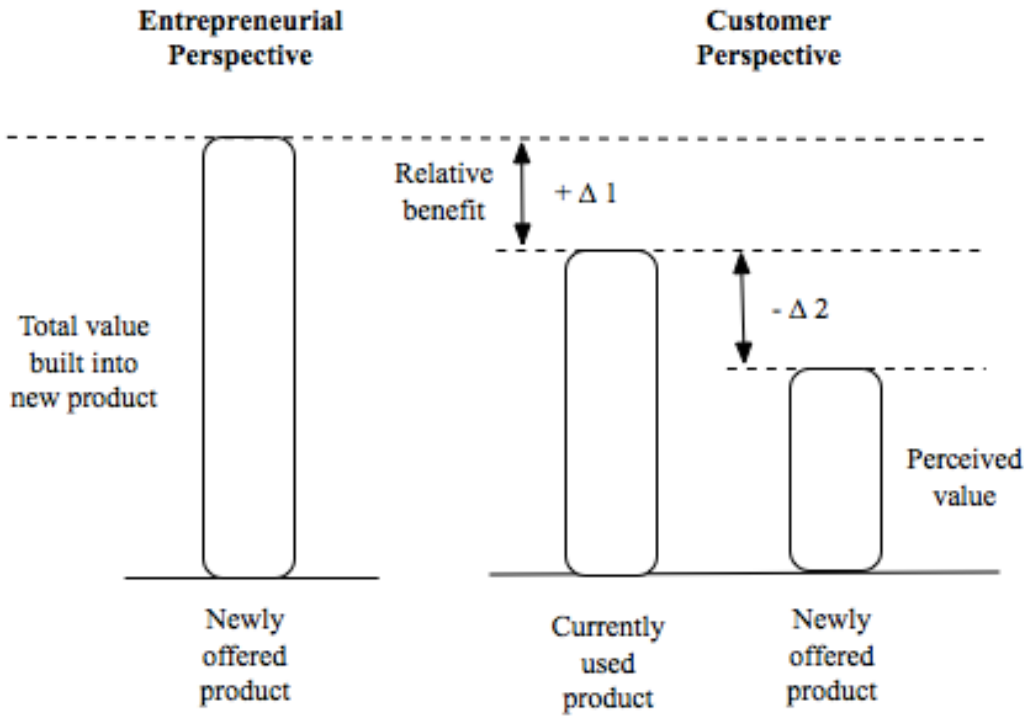

Figure 7. Visualization of the difference between the total value of a new product and its perceived customer value (Tanev & Frederiksen, 2014)

As depicted, even if the newly offered product provides a higher value than the one currently used by the customers/users, potential customers/users perceive the newly offered product to have a lower value. Suppliers and sellers of innovative products assume that customers/users know in advance what the total value of a product is, which is not always true. What customers/users really know is their perceived value of the product, which could be lower than the potential value provided by it according to the vendors. The adoption decision by customers/users will not happen unless there is a positive difference between the perceived value of the new offered product versus the value of the existing (Tanev & Frederiksen, 2014).

Based on a meta-analysis of 26 selected empirical studies by Ma and Liu (2004), TAM is one of the most influential and frequently tested models used to explain technology adoption literature. Although the TAM is a well-documented model for explaining technology acceptance by users, Park, Lee, & Cheong (2007) argued that the model has been unable to comprehensively account for the factors that affect users' acceptance of technology systems due to the original model's intended generality and parsimony. Dishaw and Strong (1999) also argued that one of the TAM's weaknesses is its lack of the explicit inclusion of antecedent variables that influence perceived ease-of-use (PEU) and perceived usefulness (PU). Moreovoer, Myers (2004) suggested that TAM did not explain more variance than the more general TPB, and that TAM was a less general model than either the theory of reasoned action (TRA) or the theory of planned behavior (TPB).

In sum, for the adoption and use of production digital printing technologies, other relevant factors in addition to perceived usefulness (PU) and perceived ease-of-

use (PEU) will be considered in this thesis to devise a more powerful model towards explaining production digital printing technology acceptance in India.

Tests of Diffusion of Innovations and the Technology Acceptance Model Combined

Many studies have tested TAM alone (e.g., Lu, Yu, Liu & Yao, 2003; Musa, 2006; Dwairi, 2011). However, Rogers' theory and Davis' model are similar in some constructs and complement each other to examine the adoption philosophies. Thus far, numerous studies have successfully integrated these two theories to investigate users' technology acceptance behavior (e.g., Hardgrave, Davis, & Riemenschneider, 2003; Wu & Wang, 2005; Chang & Tung, 2008; Lee, Hsieh, & Hsu, 2011). For instance, Suh (2004) used a combined model of TAM and DOI to examine the adoption of supply chain management system by small and medium enterprises. Also, Hong, Shin, & Kang (2008) used the combined model to predict the adoption intention of intelligent robot for home use. Wu & Wang (2005) and Lee, Hsieh and Hsu (2011) believed that integrating Rogers' theory of Diffusion of Innovations and the TAM would provide a stronger model.

The more recent study by Lee, Hsieh and Hsu (2011) studied business employees' behavioral intention to use the e-learning system. They proposed a model that included the five innovation attributes from Rogers' theory and the two TAM ones: perceived usefulness (PU) and perceived ease-of-use (PEU). These attributes were then tested to study if they affected employees' behavioral intention to use the innovation. Figure 8 presents the resulting path analysis along with the path coefficients for every path.

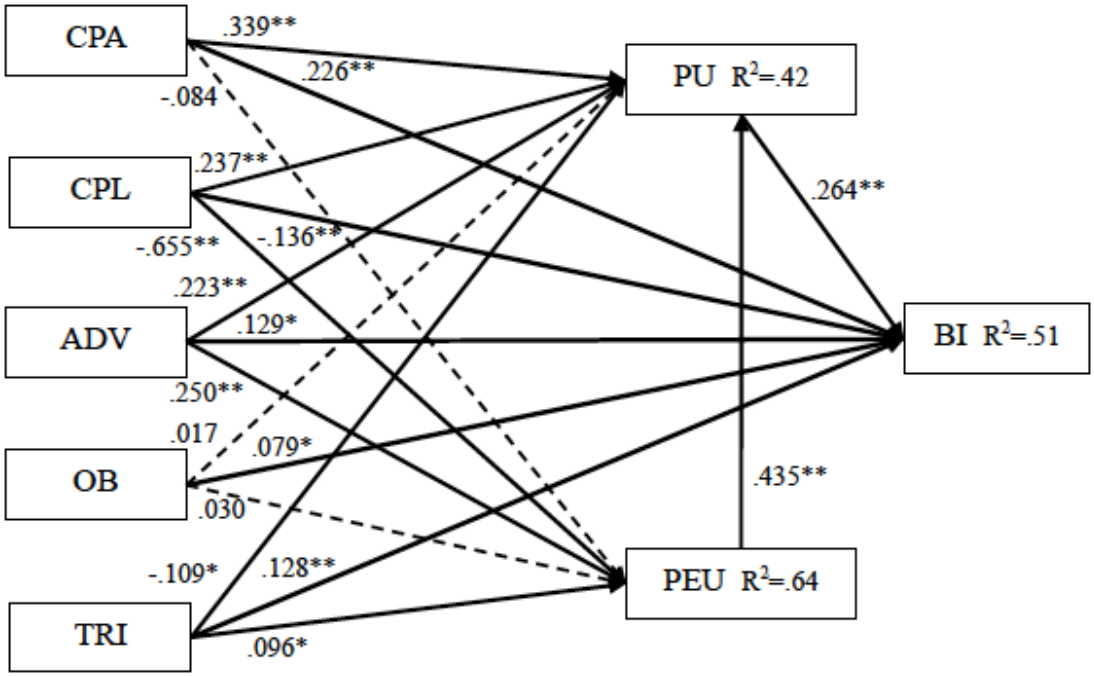

Figure 8. Results from Lee, Hsieh and Hsu (2011) study (Note. *p < .05; **p < .01)

The results of Structural Equation Modeling (SEM) showed that PU significantly influenced the behavioral intention to use, while PEU was found to be significant in influencing PU. Also, relative advantage (ADV), complexity (CPL) and trialability (TRA) had a direct as well as an indirect impact on the behavioral intentions by affecting the PU and PEU.

Moreover, each of the five attributes had a direct as well as an indirect impact on the BI. However, the indirect impact on BI via PEU and PU was stronger than the direct impact. In addition to that, three relationships were not significant: compatibility (CPA) had no effect on PEU, and observability (OB) had no effect on both PU or PEU.

This study validated the use of Rogers' theory and Davis' model in the organizational context of using innovations. However, a few findings were

inconsistent with previous studies. Complexity was found to positively affect behavioral intention instead of negatively as previously found. Earlier studies also suggested that observability positively affected perceived usefulness, while this present study showed no effect of observability on it. Understanding the reasons for these inconsistencies is a challenge for future research.

As observed above, DOI and TAM share conceptual premises that make them ideal for complementary uses. Some previous research considered TAM as essentially a part of perceived innovation characteristics and argued that its predictability may be enhanced if they are allowed to interact with each other rather than stand alone (Moore & Benbasat, 1991; Agarwal and Prasad, 1998). In short, they argue that the adoption decision regarding innovative technology is best predicted with an integrated framework which encompasses both DOI and TAM.

Although originated from different disciplines, there is a complementary relationship between TAM and DOI. Moore and Benbasat (1991) found that the relative advantage construct is similar to PU and the complexity construct is similar to PEU. This suggests that TAM and DOI reconfirm each others' findings, which enhance the confidence in the validity and reliability of these approaches (Chen et al., 2002).

Therefore, in this research the author will use constructs from each of these major theoretical paradigms to provide a stronger approach that can reliably predict adoption behavior in regard to production digital printing technologies. This thesis will use TAM's perceived usefulness and perceived ease-of-use in combination with DOI's five factors to test how these factors affect the decision of commercial printers in India to adopt production digital printing technologies. This will increase the

credibility and effectiveness of the study by offering a more comprehensive perspective.

Cross-Cultural Difference

Research summarized above was conducted in a variety of settings including developed and developing countries. Research examining differences among countries in rates of innovation adoption tested in the same study are rare. A study by Erumban and de Jong (2006) did this by investigating the differences in Information and Communication Technology (ICT) adoption rates. They suggested that while some countries are receptive to changes, other countries appear to be less so. This divergence is due to both economic and non-economic factors. Previous studies have highlighted the role of costs and level of income as the major economic factors. However, the adoption rates differ significantly across countries with similar economic situations.

Using data collected from over 100,000 individuals within 50 countries during 1967-1973, ICT adoption was measured by taking the share of ICT expenditure as compared to each country's GDP (Erumban and de Jong, 2006). The independent variables included factors that comprise the Hofstede dimentions (noted below). The countries for which Hofstede dimensions were available were considered.

The Hofstede dimensions tested were:

- Power distance: refers to the inequality of the distribution of power in a country. A high degree would reflect centralized decision structures and authority.

- Uncertainty avoidance: the degree to which members of a society feel uncomfortable with uncertainty and ambiguity. This factor has been used since the adoption of a new technology involves risk and uncertainty.
- Individualism: refers to the relation between the individual and the group to which that individual belongs. People in individualistic countries are inclined to make their own choices, while people in collective countries are more readily willing to conform to the norms of the group.
- Masculinity: characterized by competition, ambition and a focus on performance and material values.
- Long-term orientation: the extent a culture values its traditions. A high value refers to cultures focusing more on their traditional values.

The results indicated that:

- Low power distance countries show higher rates of ICT adoption;
- Low uncertainty avoidance countries show higher rates of ICT adoption;
- High individualism countries show higher rates of ICT adoption;
- Masculinity does not affect the adoption rate;
- Short-term oriented countries appear to have a higher rate of ICT adoption.

The results obtained in this study complements the existing evidence on the determinants of technology adoption by highlighting the importance of cultural factors. The results suggest that in some countries cultural differences can act as a barrier to ICT adoption.

Of particular importance to this thesis is the inclusion of these Hofstede dimensions. Using data from Erumban and de Jong, the differences between India and the US can be identified. These are presented in Table 1.

Table 1

Comparison of attributes in India and United States using Hofstede dimensions

Attribute	India	United States
Power Distance	High (77)	Low (40)
Uncertainty Avoidance	Low (40)	Low (46)
Individualism	Low (48)	High (91)
Masculinity	High (56)	High (62)
Long-term orientation	High (61)	Low (29)

The study suggests that power distance and uncertainty avoidance are the most significant cultural factors affecting the ICT adoption rates among countries. While these dimensions will not be tested in this thesis, it can be inferred that the US will have higher adoption rates than India. Next, the economic condition of India will be presented.

India's Economy

The World Bank Group (2015) reports that with 1.2 billion people and the world's fourth-largest economy, India's recent growth and development has been one of the most noteworthy stories. World Economic Outlook update by the International

Monetary Fund (2016) states that growth in emerging market and developing economies is projected to increase from 4 percent in 2015, the lowest since the 2008–09 financial crisis, to 4.3 and 4.7 percent in 2016 and 2017, respectively. India and the rest of emerging Asia are generally projected to continue growing at a robust pace. Table 2 depicts India's GDP from 2014 to 2017.

Table 2

India's GDP. Source: IMF, World Economic Outlook Update, January 2016

Year over year	Estimates (in %)		Projections (in %)	
India's	2014	2015	2016	2017
GDP	7.3	7.3	7.5	7.5

India has consolidated its position as the world's fourth largest economy, behind the United States, China and Japan, in Purchasing Power Parity (PPP) according to the World Development Indicators of the World Data Bank (2014). India also has the third largest GDP in the entire continent of Asia and is the second largest among emerging nations in terms of PPP. India is also one of the few markets in the world that offers high prospects for growth and earning potential in practically all areas of business. When the economic reforms were introduced in 1991, India chose to shift gears from a closed, license- driven economy to one, which embarked on globalization and economic liberalization (Drupa, 2007)

Developing countries mainly have small and medium enterprises (SMEs). SMEs are often referred to as the backbone of any country's economy. In India too, micro, small and medium enterprises (MSMEs) contribute significantly to the manufacturing output, employment and exports of the country (Singh, Narain, & Yadav, 2013). According to the 2013-2014 annual report of MSMEs released by

Government of India (2014), there were about 46,756 thousands MSMEs in 2012–13, employing 106,152,000 persons. The fixed investment in MSMEs accounts for production of Rupees 1,269,338 crores[3] and exports of Rupees 142,577 crores. Further, it was reported that for the year 2013–2014, the contribution of MSMEs in nation's GDP was 7.28%. It is estimated that in terms of value, Indian MSMEs accounts for about 45% of the manufacturing output and 40% of the total exports of the country.

In today's highly dynamic and rapidly changing environment, the manufacturing development has undergone a rapid change in the last two decades, more so in the last few years. The manufacturers are continuously trying to update themselves by acquiring or developing new technologies (Singh and Khamba, 2009). Information technology (IT) is believed to be the main driver of the economy ever since the country's industrial revolution. To respond quickly and effectively to the changing needs of the customer and to maintain a high level of competitiveness in the global arena (globalization), manufacturers are adopting advance manufacturing technologies such as product design, process, logistics/planning and information exchange to assist in compressing the development and manufacturing time to move products to the market more quickly and efficiently than competitors (Singh, Narain, & Yadav, 2013). This sets a favorable environment for new product adoption.

Although the Internet base is expanding and cable television is becoming increasingly accessible to people in India, a Morgan Stanley (2010) study of the Indian print media industry suggested that there is still growth due to relaxed

[3] Rupees 1 crore = Rupees 10 million. 1 USD = Rupees 53.19 in 2013.

governmental policy, allowing the expansion of foreign ownership holdings from zero to 26%. This has resulted in the launch of fresh newspaper editions in the country.

Having discussed the overall economy of India, the following section examines the printing industry in particular in this developing country.

India's Printing Industry

The printing industry in India is one of the largest and fastest growing sectors. A survey in 2008 showed that printing industry revenue growth has consistently outpaced national GDP growth (ISI Emerging Markets, 2007). The country has over 130,000 established printing presses (pieces of equipment) with a capital investment of over $1.82 billion (ISI Emerging Markets, 2007). According to one estimate, the printing industry in India provides direct employment to 700,00 people and indirect employment to over another 450,000.

Growth of the Indian Printing Industry

As per one of the Economic survey reports, the current annual turnover in Printing Industry has been to the tune of 50,000 crores in Indian rupees (Chander, 2012). The collective growth of Indian printing and packaging industries has a compound growth rate of over 13%. The Indian printing industry may reach 374 Billion in Indian rupees by the end of 2018. The graph for the years 2007-2018 is as shown in Figure 9.

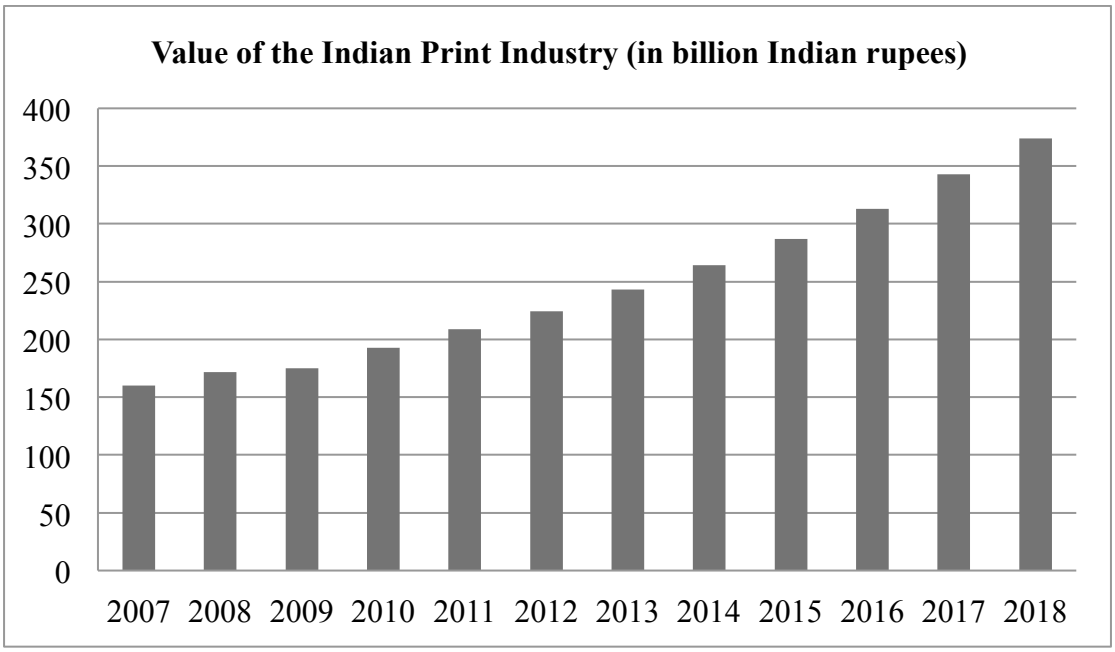

Figure 9. Value of Print Industry in India from 2007 to 2018 in Indian Billion Rupees (Chander, 2012)

To add, consider the data presented in Tables 3 and 4. Together with Figure 9, they show that even when global print market is in precipitous decline, developing nations such as India continue to show growth. Growth in the Indian print market can be attributed to the booming Indian economy, increased income of households, increased IT network connectivity and open government policies (ISI Emerging Markets, 2007).

Table 3

Global printing and printed packaging output by region, 2002-17, $ billion (Pira, 2012)

Region	$ bn 2002	$ bn 2007	$ bn 2012 estimated	% change, 2007-12	$ bn 2017 forecasted	% change, 2012-17
Western Europe	216.3	219.9	190.0	-13.6	176.8	-6.9
North America	269.5	277.0	238.1	-14.0	224.7	-5.6
Asia	210.8	265.8	301.5	13.4	356.9	18.4
Latin America	37.8	51.3	59.2	15.4	75.9	28.3
Eastern Europe	21.8	27.0	28.9	7.2	34.9	20.4
Middle East	13.7	15.7	17.1	8.7	21.3	25.1
Africa	8.3	7.9	7.5	-5.8	9.8	31.4
Australia	18.2	15.7	14.0	-10.7	13.6	-2.4
World	797.3	880.9	856.2	-2.8	913.4	6.7

Table 4

Leading national print and printed packaging markets, 2002-17, $ billion (Pira, 2012)

Rank	Country	$ bn 2002	$ bn 2007	$ bn 2012 estimated	% change, 2007-12	$ bn 2017 forecasted	% change 2012-17
1	US	243.3	248.1	213.0	-14.2	200.0	-6.1
2	Japan	121.3	132.8	122.8	-7.5	115.0	-6.4
3	China	38.3	69.8	110.2	58.0	160.2	45.4
4	Germany	46.2	44.8	40.2	-10.2	36.8	-8.3
5	UK	34.8	36.5	30.0	-17.7	28.9	-3.9
6	France	30.6	31.6	27.3	-13.6	25.4	-6.8
7	Italy	32.2	31.0	26.8	-13.5	24.9	-7.2
8	Canada	26.3	28.9	25.2	-13.0	24.7	-1.9
9	Brazil	17.3	20.6	23.3	13.2	30.0	29.1
10	India	11.6	16.6	21.2	27.8	28.3	33.4
11	Spain	17.6	19.6	16.9	-13.7	15.7	-6.8

ISI Emerging Markets (2007) identified the following primary growth drivers behind the print media industry in India:

- A booming Indian economy with a focus on increased job creation, resulting in significant rises in disposable income.
- Increased income and spending power of households due to the service sector expansion.
- Increased telecommunications and IT network connectivity in rural areas due to technological advancements.
- Open government policies and initiatives leading to convergence in the information and broadcasting space.

Moreover, according to a study by NPES entitled *World Wide Market for Print (2014)*, the size of the Indian print market will be US$29.3 billion in 2017 up from US$24.3billion in 2014. Print market growth in India has slowed since the global financial crisis, but the market is predicted to grow by NPES (2014) through 2017 at 6.8% annually. NPES reports that the two areas of the printing industry projected to grow the most in India are packaging printing and publishing printing. Package printing will grow more rapidly at 7.8% through 2017. The market size of the package-printing sector will increase from US$10.2 billion in 2014 to US$12.7 billion in 2017, and will make up 43% of total print product sales in 2017. The growth of package printing will be driven by increasing demand for non-commodity consumer goods in more developed countries in the Asia-Pacific region that are slowly shifting from producer countries to consumer countries. Publishing printing's market size will grow from US$3.9 billion in 2014 to US$4.5 billion in 2017. This

growth is due mainly because of increase in population, rising literacy rates, and a growing economy.

Despite these growth projections, commercial printing will still be the largest sector in India. This research will examine only the behavior commercial printers in India as related to the adoption of production digital printing technologies, as this sector currently offers the highest opportunities for production digital printing technologies. Pira (2015) reports that digital penetration in packaging is very low to date. Color cut-sheet machines are too small for many standard pack sizes, and the equipment is limited in stock thickness. Flexo is the most widely used process in packaging, followed by sheetfed litho and gravure. Digital remains tiny with just 1.3% of packaging value by 2020, which is only 0.3% of the volume (Smyth, 2015).

Commercial Printers

Commercial printers are chosen because digital print is growing in importance in commercial print with the value share, dominated by electrophotography, rising from 16.6% in 2010 to 38.0% by 2020 (Smyth, 2015). Pira (2015) states that the benefit of digital to the printer in commercial is seen from the processes enjoying 29.7% of the value, from 3.7% of the print volume in 2012. The high added value is a very useful part of the product mix, and is a major reason for so many commercial print suppliers investing in digital printers and presses.

Commercial print covers a very wide range of printed products, including business stationery and ID; business forms; greeting cards; postcards; menus; manuals; newsletters; games; leaflets; fine art reproductions; folders; wallets; maps; wrapping paper; gift tags; pharmaceutical leaflets; CD and DVD inserts; tapes;

stickers; calendars; timetables; event programs; and a myriad of other jobbing print products.

Commercial printers also provide various services necessary to prepare printed material. These services may include art, binding, composition, graphic design, layout, paste-up, plate making, press production, or trim and fold. This study will focus on commercial printers because it is the largest market segment and most likely includes the use of a mix of both conventional and production digital printing technologies. Romano (2013) suggests that by integrating wide-format inkjet technology into a company's current workflow, commercial printers can expand the scope of services offered, opening up new profit centers. As a result, more and more commercial printers are looking at adding wide-format to their offerings.

According to Romano (2013), not only is wide-format the fastest growing area in the printing industry today, it is one of the few applications not easily replaced by online and mobile technologies. Additionally, according to industry analyst firm InfoTrends, commercial printers are the first choice of more than 39 percent of buyers looking for wide-format graphics.

Conventionally for commercial printers, sheetfed has been extremely useful in producing short, medium and long runs due to its flexibility and high quality. Modern sheetfed presses can be extremely efficient and these are being used in new ways. Pira (2015) suggests there is a growing market for online companies to use large-format presses to gang many products together on a single sheet to amortize the setup costs. These use high levels of workflow automation and imposition to minimize waste, and to track the products from order to finishing and distribution.

Additionally, heatset web offset has been conventionally used to print a wide variety of leaflets, brochures and sundry commercial products, including report and accounts, manuals, guides, collateral, and event programs. In the commercial sector coldset is used to print business forms; some stationery; manuals; newsletters; wrapping paper; timetables; exam papers; and various other items, such as high-volume pharmaceutical leaflets and school exercise books.

Today, electrophotography is widely used in commercial print for many diverse, short-run and variable data applications (Smyth, 2015). Photobooks have grown significantly, with high-quality toner printing replacing much silver halide film imaging. Inkjet is growing in many commercial print markets. There are many photo-realistic specialists using inkjet with specialist kiosk print systems. These are used for photo applications in stores; leisure facilities, such as theme parks; and for tickets and boarding cards. Inkjet is used for art prints; catalogues; directories; business cards and short-run stationery; folders; leaflets; transfers; and tapes.

Conclusion

This chapter reviewed literature that tested adoption theories across a number of developing countries. Some research has suggested that it is more effective to combine models than using just one by itself to give a more complete understanding of factors affecting technology adoption. India's economy and the printing industry were also reviewed and show that the printing industry may be primed to adopt digital printing. With this, the goal of this thesis research is to study how the commercial printing industry in India behaves with respect to the adoption of production digital printing technologies and to understand the factors that predict it.

Chapter 4

Research Objectives

This chapter provides the objectives for the research study. Applying the theoretical framework presented in Chapter 2, these research questions will add to the current body of literature discussed in Chapter 3.

Research Questions

1. What is the current adoption ratio of production digital printing (PDP) technologies by commercial printers in India?
2. Are Indian commercial printers aware of benefits provided by production digital printing technologies? The benefits tested will include economical short-run printing, print on-demand, variable data printing, and electronic collation.
3. What are the main factors affecting the adoption of production digital printing technologies by Indian commercial printers and in what order of importance? The factors tested will include DOI factors such as relative advantage, compatibility, complexity, trialability and observability as well as the two attributes from TAM: PU and PEU.

Chapter 5

Methodology

To achieve the goals of the research study, a quantitative methodology was followed. This chapter will (1) explain the sample selection process, (2) describe the procedure used in designing the instrument and collecting the data, and (3) provide an explanation of the statistical procedures used to analyze the data.

Sample

A survey questionnaire was prepared for the sample selected from the population of print service providers in the commercial printing industry in India. The population target for this research included the CEOs of all the commercial printing companies in India. A sample from the population was selected from two lists. The first list of 417 commercial printers in India was received from a business professional, the owner of a sole proprietary business called Nippon Color. To further support the analysis, another list of 385 commercial printers was secured from NPES India.

Survey Instrument

As a method of data collection, surveys have several crucial potential advantages over less systematic approaches (Diamond, 2011). When properly designed, executed, and escribed, surveys economically present the characteristics of a large group of objects or respondents, and permit an assessment of the extent to

which the measured objects or respondents are likely to adequately represent a relevant group of objects, individuals, or social units.

Web surveys were created for convenience due to the geographic distance between the researcher and the sample population. The responders were able to complete the questionnaire online. This may have affected the response rate but it allowed the participant to respond as per their preference and availability of time. The questionnaire of the survey was sent via Survey Monkey's secured server to respondents. The survey instrumentation followed Dillman's (2000) Tailored Design Method as discussed in the next section.

Before sending out the surveys, they were first sent to the *Human Subjects Research Office, RIT* for their approval. Form A was completed and sent for IRB approval along with supporting documents including an abstract in every-day language, data collection tool – survey, an introduction letter, an informed consent document, a reminder letter and evidence of Human Subjects Protections Training. The study was conducted according to the IRB-approved protocol and complied with all IRB determinations at the time of consent. The IRB approval form can be seen in Appendix B.

Dillman's Tailored Design Method

Dillman's (2000) Tailored Design Method (TDM) was followed to maximize the quality of responses and the response rate. The TDM involves strategies to establish trust among potential, respondents, increase their perceived rewards for responding, and decrease their perceived costs for responding. Dillman (2000) suggests that as a stand-alone mode of data collection, web surveys are attractive

because of speed, low cost, and economies of scale. Responses can be gathered from large numbers of people in a very short amount of time.

Pilot Test

Before implementing the web survey, a pilot test was first conducted within the Thesis committee. Dillman, Smyth, & Christian (2009) suggest "pilot studies can be very useful for web surveys as they give the surveyor the opportunity to test the entire survey process from start to finish and to assess its success in a number of useful ways" (p. 343).

Web Survey Design

The web survey were designed in a way that there were multiple questions per page. Dillman et al. (2009) advise that having a page-by-page design allows responses to be submitted to the server and stored in the database after every page, since the respondents have to hit a button to navigate to the next page. Thus, surveyors received responses to each page answered as responders progressed through the survey, even if they chose not to complete the entire survey. Although this design may have made the survey look longer (Couper, Traugott, & Lamias, 2001), a progress bar was shown on the top of each page to keep the respondents informed. If respondents could track their progress in the survey, they were less likely to quit in the middle.

Web Survey Implementation

Web survey implementation included procedures for contacting sample members by e-mail, tracking who has responded, and monitoring survey's progress. Following the guidelines by Dillman et al. (2009) for web survey implementation, each respondent was sent a personalized introduction letter along with the survey to establish a connection that is necessary to invoke social exchange. The effectiveness of e-mail invitation personalization was tested in a sample of first-year university students in Belgium. Students were randomly assigned to receive a personalized or an impersonalized e-mail invitation to participate in a web survey. The personalized invitations resulted in nearly an 8-percentage point increase in response rates over the impersonalized invitations (Heerwegh, 2003).

Dillman (2000) suggests that the introduction must include an explanation of what action is being requested, why the action is requested, why the action is appropriate and useful, and how the respondent was selected. However, he cautions authors to avoid any biased explanations that may influence the respondent in any way. This letter can be reviewed in Appendix C.

Two days after the introduction letter, an invitation to the survey questionnaire was sent along with the informed consent. The participants of the survey were fully disclosed to the nature of the research via an informed consent that is the voluntary choice of an individual to participate in research based on an accurate understanding of its purposes, procedures, risks, benefits, alternatives, and any other factors that may affect a person's decision to participate. This can be reviewed in Appendix D.

Follow-up E-mails

The web survey implementation sequence generally starts with a survey invitation, which is then followed up with a number of reminder e-mails (Dillman et al., 2009). Two follow-up e-mails were sent to survey participants to increase the response rate. Cook, Heath, & Thompson (2000) reported that sending multiple contacts to potential web survey respondents is one of the most effective ways to increase response rates. In one study of college undergraduates, using four follow-up contacts resulted in a 37-percentage point increase in response rate over sending only a survey invitation and no follow-ups (Olsen, Call, & Wygant, 2005).

Participants were given adequate time to respond before reminders begin arriving, at the same time not allowing so much time to pass that the initial requests are forgotten. After the initial e-mail invite, the first e-mail reminder was sent in one week. A second reminder was sent after two weeks of sending the first reminder. These follow-up e-mails were short, engaging and to the point to avoid being pushy and irritating, as guided by Dillman et al. (2009). The e-mail reminders can be reviewed in Appendix E.

Survey Design

The survey questionnaire started with an introduction to the study and comprised of two parts. The first recorded the subject's demographic information. This helped the researcher to breakdown overall survey response data into meaningful groups of respondents. The second recorded the dependent variable of the adoption decision with a simple yes or no response. The responses to the subject's perception of production digital printing technologies with respect to the seven independent

variables from DOI and TAM were then be recorded using 5-point Likert scales. The levels of these scales have been adopted from a study by Vagias (2006). Care was taken to word the questions in a way that will not lead the respondent to a biased answer.

The dependent variable was measured by the simple question, "Do you currently use production digital printing (PDP) technologies?" Those that respond "yes" were categorized as the adopters. The surveys also included contingency questions. For example, "no" responders to the above were asked the question "Do you plan to adopt PDP technologies?" and if yes, "How soon do you plan to adopt?" These were categorized as intended adopters. Responders with "no" responses to "Do you plan to adopt PDP technologies?" were categorized as non-adopters.

The independent variables included Rogers' (1983) five attributes: relative advantage, cost of adoption, perceived complexity, observability and trialability as well as Davis' (1989) two key factors: perceived usefulness and perceived ease-of-use. Each of these factors were measured by using multiple 5-point Likert scales representing Strongly Disagree, Disagree, Neither Agree Nor Disagree, Agree, and Strongly Agree. For instance, intended adopters were asked to rate the importance of relative advantage by "Production digital printing technologies will provide you a competitive advantage in the industry" and "Production digital printing technologies will increase your profit margins." The options told us if the participant strongly agreed to the statement or strongly disagreed to show the respective factor's importance. This scale has been used consistently in prior research.

In addition to that, the responses included a "don't know or no opinion" choice. Dillman et al. (2009) report that "when respondents do not have an answer to

a question but are required to provide one anyway, they have two options: get frustrated and terminate the survey or lie and provide an answer that is not true for them" (p. 321). The first option increased the likelihood of nonresponse error in the data, while the second introduced measurement error. To avoid these errors, quasi-filter responses were utilized. Diamond (2011) states that a direct question (with no filters) obliges the responder to select one of the available options as a response even if the responder has no opinion or knowledge of it. Moreover, there is some evidence that full-filter questions discourage respondents who actually have opinions from offering them by conveying the implicit suggestion that respondents can avoid dif cult followup questions by saying that they have no opinion (Diamond, 2011).

In general, a survey that uses full-fillters provides a conservative estimate of the number of respondents holding an opinion, while a survey that no filters may overestimate the number of respondents with opinions, if some respondents offering opinions are guessing. The strategy of including a "no opinion" or "don't know" response as a quasi-filter avoids both of these extremes (Diamond, 2011).

Statistical Tests

The data collected from all the responses from commercial printers were used for the following statistical tests.

Non-response Bias

Non-response bias can be described as the result of people who respond to a survey being different from sampled individuals who did not respond. When

respondents differ from non-respondents, statistics (e.g.,, regression and path coefficients) based on responses alone often do not validly depict the population investigated and may result in predictions that are inaccurate, unreliable and misleading (Wagner & Kemmerling, 2010). Non-response bias can be assessed by the comparison of responses from early vs late respondents (assuming that late respondents are most similar to non-respondents because their replies required more prompting and took the longest time).

Thus, non-response bias was tested by comparing early participants with late participants in terms of responses to the key variables as well as the demographics of participants using T-test statistics at the five percent significance level ($p < 0.05$).

Reliability

Reliability and validity are two fundamental elements in the evaluation of a measurement instrument. Reliability is concerned with the ability of an instrument to measure consistently. It should be noted that the reliability of an instrument is closely associated with its validity. An instrument cannot be valid unless it is reliable.

Tests for reliability were conducted by calculating Cronbach's alpha. Alpha was developed by Lee Cronbach (1951) to provide a measure of the internal consistency of a test or scale; it is expressed as a number between 0 and 1. Internal consistency describes the extent to which all the items in a test measure the same concept or construct and hence it is connected to the inter-relatedness of items within the test. An item-total correlation test is performed to check if any item in the set of tests is inconsistent with the averaged behavior of the others, and thus can be discarded. The analysis is performed to purify the measure by eliminating

insignificant items prior to determining the factors that represent the construct (Churchill, 1979).

There are different reports about the acceptable values of alpha, ranging from 0.70 to 0.95 (Tavakol & Dennick, 2011). A low value of alpha could be due to a low number of questions, poor interrelatedness between items or heterogeneous constructs. For example if a low alpha is due to poor correlation between items then some should be revised or discarded. The easiest method to find them is to compute the correlation of each test item with the total score test; items with low correlations (approaching zero) are deleted. If alpha is too high it may suggest that some items are redundant as they are testing the same question but in a different guise. A maximum alpha value of 0.90 has been recommended (Streiner, 2003).

Validity

Validity is concerned with the extent to which an instrument measures what it is intended to measure. Face validity was obtained by running a pilot test of the survey instrument to the thesis committee.

To ensure content validity of the scales, the items chosen for the constructs were adapted from prior research on technology adoption (e.g., Tan & Teo, 2000; Grandon & Pearson, 2004; Laukkanen & Cruz, 2009. The measurement items are shown in Table 5 and are reflected in the draft of the questionnaire in Appendix A.

Table 5

Measurement items adopted from prior research

Independent Variable	Measurement Item
Relative Advantage	Reduce costs of business operations and increase profit margins (Grandon & Pearson, 2004); CEO's innovativeness and involvement (Al-Qirim, 2007); Increase ability to compete in industry (Grandon & Pearson, 2004); Internal staff is receptive to adoption of new technology.
Compatibility	With preferred work practices (Grandon & Pearson, 2004); With cultural values (Grandon & Pearson, 2004); With the technological infrastructure.
Complexity	Difficult to use and understand; Requires a lot of technical skills (Laukkanen & Cruz, 2009); Requires an advanced workforce.
Trialability	Want to use on a trial basis to see what it can do (Tan & Teo, 2000); Suppliers provide easy trials.
Observability	Buyer pressure (Al-Qirim, 2007); Support from technology vendors (Al-Qirim, 2007).
Perceived Ease-of-use	Using would be clear and understandable (Grandon & Pearson, 2004); Easy to become skillful at using it (Grandon & Pearson, 2004).
Perceived Usefulness	Would enable company to accomplish tasks quickly (Grandon & Pearson, 2004); Would improve productivity (Grandon & Pearson, 2004).

Moreover, discriminant validity offers statistical support that a theoretical distinction exists between the constructs of interest (Campbell, Parks, & Wells, 2015). Discriminant validity was achieved by calculating the average inter-tem correlation within and between the scales for each independent variable. For this, a correlation matrix will be generated while analyzing the collected data. A result less than 0.85 suggests the existence of discriminant validity between the two factors.

Multicollinearity

The term multicollinearity refers to the correlation among the independent variables. When the independent variables are highly correlated, it is not possible to determine the separate effect of any particular independent variable on the dependent variable (Anderson, Sweeney, Williams, Camm, & Cochran, 2012). Every attempt will be made to avoid including independent variables that are highly correlated. A correlation matrix generated during data analysis showed the variables that have a high correlation. Using the procedure of variable selection, the final model included only the most significant of the correlated variables, thus providing discriminant validity.

Descriptive Statistics

The data were first checked for outliers, which are observations that appear to deviate markedly from other observations in the sample. Identification of potential outliers is important because it may point out any bad data that has incorrectly been coded.

The level of significance (α) was chosen to be 0.05 for all the calculations and tests performed for this study. The level of significance is the probability of making a Type I error i.e. rejecting a true null hypothesis. This α of 0.05 is selected to be fairly confident and precise about all analyses, as it does not provide a large margin of error. The lower levels of α may result in a higher probability of Type II error (accepting a false null hypothesis), which could hamper the final model. Whereas higher values of α might result in a higher Type I error and any significant factors affecting the adoption decision may be missed, deteriorating the quality of the study. Thus, keeping

all the above points in mind the level of significance was chosen to be 0.05 resulting in a 95% confidence interval.

Initially, the means were observed to check for potential strong variables affecting the decision to adopt production digital printing technologies. To strengthen the analysis, logistic regression was run through the data.

Logistic Regression

The attributes found to affect the adoption decision were tested for significance using a logistic regression model, as suggested by the statistician Prof. Hank Mattice, RIT. This was due to the binary nature of the dependent variable; adoption of the technology can take only two discrete values, yes or no. Adopters fall under the "yes" category, whereas intended adopters and non-adopters fall under the "no" category.

Depending on the responses from adopters, logistic regression estimated the probability that the commercial printer will adopt the production digital printing technologies given a particular set of values for the chosen independent variables (Anderson et al., 2012). The logistic regression model can be considered as a special case of multiple regression model, where the dependent variable may only assume two discrete values. Multiple regression analysis is an extension of simple linear regression, used when the value of a variable is to be predicted based on the value of two or more other variables. The variable to be predicted is called the dependent variable. The variables being used to predict the value of the dependent variable are called the independent variables. The equation that describes how the dependent variable y, the decision to adopt production digital printing technologies, is related to

the independent variables $x_1, x_2 \ldots x_p$ and an error term is called the multiple regression model:

$$E(y) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p + \varepsilon$$

where: E(y) is the mean or expected value of y, and $\beta_0, \beta_1, \beta_2 \ldots \beta_p$ are the regression coefficients. For instance, if $\beta_1 = 0.5$, it indicates that *y* will increase by 0.5 units for every increase of 1 unit of x_1 and so on. ε is a random variable called the error term. Ordinal regression will allow the researcher to determine which of the independent variables (if any) have a statistically significant effect on the dependent variable, here the decision to adopt production digital printing technologies. It also predicts if one independent variable had a stronger effect on the dependent variable than the other.

However, in logistic regression the relationship between y and $x_1, x_2, \ldots, x_p$ is better described by the following nonlinear equation:

$$E(y) = \frac{e^{\beta 0 + \beta 1 x 1 + \beta 2 x 2 + \cdots + \beta p x p}}{1 + e^{\beta 0 + \beta 1 x 1 + \beta 2 x 2 + \cdots + \beta p x p}}$$

Testing for significance in logistic regression is similar to testing for significance in multiple regression. A *G* test was used to determine whether a significant relationship exists between the dependent variable and the set of all the independent variables. This is referred to as the test for overall significance. While the *G* test showed an overall significance, a *z* test was used to determine whether each of the individual independent variables was significant. A separate *z* test was conducted for each of the independent variables in the model. These *z* tests are referred to as tests for individual significance.

The output to logistic regression also presented the odds ratio for each independent variable. The odds ratio for an independent variable represented the change in the odds for a one-unit change in the independent variable holding all the other independent variables constant (Anderson et al., 2012). This helped the researcher understand which independent variable has a greater impact on the dependent variable helping us rank the factors based on the adopters.

Variable Selection – Backward Elimination

It is widely recognized that there are independent variables that do not affect the dependent variable. These variables need to be removed.

For this, a process of backward elimination was carried out where the analysis began with a model that included all the independent variables. It then attempted to delete one variable at a time by determining whether the least significant variable currently in the model can be removed. Once a variable was removed from the model it cannot re-enter at a subsequent step. This process was over when no more variables can be removed from the model, as it included only the statistically significant variables.

Regression Assumptions

Once the final model was obtained with the remaining significant independent variables, logistic regression was rerun to get the residual and normal probability plots to verify the regression assumptions.

Stoltzfus (2011) suggests that the verification of the following assumptions validates the regression model:

1. No significant variables are omitted and no extraneous variables are included – the model is correctly specified;
2. All responses are independent – if one's data include repeated measures or other correlated outcomes, errors will be similarly correlated;
3. There is a linear relationship between the logit of the independent and dependent variables. However, a linear relationship between the actual dependent and independent variables is not necessary;
4. The sample is 'large' – reliability of estimation declines when there are only a few cases;
5. There must be no outliers in data – outliers compromise the model's accuracy; and
6. There is little or no multicollinearity – a logistic regression model with highly correlated independent variables will usually result in large standard errors.

The next chapter discusses the results obtained from the survey data.

Chapter 6

Results

This chapter includes the demographic characteristics of the respondents and the results from statistical tests of the survey data. It also provides further interpretation of the data along with meaningful discussions of the results.

Response Rate and Non-Response Bias

A total of 132 out of 802 surveys were returned over a 4-week period, providing a response rate of 16.46%. According to Peduzzi, Concato, Kemper, Holford, and Feinstein (1996), responses-per-variable values of 10 or greater are desirable to help avoid bias in the regression coefficients. Given eight variables in this study, at least eighty responses were recommended. Thus, the 132 responses likely provide sufficient statistical power for the present analysis (Peduzzi et al., 1996).

Using a method suggested by Armstrong and Overton (1977), the possibility of non-response bias was evaluated by comparing responses between early and late respondents using T-test statistics at five percent significance level. Early respondents were those who had completed the questionnaire within the initial two weeks while late respondents were those who completed it in the final two weeks. Approximately 76% of the responses were from early respondents. The test showed no significant differences between early and later respondents on key variables as well as the demographic information (Armstrong & Overton, 1977).

Demographics of Sample

The demographic characteristics of the respondents are summarized in Appendix F. The majority (90.14%) have been in business for over 10 years as depicted in Figure 10.

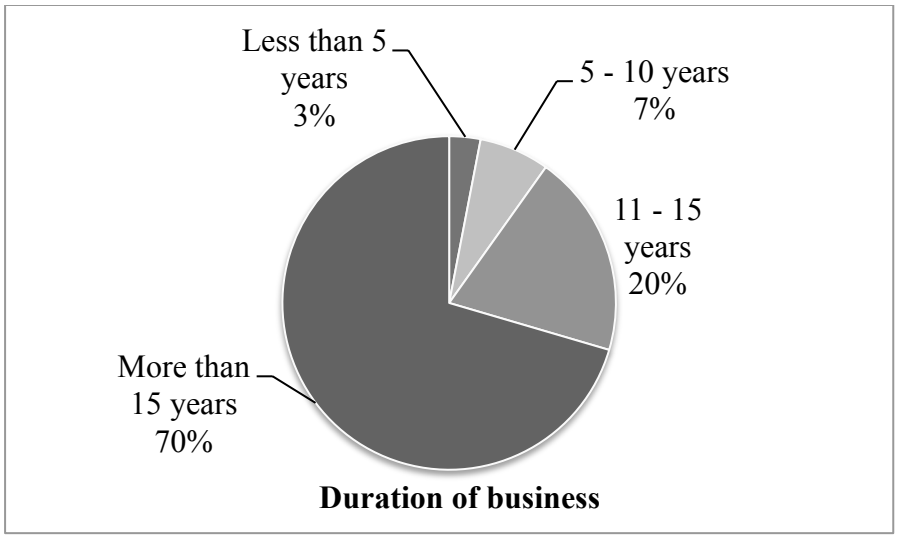

Figure 10. Duration of business (N = 132)

Moreover, it was observed that promotional and publishing were the two markets highly served by the printers surveyed. The markets served are portrayed in Figure 11.

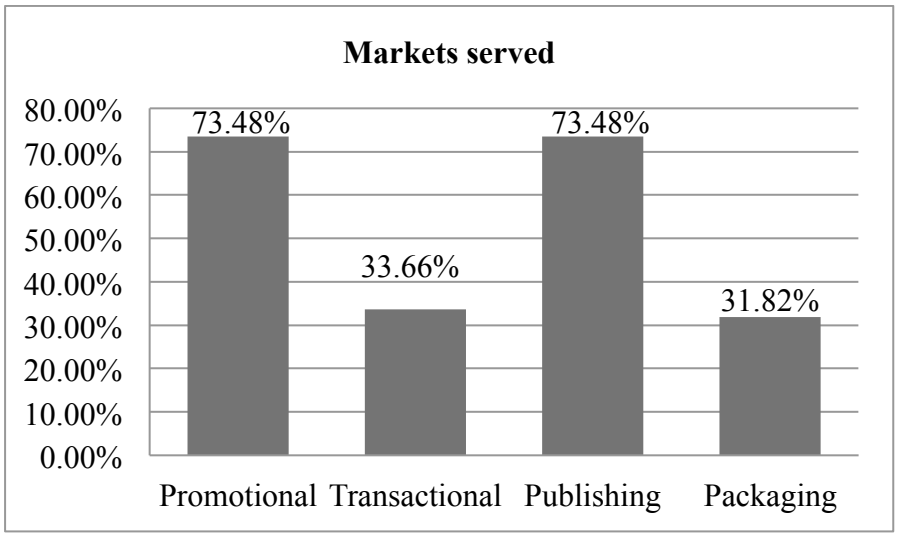

Figure 11. Markets served by the Indian commercial printers (N = 132)

The study also suggested that although print was the major revenue-earner for the commercial printers, finishing and pre-media played important roles for commercial printers in India. The respondents averaged nearly 14% revenue from pre-media, 62% from print, and 24% from finishing. The frequency distribution for revenue earned from print broken down into quartiles is depicted in Figure 12.

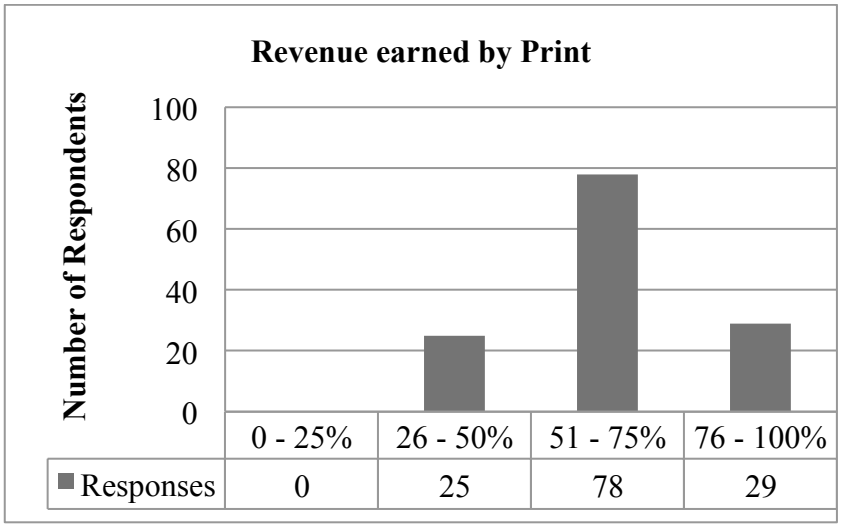

Figure 12. Frequency distribution for revenue earned from print (N = 132)

As seen, 81.06% of the commercial printers studied (107 out of 132 respondents) earned over 50% of their revenue providing printing services.

The next sections will present the results organized by research questions.

Research Question 1: What is the current adoption ratio of production digital printing (PDP) technologies by commercial printers in India?

Results indicated that nearly 61.36% of the commercial printers surveyed (81 out of 132) were currently using PDP technologies. Moreover, 66.67% of the non-adopters (34 out of 51) plan on adopting the technology in the next 36 months. The adoption of different PDP technologies can be seen in Figure 13.

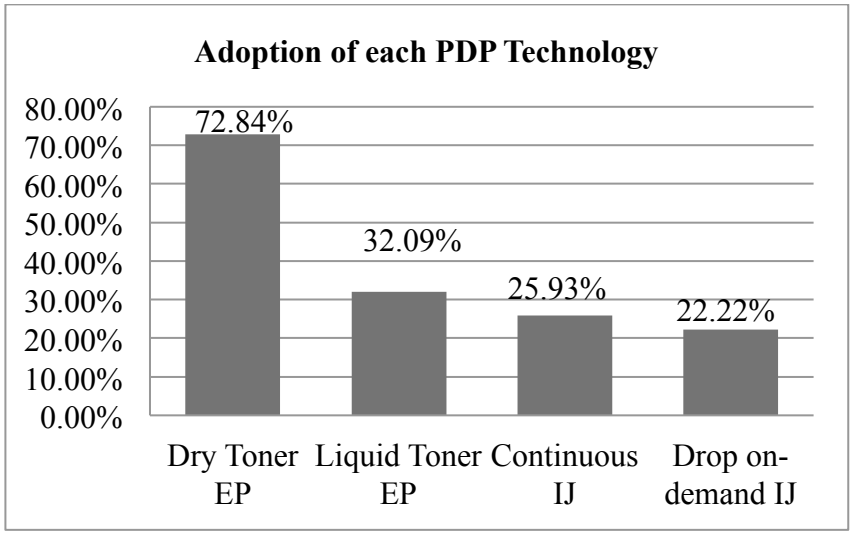

Figure 13. Adoption of each PDP technology (N = 81)

The study suggested that out of the four major PDP technologies, dry toner electrophotography (EP) was the most widely adopted with 72.84% of the printers using this particular technology. On the other hand, drop on-demand inkjet (IJ) with

22.22% had the lowest adoption. This could likely imply that as the inkjet technology for these markets is continuously being developed, it is still not completely ready.

Adopters of PDP technologies averaged about 35% of their production using PDP technologies. However, 18.52% of the printers studied produced more than 50% of their products using PDP technologies, while one respondent is a digital-only printer. Figure 14 shows the frequency distribution of adopters' production using PDP technologies.

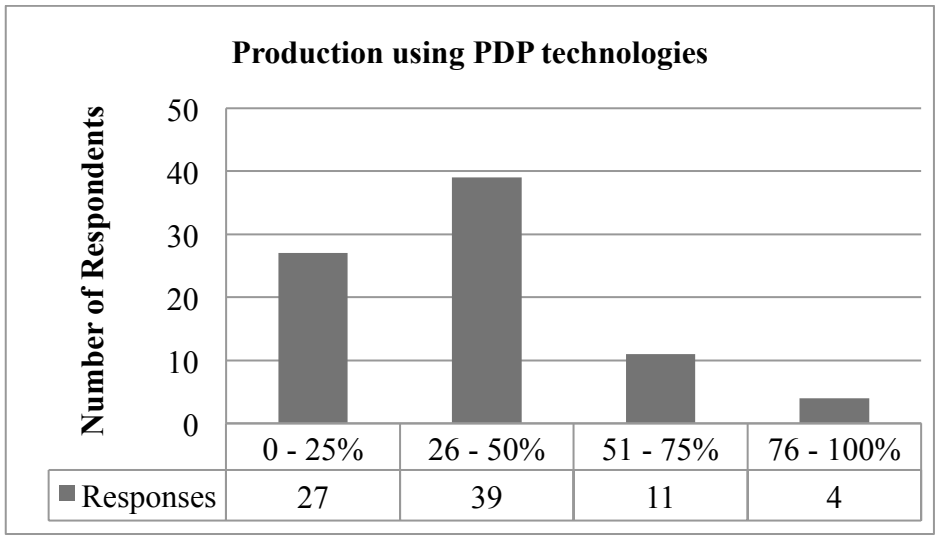

Figure 14. Production using PDP technologies by adopters (N = 81)

Research Question 2: Are Indian commercial printers aware of benefits provided by PDP technologies?

Figure 15 shows that about 93% of the printer respondents had moderate to extremely high awareness of the benefits of PDP technologies. There were no significant differences between adopters and non-adopters in terms of awareness of benefits of PDP technologies.

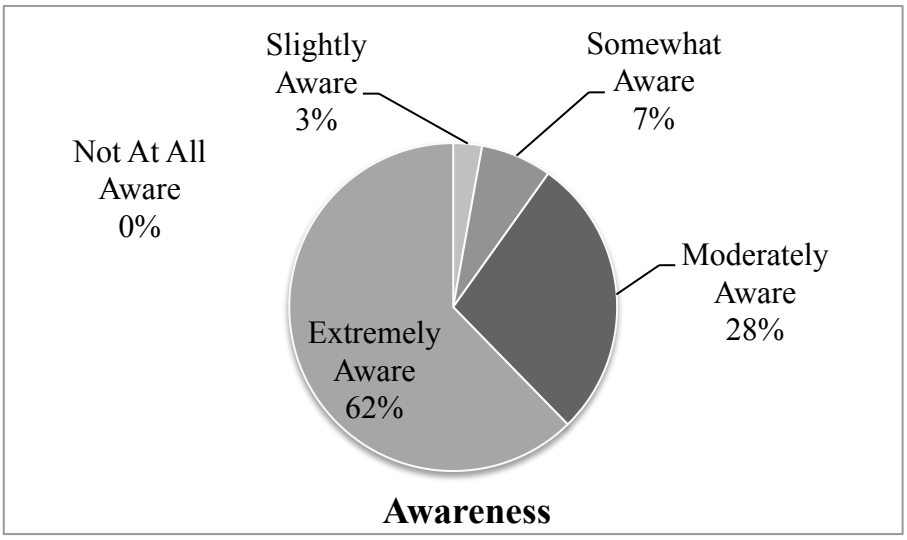

Figure 15. Awareness of the benefits of PDP technologies (N = 132)

Research Question 3: What are the main factors affecting the adoption of PDP technologies by Indian commercial printers and in what order of importance?

To answer this vital research question, the next sections analyze the survey data using various statistical tests to establish the relative importance of each factor affecting adoption. The approach involved combining DOI and TAM into a single model and first testing it for reliability and validity.

Reliability

The items in the study constructs were tested for reliability using Cronbach's Alpha analysis. The coefficients ranged between 0.742 and 0.889, which are all above the value of 0.70 and below 0.90 as recommended by Streiner (2011). This indicates that all measurement items used for the independent variables in this study are reliable. Cronbach's Alpha reliability coefficients are presented in Table 6.

Table 6

Cronbach's coefficient of reliability

Variable	Measurement Items	Cronbach's Alpha
Relative Advantage	Reduce costs of business operations and increase profit margins (Grandon & Pearson, 2004) CEO's innovativeness and involvement (Al-Qirim, 2007) Increase ability to compete in industry (Grandon & Pearson, 2004) Internal staff is receptive to adoption of new technology	0.889
Compatibility	With preferred work practices (Grandon & Pearson, 2004) With cultural values (Grandon & Pearson, 2004) With the technological infrastructure	0.805
Complexity	Difficult to use and understand Requires a lot of technical skills (Laukkanen & Cruz, 2009) Requires an advanced workforce	0.839
Trialability	Want to use on a trial basis to see what it can do (Tan & Teo, 2000) Suppliers provide easy trials	0.835
Observability	Buyer pressure (Al-Qirim, 2007) Support from technology vendors (Al-Qirim, 2007)	0.876
Perceived Ease-of-use	Using would be clear and understandable (Grandon & Pearson, 2004) Easy to become skillful at using it (Grandon & Pearson, 2004)	0.834
Perceived Usefulness	Would enable company to accomplish tasks quickly (Grandon & Pearson, 2004) Would improve productivity (Grandon & Pearson, 2004)	0.742

Validity

To ensure face validity, pilot tests of the survey instrument were sent to the thesis committee before sending out the surveys to potential respondents. In addition, using previously tested items for the independent variables supported content validity, as depicted in Table 6. Moreover, discriminant validity was achieved as the inter-term correlation within and between the scales for each independent variable had a correlation index lower than 0.85. The correlations between the scales for each independent variable were much lower, ranging from 0.001 to 0.292, as portrayed in in Table 7. Additional detail on the inter-term correlation within each independent variable is provided in Appendix G.

Table 7

Correlation matrix between independent variables

		1	2	3	4	5	6	7
1	Relative Advantage	-						
2	Compatibility	0.063	–					
3	Complexity	-0.130	-0.158	–				
4	Observability	-0.047	-0.008	0.111	–			
5	Trialability	0.292	0.208	-0.017	-0.058	–		
6	PEU	0.050	0.010	-0.290	0.017	0.062	–	
7	PU	-0.076	0.001	0.153	0.149	0.077	0.165	–

Descriptive Statistics

Descriptive statistics on the seven factors were conducted. The means (5-point scale) for each variable broken down by adopters and non-adopters are presented in Table 8. A *t*-test was used to test the difference between means. The results indicated that the means on all but one of the variables were statistically significant between the two groups.

Table 8.

Descriptive statistics grouped by adoption decision

Independent Variable	Mean		Standard Deviation		
	Non-adopters	Adopters	Non-adopters	Adopters	*t*-difference
Relative Advantage	3.529	4.102	0.482	0.504	6.534*
Compatibility	3.468	3.872	0.843	0.534	3.058*
Complexity	3.634	2.673	0.603	0.891	7.386*
Trialability	3.413	3.185	0.889	0.654	1.528
Observability	3.509	3.994	0.529	0.659	4.656*
PEU	3.452	3.839	0.579	0.702	3.44*
PU	3.952	3.765	0.435	0.694	1.903*

Note. Only the *t*-differences with an asterisk [*] are significant at 95% confidence.

The *t*-tests suggested that there exists a significant difference in the means of each independent variable between adopters and non-adopters except for trialability. This could imply that adopters perceived PDP technologies differently than non-adopters. To provide further analysis, logistic regression was used as the main statistical tool to test the model and check for significance of the unique effect of each independent variable on the dependent variable of adoption. An odds ratio was performed to rank the importance of these factors.

Logistic Regression

After verifying the regression assumptions, a binomial logistic regression was performed to ascertain the effects of relative advantage, compatibility, complexity, trialability, observability, perceived ease-of-use and perceived usefulness on the likelihood that respondents have adopted PDP technologies. There were four studentized residuals (outliers) with values of 3.621, 3.236, -3.065 and -2.735 standard deviations, which were retained in the analysis. The logistic regression

model was statistically significant, $\chi^2 = 91.869$, $p < 0.0001$. The model explained 67.6% (Nagelkerke R^2) of the variance in adoption and correctly classified 84.2% of cases. Sensitivity was 88.9%, specificity was 76.9%, positive predictive value was 85.71% and negative predictive value was 84.48%. Of the seven predictor variables, five were statistically significant: Relative advantage, compatibility, complexity, observability and perceived ease-of-use as shown in Table 9.

Table 9

Final regression model for adoption of PDP technologies

Variable	Estimate	*Z*-stat	*P*-value	Odds Ratio
Intercept	-15.211	-3.789	0.002	
Relative Advantage	2.458	4.212	<0.0001	11.686
Compatibility	1.010	2.097	0.036	2.747
Complexity	-1.576	-4.448	<0.0001	0.207
Observability	1.132	2.242	0.025	3.101
PEU	0.871	2.099	0.036	2.389

Dependent Variable: Adoption; $G = 90.825$; $\alpha = 0.05$.

A method of backward elimination was used as the variable selection process to present the final model. The tests suggested that relative advantage, compatibility, observability, and PEU positively affected the adoption decision, while complexity had a significant negative effect on the adoption. Trialability and PU were found to be insignificant.

The final regression equation for adopters is:

$$E(1) = \frac{e^{-15.21 + 2.45RA + 1.01CMP - 1.58CPL + 1.13OBS + 0.87PEU}}{1 + e^{-15.21 + 2.45RA + 1.01CMP - 1.58CPL + 1.13OBS + 0.87PEU}}$$

where RA, CMP, CPL, OBS, and PEU refer to the significant independent variables relative advantage, compatibility, complexity, observability, and perceived ease-of-use respectively. The final model is depicted in Figure 16.

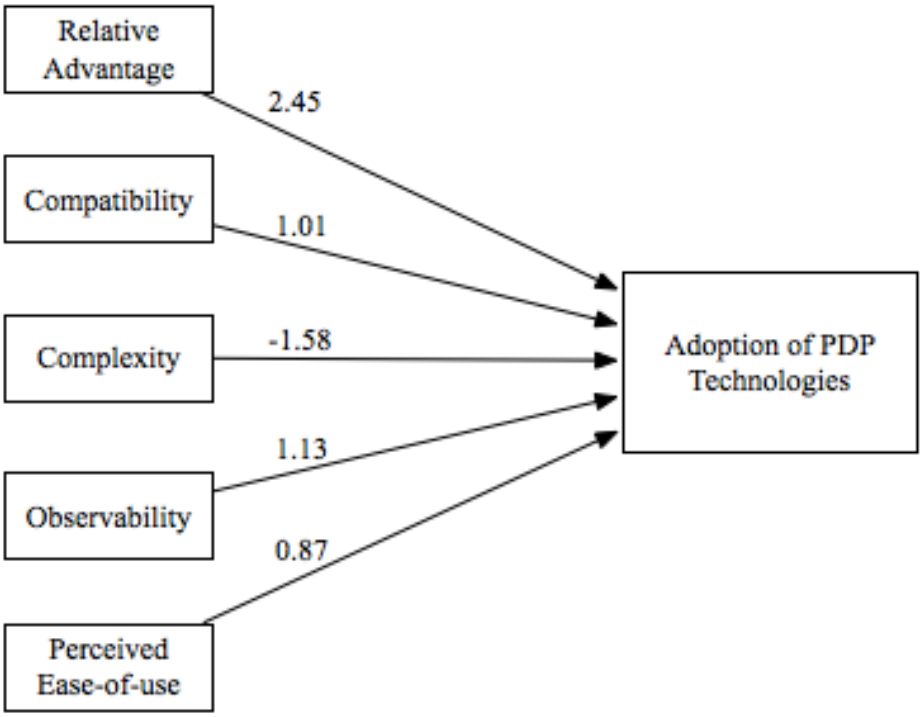

Figure 16. Final Model

The numbers seen in the figure are the estimates derived from Table 9. The negative sign on the estimate for complexity denotes its negative effect on the adoption of PDP technologies.

Odds Ratio

The odds ratios were used to compare the independent variables. The higher the odds ratio for an independent variable, the stronger is its comparative effect on the

dependent variable. This study suggested that relative advantage had the strongest effect on the adoption of PDP technologies for adopters. The rank of the factors affecting adoption for adopters in terms of their importance is presented in Table 10.

Table 10

Odds ratio

Rank	Variable	Odds Ratio
1	Relative Advantage	11.686
2	Complexity	4.831[4]
3	Observability	3.101
4	Compatibility	2.747
5	Perceived ease-of-use	2.389

Goodness-of-Fit Test

Goodness-of-fit (GOF) tests help decide whether a model is correctly specified. The Hosmer-Lemeshow test is a commonly used procedure for assessing goodness of fit in logistic regression (Paul, Pennell, & Lemeshow, 2013). It has, for example, been widely used for evaluation of risk-scoring models. The test produces a p-value – if it's low (below .05), model is rejected. If it's high, then the model passes the test. The p-value for the GOF test in this study is a high 0.7495, as shown in Table 11, implying that the model is a good fit, correctly specified and consistent with the data.

[4] The odds ratio for complexity was 0.207. Odds ratios lower than 1.0 indicate a decrease in odds for each unit increase in the variable. The odds ratios in these relationships are inverted (here, 1/0.207 = 4.831) to provide clarity for the reader for ranking in terms of importance.

Table 11

Hosmer-Lemeshow Goodness-of-Fit Test

Statistic	DF	Value	P-value
HL-GOF	8	5.075	0.7495

Discussion

The primary research objective of this thesis research was to determine the current adoption ratio of PDP technologies in India. The survey showed the growing importance of digital print with 61.36% of the sample reporting that they have adopted digital printing. This research complements the findings of the study by Drupa (2014), which suggests that 85% of all commercial printers worldwide have digital print; moreover, 31% of the printers that Drupa surveyed reported that 25% or more of their turnover is digital print.

In comparison, 38% of publishing printers and 57% of packaging printers surveyed in the Drupa (2014) study have no digital print capability relying on more conventional business models that demand more traditional print formats and longer print runs. This current thesis results are in line with 26.52% of publishing printers and 68.18% of packaging printers reporting no digital print capability. Digital print has yet to have a significant impact on primary packaging, with the exception of label production where its use is much more widespread.

The second research objective was to determine the factors affecting the adoption of PDP technologies by commercial printers in India. This research confirmed the use of DOI with TAM to study technology adoption, as both models provided significant variables in explaining the adoption of PDP technologies by

commercial printers in India. The two models combined together provided a holistic view of the factors' relationship with the adoption decision.

The results were consistent with most previous studies showing relative advantage, compatibility, observability, and PEU to have significant positive effects on adoption, while complexity negatively affecting adoption (e.g., Al-Gahtani, 2003; Grandon & Pearson, 2004, Wu & Wang, 2005, Lee, Hsieh & Hsu, 2011). It could be implied that commercial printers in India would likely adopt technology to gain competitive advantage in the market, provided the technology fits well into the business model and is easy to use. Conversely, commercial printers were less likely to adopt the technology if they perceived PDP technologies as difficult to understand and use, requiring an advanced workforce with vast technical skills. While relative advantage serves as a strong facilitator of adoption, complexity acts as a strong inhibitor of adoption as depicted in Figure 17. Print service providers must overcome the complex barriers to adoption if they want to have an edge in the fierce competition in the Indian print market.

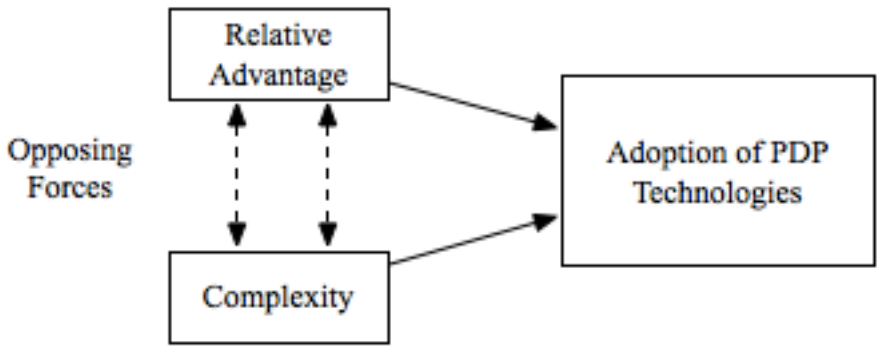

Figure 17. Opposing Forces

In addition, it is recognized that support from their suppliers and technology vendors, as well as pressure/demand from the buyers are additional significant factors that drive the adoption of PDP technologies.

Chapter 7

Summary and Conclusions

This chapter begins with a model-centric summary of the conclusions drawn from the results which is followed by an industry-centric summary with action plans specified for both the print service providers (PSP's) and the technology vendors. The chapter then turns towards implications for the Indian printing industry, and ends with the limitations of the study and an agenda for future research.

Model-Centric Summary

This section discusses the effect on adoption of each independent variable provided by DOI and TAM, with respect to the Indian printing industry.

Relative Advantage

Relative advantage was found to be the most significant determinant in predicting the adoption of production digital printing (PDP) technologies. The significance of this factor is similar to findings of previous studies (e.g., Al-Gahtani, 2003; Lee, Hsieh & Hsu, 2011, Al-Jabri & Sohail, 2012). These studies have shown that relative advantage of an innovation has a positive effect on adoption of a broad range of innovations. This implies that if print service providers perceived PDP technologies to give them a competitive edge in the industry, they will be more likely to adopt them.

In this study, competition seemed a logical driver in the adoption of PDP technologies. Nearly all respondents perceived that PDP technologies were a means of gaining a competitive edge in the market. The research by Drupa (2014) suggested very clearly that strong competition at 57% and lack of sales at 39% were the major constraints to growth for printers worldwide. Today, printers need new services to differentiate their businesses and remain competitive. The market space is increasingly fierce driven by the rise of retail consumerism, brand awareness and technologically enabled populations (Drupa, 2014). Printers need new options to differentiate their businesses, remain relevant to the changing marketing mix and at the same time find new and more profitable revenue streams.

For technology vendors, this could mean that as the trend of migration to short-run printing continues, vendors must offer print service providers a variety of products and services to help ease this process of adoption. For vendors to be successful, they must continuously develop PDP technologies to make them more compatible and easy to use for print service providers. As a supplier, their main task must be to provide clear responses and solutions to printers who want to invest in these technologies.

Compatibility

Compatibility was found to have a positive effect on adoption. This result is consistent with and supports prior research related to technology adoption (e.g., Al-Gahtani, 2003; Grandon & Pearson, 2004; Wu & Wang, 2005; Lee, Hsieh & Hsu, 2011, Al-Jabri & Sohail, 2012). It could be implied that respondents felt that PDP technologies fit well within their business models. When print service providers

perceive that using PDP technologies is completely compatible with their current ways of work practices and it fits well with their technological infrastructure, they will tend to adopt it.

For non-adopters, this study suggested that lack of a technological infrastructure was one of the major factors hindering commercial printers from adopting PDP technologies. One key point commercial printers should take from this study is to upgrade their technological infrastructure to have future disruptive technologies compatible to their business. This is because innovations are often not viewed singularly by individuals (Rogers, 1996). They may be perceived as an interrelated bundle of new ideas. The adoption of one new idea may trigger the adoption of several others. For commercial printers adopting PDP technologies, it is likely beneficial for them to also invest in value-added services such as web-to-print, management information systems, data asset management, content management, digital storefront, as well as cross-platform media deployment. Drupa (2014) suggested that a lack of added value services was impacting 22% of the commercial printers in the developing markets. This does not appear to be an issue in the developed regions especially in Australia/Oceania where only 5% of respondents thought it was a constraint to sales. However, just over one-third of printers in the Middle East, South and Central America, and Asia report that this is a major barrier to growth. This implies that vendors should not only sell the technology but also offer related value-added services in a package.

Complexity

Complexity was found to be the second-most significant determinant in predicting the adoption of PDP technologies. Its negative effect on adoption is in line with most of the previous research findings (e.g., Al-Gahtani, 2003), which suggests that print service providers perceive complexity as a major impediment to the adoption of PDP technologies. This suggests that printers who perceive PDP technologies as complex are less likely to adopt. This includes printers who perceive the technologies as difficult to understand and use and those who believe such technologies would require an advanced workforce with exceptional skills.

To achieve differentiation and competitive advantage as discussed earlier, having a skilled workforce is extremely important. In this thesis research, one of the reasons cited for inhibiting the adoption of PDP technologies was the perceived need of a more advanced workforce. This was consistent with the research done by Drupa (2014), which suggested that skills shortages and recruitment are holding companies back. With many print companies managing an aging staff and with the industry widely being perceived as in decline, recruiting the next generation of information technology savvy workers that can bring new energy and skills is likely to remain a significant challenge.

Furthermore, the print industry is in a global transition from offering stand-alone traditional print products to a range of complementary digital print and cross media services. The importance of skilled workers is recognized as critical for the development of printing businesses; a shortage of such workers hampers growth. The vendors and suppliers to the industry should give training and education a much higher priority.

Trialability

Trialability was not found to have a significant effect on adoption of PDP technologies in this thesis research. This result is consistent with Al-Jabri & Sohail (2012) in their study of technology adoption. One implication is that trialability is not required: if potential adopters believed that the technology be compatible to their business model, be easy to use and provide competitive advantage, they would adopt the technology without a trial.

Observability

Observability was found to have a positive effect on adoption and is consistent with previous studies (e.g., Al-Gahtani, 2003; Al-Jabri & Sohail, 2012). This could imply that commercial printers who observe other print service providers using PDP technologies and see the potential for their businesses will be more likely to adopt.

The findings of the present study suggested that suppliers to the Indian printing industry should market the positive business results of PDP technologies to commercial printers. Once the potential of these technologies is visible to commercial printers, they would be more likely to adopt the technology. However, Rogers (1996) suggests that adoption is not a snapshot or one-time decision, but rather a continuously staged process. Suppliers must continue to offer information to printers throughout the buying cycle.

While this study suggests that observability has a significant positive effect on adoption, vendors must use this information and opportunity to educate print service providers in India on the operations of PDP technologies to see their actual potential. Once a number of print service providers adopt the technology, the adopters will

themselves help with the diffusion of PDP technologies. Communication channels are an important element of diffusion of an innovation. Rogers (1996) defines communication as the process by which participants create and share information with one another in order to reach a mutual understanding. Diffusion is a particular type of communication in which the information that is exchanged is concerned with new ideas. The essence of the diffusion process is the information exchange by which one individual communicates a new idea to one or several others.

Mass media channels are often the most rapid and efficient means to inform an audience of potential adopters about the existence of an innovation and create awareness and knowledge. Technology vendors must take note of this and develop new sales channels highlighting product launches and upgrades. The research by Drupa (2014) suggested that these were the top priorities for suppliers along with direct product training. Trade shows remained an important channel. However, interpersonal channels are more effective in persuading an individual to adopt a new idea, especially if the interpersonal channel links two or more individuals who are near peers. Rogers (1996) suggests that the results of various diffusion investigations show that most individuals do not evaluate an innovation on the basis of scientific studies of its consequences. Instead, most people depend mainly upon a subjective evaluation of an innovation that is conveyed to them from other individuals like themselves who have previously adopted the innovation. This dependence on the communicated experience of near-peers suggests that the heart of the diffusion process is the modeling and imitation by potential adopters of their network partners who have adopted previously. Thus, vendors must maintain good relationships with the adopters of their technology by providing unparalleled after-sales service, and

must motivate adopters to communicate the benefits of the technology to potential adopters. This will potentially shorten the amount of time required for the innovation-decision after an individual is aware of a new idea.

Perceived Ease-of-Use

Perceived ease-of-use was found to have a positive effect on adoption. This supported existing research (e.g., Grandon & Pearson, 2004; Wu & Wang, 2005; Lee, Hsieh & Hsu, 2011). It could be implied that for commercial printers who find PDP technologies to be clear and understandable to use, as well as easy to become skillful at using, the probability of adoption is high. Therefore, this study suggests that well-designed trainings should be provided for the staff to familiarize them on the fundamental knowledge and use of PDP technologies. This will assist potential adopters in realizing that PDP technologies offer an easy alternative technology that may require only one operator due to the benefit of automation.

Perceived Usefulness

Perceived usefulness was found have no significant effect on adoption. This result is unexpected and contradictory to findings of several prior studies (e.g., Grandon & Pearson, 2004; Wu & Wang, 2005; Lee, Hsieh & Hsu, 2011). It can be inferred that since the majority of the commercial printers (adopters as well as non-adopters) equally perceived PDP technologies to be useful in improving productivity of the business, it only resulted in a marginal effect on the adoption decision. It could be implied that for commercial printers in India to adopt PDP technologies, the

technologies being useful is not alone sufficient, as there exist other more significant factors to be considered.

Industry-Centric Summary

This section presents the summary discussed above in an action-oriented format specified for print service providers as well as the technology vendors in the Indian printing industry. The determinants are presented in the ranked order provided by the odds ratio. Although trialability and PU were found to be statistically insignificant, they have been included in the table because in many instances they could be relevant to technology adoption.

For Print Service Providers

Table 12 suggests an action plan specified for PSP's on how to use the results provided by this research study and use the determinants to their benefit.

Table 12

Action plan for PSP's

Rank	Determinant	Implications	Recommendations
1	Relative Advantage	Gaining a competitive edge is the strongest determinant to adoption of PDP technologies	Invest in PDP technologies coupled with value-added services to create competitive differentiation
2	Complexity	Fear of PDP technologies being difficult to understand and use is a major impediment to adoption	Recruit experienced employees and train existing employees to ensure a more advanced workforce with specific skills aimed at PDP technologies
3	Observability	Observing other PSP's use and reap the benefits of PDP technologies increases the likeliness of adoption	Form peer groups with adopters to learn about PDP technologies and their benefits, ask technology vendors for support and demonstration of the use of PDP technologies
4	Compatibility	Adoption is more likely when current work practices and technological infrastructure are aligned with PDP technologies	Upgrade technological infrastructure to accommodate PDP and future disruptive technologies
5	PEU	Adoption of PDP technologies is more likely if perceived as easy to understand and use	Attend trade shows for exposure, and train workforce with fundamental knowledge about how to use PDP technologies
6	PU	Perceiving PDP technologies as useful is not alone sufficient, as there exist other more significant factors to be considered	Focus on diversifying to increase revenue, and quantify the value of PDP technologies with ROI analysis
7	Trialability	PSP's are reluctant to use the technology merely on a trial-basis to see its potential	Work with suppliers and peers to obtain working knowledge of PDP technologies with minimal risk

For Technology Vendors

Table 13 suggests an action plan specified for technology vendors on how to use the results provided by this research study and use the determinants to their benefit.

Table 13

Action plan for technology vendors

Rank	Determinant	Implications	Recommendations
1	Relative Advantage	Gaining a competitive edge is the strongest determinant to adoption of PDP technologies	Consider the entire value chain and offer a variety of services and products complimentary to PDP technologies to facilitate the process of adoption
2	Complexity	Fear of PDP technologies being difficult to understand and use is a major impediment to adoption	Give training and education a much higher priority to change the wider public perception of how print is transforming itself to remain relevant in the digital age
3	Observability	Observing other PSP's use and reap the benefits of PDP technologies increases the likeliness of adoption	Educate PSP's in India on the operations of PDP technologies, develop new sales channels, and establish peer user groups to encourage communication between various PSP's to help diffusion of PDP technologies
4	Compatibility	Adoption is more likely when current work practices and technological infrastructure are aligned with PDP technologies	Continue to develop products with PDP technologies to make them more compatible and easy to use for PSP's, and extend portfolio with partners and alliances to bridge the infrastructure gaps
5	PEU	Adoption of PDP technologies is likely if perceived as easy to understand and use	Provide well-designed training, case studies, and videos on the fundamental knowledge and use of PDP technologies
6	PU	Perceiving PDP technologies as useful is not alone sufficient, as there exist other more significant factors to be considered	Leverage early adopter experiences; e.g., case studies, plant tours, and testimonials to help portray usefulness of technology directly with PSP's
7	Trialability	PSP's are reluctant to use the technology merely on a trial-basis to see its potential	Provide alternative means for PSP's to experiment with PDP technologies to promote adoption

Implications for the Indian Printing Industry

First, the results of this thesis research suggested that lack of awareness of the benefits of PDP technologies was not an issue for the Indian commercial printers. Rogers (1996) suggested that the knowledge stage is the beginning of the innovation-decision process, where the individual is exposed to the innovation's existence and gains some understanding of how it functions. In this research, most commercial printers (93%) were found to be moderately or extremely aware of the benefits of PDP technologies.

Additionally, the commercial printers were found to be receptive to technology adoption with 61.36% of respondents reporting owning some PDP technologies. In addition, 66.67% of commercial printers who do not currently use the technology plan to adopt within the next 36 months. It could be suggested that the high adoption of PDP technologies is because Indian commercial printers have started to realize that the nature of print is changing from classic long runs to short-run personalized printing.

Given the challenging market conditions, it was important to ascertain priorities for both printers and suppliers that would likely affect the decision to adopt PDP technologies to raise profitability. Relative advantage and complexity were found to have the strongest effects on adoption of PDP technologies, with compatibility, observability, and perceived ease-of-use as other significant variables positively affecting the adoption decision. Ultimately, the study suggested that a priority must be given to education and training related to PDP technologies. Such training could help printers to realize the potential of the technology, and perceive it

as easier to use. In turn, this would enable printers to build a compatible business model and infrastructure allowing them to gain that competitive edge in the market.

The global printing industry has seen a dramatic shift from mass production of static print to an ever-increasing proportion of small runs of digital print and down further to individual runs of one. Digital communication has driven this shift to mass customization, supported by sophisticated data management and workflows. Variable data print (VDP) is the essential prerequisite for customization. A report by Drupa (2014) forecasts a slow decline in static print (0.5% per annum [pa] to 2017) contrasted with rapid growth of digital (electrophotographic at 1.5% pa and inkjet at 14% pa). This will double digital print's share of total print volume to 14% by 2017 in the US. The Indian printing industry is expected to follow similar trends. With the Indian economy on the rise, the printing industry is set to transform from a volume driven industry to a value driven industry with commercial printers being more services oriented, as depicted in Figure 18.

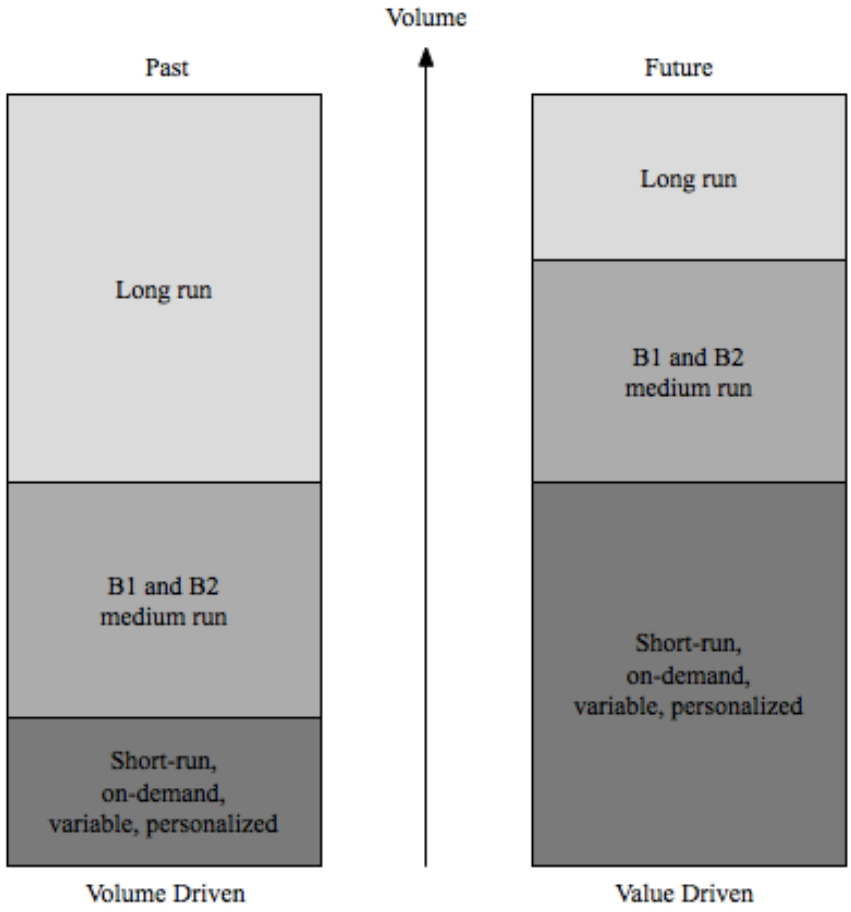

Figure 18. Nature of Print

This research also revealed that CEO's innovativeness and involvement – a construct used to measure relative advantage in this study – significantly affects the adoption decision. This suggests that personal innovativeness is a strong variable influencing the adoption. Personal innovativeness epitomizes the risk-taking propensity that is higher in certain individuals than in others. Research indicates that the success of a technology innovation implementation depends as much on individual differences as on the technology itself (Zmud 1979; Nelson, 1990; Harrison & Rainer, 1992). In general innovation diffusion research, it has long been recognized that highly innovative individuals are active information seekers of new

ideas. They are able to cope with high levels of uncertainty and develop more positive intentions toward acceptance (Rogers, 1996). Agarwal and Prasad (1998) defined personal innovativeness as the willingness of an individual to try new technology. They postulated that individuals with higher level of innovativeness with respect to technology are expected to develop more positive perceptions about the innovation in terms of advantage, ease-of-use, compatibility, and therefore will have higher intentions toward use of a new technology.

Overall, the results could help suppliers to the Indian printing industry understand commercial printers' perceptions of the strategic value of digital printing and its future. With India's growing economy and printing industry, it is an important country for analysis of PDP technologies development in business and emerging markets. The high level of adoption as well as intention to adopt PDP technologies suggested in this research imply that India is following the US with the trends of a shift toward shorter print runs (i.e. fewer than 1,000 copies) and tighter deadlines, which has resulted in commercial printers increasingly investing in new technology and equipment to remain competitive. This factor has also increased the amount of revenue generated from digital printing, which is a small but rapidly growing service offering for the industry.

Looking to the future, as digital media continues to grow, commercial printers may continue to diversify into outsourcing document processes. Moldvay (2012) suggests that this would involve delegating any task or process in the document life cycle, from creation through delivery. Printers are also diversifying into cross-media products such as multimedia layout and design. In short, successful commercial

printers will transform their businesses from manufacturing-focused to service-focused businesses.

Limitations

Despite careful attention to the research methodology, improvements can be made in future studies in the following areas. First, although the findings provided meaningful insights for the adoption of PDP in the commercial print sector in India, there may be a potential research bias in the sampling frame due to the selection of a sample of willing respondents. To compensate for this drawback, future researchers could utilize different frames using random sampling.

Furthermore, the study data were collected using web surveys. Care was taken on the length of survey to reduce the possibility of respondent fatigue. This limited the number of questions. Also, the responses were mainly closed ended. Thus, deeper information could not be gathered. Other methods of data collection such as interviews and case studies could be conducted to provide a more in-depth understanding of the results of the adoption decision.

Lastly, the insignificance of two factors, trialability and perceived usefulness, in the adoption of PDP technologies represented a challenge in this research. For example, it was expected that most Indian commercial printers who perceived PDP technologies to be useful would adopt the technologies with a very high probability. However, the factor appeared insignificant in this research. Moreover, it was expected that commercial printers would want to experiment with the innovation on a limited basis before adopting the innovation. However, trialability was also found to be an insignificant factor in the adoption of PDP technologies. This could be because some

innovations are more difficult to divide for trial than others (Rogers, 1996). Future studies can use this opportunity and undertake a qualitative to study the reasons of these issues more fully.

Future Work

This research lays a potential valuable foundation for future research. While this research evaluates the Indian printing industry with respect to PDP technologies, future research could use this study's approach to evaluate the printing industry in another developing nation.

Next, this study was cross-sectional and not longitudinal. Therefore, it was uncertain whether the adoption of PDP technologies was influenced by the individuals' expectations at that particular time. Venkatesh and Davis (2000) suggest that an individual's perceptions change over time when they gain more experience. Therefore, longitudinal research should be conducted to evaluate the validity of the proposed model and our findings.

A future researcher could also study cost as a factor affecting the adoption decision. Wu & Wang (2005) found cost to be a significant factor influencing technology adoption in their research. Although cost was found to be one of major concerns in the initial stage, it had less influence than other predictors because sometimes the benefits of a technology outweigh the factor of cost. However, it would be an interesting future work to study and compare the cost models of conventional and digital printing technologies.

Another idea is to compare the trends of conventional technologies with digital. Drupa (2014) suggested that despite the growing impact of digital print in the

US commercial market, it would be reassuring for most printers that overall revenue growth is not at the cost of conventional print production. Specifically, 57% of commercial printers surveyed in the study by Drupa (2014) reported that digital production had taken away either nothing or less than 10% of conventional print turnover. A new research study could assess the impact of digital printing technologies on conventional print in India.

Future work could also focus on the price of consumables such as paper, ink, and other input costs. Paper is one of the primary inputs required in the printing industry and directly affects the demand for printed material. The printing industry's input costs have increased in the five years from 2007 to 2012 due to higher prices for materials, including ink and paper (Moldvay, 2012). Additionally, the more extensive use of color and client demands for faster turnaround times have increased costs. Printing consumable costs are continually increasing, notably the price of paper and ink increased dramatically in both 2007 and 2008 (Moldvay, 2012). Although prices for material inputs eased somewhat in 2009, a modest increase from 2010 to 2012 could mitigate declining revenue as printing companies pass costs on to clients (Moldvay, 2012). Future work may study such trends in India and if these costs are significant factors in change in demand.

Moreover, while this research investigated only the adoption of PDP technologies, new research could study what other equipment Indian commercial printers are investing in. Drupa (2014) suggested for printing companies in every region and market sector, the number one investment priority in the next twelve months was print technology at 52%, followed by finishing equipment at 49% and

prepress/workflow/MIS at 41%. It would be interesting to examine how Indian commercial printers are using their revenues to keep up in the competitive market.

Conclusion

This study has added to the continued validation of the use of DOI and TAM in the printing industry context and provided a further understanding into the commercial printers' perceptions about the adoption of PDP technologies. While the merits of the DOI and TAM were manifested, the findings of this study provided greater insights into commercial printers' readiness and receptivity to the adoption PDP technologies. As indicated by the lack of multicollinearity in the constructs which comprise DOI and TAM, this study supports previous researchers who conclude that together these model offer an improved understanding of adoption decisions than one utilized alone.

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Appendices

Appendix A

Questionnaire

This appendix covers a draft of the questionnaire. The questionnaire is divided into two sections: (I) Demographics, and (II) Adoption of PDP.

I. Demographics

a. How long has your company been in the printing industry?

Less than 5 years	5 – 10 years	11– 15 years	More than 15 years

b. What markets do you serve? Select all that apply:

Promotional; includes advertising print such as posters, point of sale displays, direct mail, leaflets, fliers, catalogs, brochures, inserts, sundry promotional items, billboards, and outdoor signage.
Transactional; includes bills and invoices; reminders; national and local tax demands; statements; pay slips and employment documents; pension and healthcare programs; proposals and certificates (e.g., insurance); and sundry support, and fulfillment services.
Publishing; includes books, manuals, magazines, newspapers, and directories.
Labels & Packaging; includes labels for beer, water, and soda bottles; food cans; commercial consumer products, from household cleaners to shampoo; flexible cartons; and corrugated boxes.
Other (Please Specify):

c. Please indicate the percentages of contribution to your total revenue in the below categories to the best of your knowledge. The sum of the contributions should equal 100%.

Pre-media	Print	Finishing	Other

II. Adoption of Production Digital Printing Technologies

The following questions pertain to production digital printing technologies. For the purpose of this research, a definition developed by InfoTrends, a worldwide market research organization for the digital imaging industry is utilized:

Production digital printing devices output color production at greater than 70 pages per minute using inkjet or electrophotographic technologies. In addition, production digital printing technologies require a staffed operator, therefore small office/home office printers are excluded.

Contingency Logic:

Adopters: Participants responding yes to Q1 will be asked questions denoting the letter ‘a’ after the question number (e.g., 5a, 6a, 7a, etc.).

Intended adopters: Participants responding yes to Q2 will be asked questions denoting the letter ‘b’ after the question number (e.g., 5b, 6b, 7b, etc.).

Non-adopters: Participants responding no to Q2 will be asked questions denoting the letter ‘c’ after the question number (e.g., 5c, 6c, 7c, etc.).

1. Do you currently use production digital printing technologies?

Yes	No

If response to Q1 is yes:

a. In which year did you first adopt?

b. Please indicate the percentages of your print production in the below categories to the best of your knowledge. The sum of the contributions should equal 100%.

Digital	
Traditional	

c. What type of production digital printing technologies do you use? Select all that apply:

Dry Toner Electrophotography	Liquid Toner Electrophotography	Continuous Inkjet	Drop on-demand Inkjet
Other (Specify):			

If response to Q1 is no:

2. Do you plan to adopt production digital printing technologies in the next 36 months?

Yes	No

Awareness

The following questions pertain to your awareness level of the primary benefits of production digital printing technologies. Awareness is defined as having knowledge of and familiar with a fact or facts.

3. Indicate your level of **awareness** of the following statement: Production digital printing technologies are more cost effective in printing short runs than conventional methods.

Not At All Aware	Slightly Aware	Somewhat Aware	Moderately Aware	Extremely Aware

4. Indicate your level of **awareness** of the following statement: Production digital printing technologies can print "on-demand" and therefore avoid inventory storage costs.

Not At All Aware	Slightly Aware	Somewhat Aware	Moderately Aware	Extremely Aware

5. Indicate your level of **awareness** of the following statement: Production digital printing technologies have the ability to deliver electronic collation, which provides greater flexibility as full book blocks can be delivered in an automated, in-line process.

Not At All Aware	Slightly Aware	Somewhat Aware	Moderately Aware	Extremely Aware

6. Indicate your level of **awareness** of the following statement: Production digital printing technologies have the capability to produce variable data printing (personalization).

Not At All Aware	Slightly Aware	Somewhat Aware	Moderately Aware	Extremely Aware

Relative Advantage

The following questions pertain to your perception of production digital printing technologies in terms of its relative advantage. Relative advantage is the degree to which production digital printing technologies are perceived as being better than traditional printing technologies.

5a. Adoption of production digital printing technologies has provided your company a **competitive advantage** in the industry.

5b. Adoption of production digital printing technologies will likely provide your company a **competitive advantage** in the industry.

5c. Should you decide to adopt production digital printing technologies, they would likely provide your company a **competitive advantage** in the industry.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

6a. As a key **decision-maker** for your company**,** your position on the adoption of production digital printing technologies influenced the adoption decision.

6b. As a key **decision-maker** for your company**,** your position on the adoption of production digital printing technologies will likely influence the adoption decision.

6c. As a key **decision-maker** for your company**,** your position on the adoption of production digital printing technologies can influence the adoption decision.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

7a. Adoption of production digital printing technologies has reduced your indirect costs (labor) and increase **profit** margins.

7b. Adoption of production digital printing technologies will likely reduce your indirect costs (labor) and increase **profit** margins.

7c. Should you decide to adopt production digital printing technologies, they would likely reduce your indirect costs (labor) and increases **profit** margins.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

8a. Your production and **sales staff** were receptive to adoption of production digital printing technologies.

8b. Your production and **sales staff** are receptive to adoption of production digital printing technologies.

8c. Your production and **sales staff** are receptive to adoption of production digital printing technologies.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

Compatibility

The following questions pertain to your perception of production digital printing technologies in terms of compatibility. Compatibility is the degree to which production digital printing technologies are perceived as consistent with the existing socio-cultural values, beliefs, past experiences, and needs of potential adopters.

9a. You have adopted production digital printing technologies because they were **compatible** with your business model and sales process.

9b. You will likely adopt production digital printing technologies because they are **compatible** with your current business model and sales process.

9b. Production digital printing technologies are **compatible** with your current business model and sales process.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

10a. You have adopted production digital printing technologies because they were **compatible** with the cultural values of your company.

10b. You will likely adopt production digital printing technologies because they are **compatible** with the cultural values of your company.

10c. Production digital printing technologies would likely be **compatible** with the cultural values of your company.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

11a. Your technological **infrastructure** supported the use of production digital printing technologies.

11b. Your technological **infrastructure** will likely support the use of production digital printing technologies.

11c. Your technological **infrastructure** could support the use of production digital printing technologies.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

Complexity

The following questions pertain to your perception of production digital printing technologies in terms of its complexity. Complexity is the degree to which production digital printing technologies are perceived as relatively difficult to understand and use.

12a. **Complexity** was a major factor in delaying the adoption of production digital printing technologies.

12b. **Complexity** is a major factor delaying the adoption of production digital printing technologies.

12c. **Complexity** is a major factor affecting your adoption of production digital printing technologies.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

13a. Adoption of production digital printing technologies required you to hire a more advanced and technically diverse **workforce**.

13b. Adoption of production digital printing technologies will likely require you to hire a more advanced and technically diverse **workforce**.

13c. Adoption of production digital printing technologies requires hiring of a more advanced and technically diverse **workforce**.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

Trialability

The following questions pertain to your perception of production digital printing technologies in terms of its trialability. Trialability is the degree to which production digital printing technologies may be evaluated on a trial-basis under one's own conditions.

15a. The availability of ease-of-entry programs to facilitate no-risk **trials** of production digital printing technologies facilitated your decision to adopt.

15b. The availability of ease-of-entry programs to facilitate no-risk **trials** of production digital printing technologies will likely facilitate your decision to adopt.

15c. The availability of ease-of-entry programs to facilitate no-risk **trials** of production digital printing technologies would likely facilitate your decision to adopt, should you decide to do so.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

16a. Before adoption, your company would have liked to use production digital printing technologies on a **trial-basis** to evaluate its capability.

16b. Before adoption, your company would like to use production digital printing technologies on a **trial-basis** to evaluate its capability.

16c. Your company would like to use production digital printing technologies on a **trial-basis** to evaluate its capability.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

Observability

The following questions pertain to your perception of production digital printing technologies in terms of its observability. Observability is the degree to which the results of production digital printing technologies are visible (observed and communicated) to others.

17a. At the time of adoption, you had confidence in your **supplier's ability** to support you in terms of technology adoption.

17b. You have confidence in your **supplier's ability** to support you in terms of technology adoption.

17c. Should you decide to adopt production digital printing technologies, you have confidence in your **supplier's ability** to support you in terms of technology adoption.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

18a. **Pressure** from customers' changing needs (for example, short-run printing, personalization) facilitated your decision to adopt production digital printing technologies.

18b. **Pressure** from customers' changing needs (for example, short-run printing, personalization) is facilitating your decision to adopt production digital printing technologies.

18c. **Pressure** from customers' changing needs (e.g., short-run printing, personalization, etc.) would facilitate your decision to adopt production digital printing technologies, should you decide to do so.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

Perceived Ease-of-Use

The following questions pertain to your perception of production digital printing technologies in terms of its ease-of-use. Perceived Ease-of-Use is the degree to which you believe that using production digital printing technologies would require minimal effort.

19a. Production digital printing technologies were **easy to understand** by individuals in your company.

19b. Production digital printing technologies are likely **easy to understand** by individuals in your company.

19c. Should you decide to adopt production digital printing technologies, you anticipate that they would be **easy to understand** by individuals in your company.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

20a. Your company found it **easy** to become skillful at using production digital printing technologies.

20b. Your company will likely find it **easy** to become skillful at using production digital printing technologies.

20c. Should you decide to adopt production digital printing technologies, your company will likely find it **easy** to become skillful at using it.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

Perceived Usefulness

The following questions pertain to your perception of production digital printing technologies in terms of its usefulness. Perceived Usefulness is the degree to which you believe that using production digital printing technologies would enhance your company's performance.

21a. Production digital printing technologies enabled your company to **accomplish tasks** quickly.

21b. Production digital printing technologies will likely enable your company to **accomplish tasks** quickly.

21c. Should you decide to adopt production digital printing technologies, they will likely enable your company to **accomplish tasks** quickly.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

22a. Production digital printing technologies increased **productivity** for your company.

22b. Production digital printing technologies will likely increase **productivity** for your company.

22c. Should you decide to adopt production digital printing technologies, they will likely increase **productivity** for your company.

Strongly Disagree	Disagree	Neither Disagree, Nor Agree	Agree	Strongly Agree	Don't Know/ No Opinion

End of Survey

Thank you for your time and valuable responses. You will be sent an electronic copy of the final thesis research via e-mail when completed.

Appendix B

IRB Approval Form

R·I·T

Rochester Institute of Technology

RIT Institutional Review Board for the
Protection of Human Subjects in Research
141 Lomb Memorial Drive
Rochester, New York 14623-5604
Phone: 585-475-7673
Fax: 585-475-7990
Email: hmfsrs@rit.edu

Form C
IRB Decision Form

TO: Akshat Pardiwala

FROM: RIT Institutional Review Board

DATE: **March 30, 2016**

RE: Decision of the RIT Institutional Review Board

Project Title – Factors affecting the rate of adoption of digital printing technologies in the commercials print sector of the graphic communications industry in India

1. Addition of reminder email
2. Addition of introduction letter
3. Survey Changes

The Institutional Review Board (IRB) has taken the following action on your amendment named above.

☒ Exempt 46.101 (b) (2)

Now that your project is approved, you may proceed as you described in the Form A.

You are required to submit to the IRB any:

- **Proposed** modifications and wait for approval before implementing them,
- Unanticipated risks, and
- Actual injury to human subjects.

Heather Foti, MPH
Associate Director
Office of Human Subjects Research

Revised 10-18-06

Appendix C

Introduction Letter

Respected [First Name] [Last Name],

You are invited to participate in a research study conducted by Akshat Pardiwala at Rochester Institute of Technology, because you are a well-respected commercial printer serving a critical market in the Indian printing industry.

The purpose of this research is to determine the key factors affecting the adoption of production digital printing technologies of commercial printers in India. Your participation involves filling an online survey that will take approximately 15 minutes.

Your responses will provide rich information necessary to represent the perspective of Indian commercial printers. This study will evaluate print service providers' receptivity and readiness to incorporate new technologies in their companies, while gaining a better understanding of the Indian print market (technological adoption trends, barriers to adoption). This research will also help suppliers to better serve the Indian print market.

You will be receiving another email in two days with the link to take the survey. Your time and assistance in providing input is highly appreciated.

Appendix D

Informed Consent

This appendix covers the informed consent that will be provided to each participant taking the survey.

Welcome to the Survey

You have been selected to participate in this research because you are a well-respected commercial printer in the Indian printing industry. Your feedback is an important part of this research conducted by Akshat Pardiwala, a graduate student at Rochester Institute of Technology. Your input involves completing an online survey that will take approximately 15 minutes. The results of this study will be used for scholarly purposes only. In consideration for your efforts to complete this survey, you will receive an electronic version of the final thesis research [PDF].

Thank you in advance for your participation.

About the Research

Purpose

- To determine the factors affecting the adoption of production digital printing technologies by commercial printers in India, and
- Rank the importance of factors affecting technology adoption decision.

Benefits

- Evaluate print service providers' receptivity and readiness to incorporate new technologies in their companies,

- Gain a better understanding of the Indian print market (technological adoption trends, barriers to adoption),
- Help suppliers to better serve the market, and
- Provide commercial printers with better insight into technology adoption.

About the Questionnaire

- This survey is designed to be completed by the CEO or other key decision-maker in your company.
- Your participation in this survey questionnaire is voluntary.
- This survey will provide anonymity. No responses will be linked to you.
- Your responses will be confidential. Your name, email address or IP address will not be used.

For any questions about this research, please contact Akshat Pardiwala at ajp1331@rit.edu. This research has been reviewed according to Rochester Institute of Technology research procedures for the protection of human subjects.

Electronic Consent

Clicking on the "next" button below indicates that:

- **You have read the above information**
- **You voluntarily agree to participate**
- **You are at least 18 years of age.**

If you do not wish to participate in the research study, please do not continue with the survey.

Appendix E

E-mail Reminder

Respected [First Name] [Last Name],

You were recently contacted as a well-respected Indian commercial printer by Akshat Pardiwala at Rochester Institute of Technology to request your participation in an online survey regarding the adoption of production digital printing technologies.

If you have not yet completed the survey, we would like to extend a reminder to you that you are still able to do so. All participants will be provided with the electronic version of the final thesis research [PDF], which will provide commercial printers with significant insights into adoption of production digital printing technologies.

To participate in the online survey, simply click on the "Begin Survey" link below. If you previously began the survey but have not yet completed it, you may simply click on the above link and be taken to the point in the survey at which you left off. Your time and assistance in providing input is highly appreciated.

Appendix F

Demographic Characteristics

This appendix covers the demographic characteristics of respondents in Table F1.

Table F1

Demographic characteristics of respondents

Variable		N	%
Time since company has been in the printing industry	Less than 5 years	4	3.03%
	5 – 10 years	9	6.82%
	11 – 15 years	26	19.69%
	More than 15 years	93	70.45%
Markets served	Promotional	97	73.48%
	Transactional	34	33.66%
	Publishing	97	73.48%
	Packaging	42	31.82%
Average revenue per category	Pre-media		14%
	Print		62%
	Finishing		24%
Currently using PDP technologies	Yes	81	61.36%
	No	51	38.64%
Adopters' average print production	Digital		35%
	Traditional		65%
Type of PDP technologies used by adopters	Dry Toner EP	59	72.84%
	Liquid Toner EP	26	32.09%
	Continuous IJ	21	25.93%
	Drop on-demand IJ	18	22.22%
Plan to adopt in the next 36 months	Yes	34	66.67%
	No	17	33.33%

Appendix G

Correlation within Variables

This appendix tabulates the correlation within each factor.

Table G1

Correlation matrix within relative advantage constructs

	Relative Advantage	1	2	3	4
1	Competitive Advantage	–			
2	CEO's influence	0.611	–		
3	Reduce costs and increase profits	0.734	0.705	–	
4	Sales staff receptive	0.643	0.668	0.676	–

Table G2

Correlation matrix within compatibility constructs

	Compatibility	1	2	3
1	With business model	–		
2	With cultural values	0.618	–	
3	Supporting technological infrastructure	0.474	0.652	–

Table G3

Correlation matrix within complexity constructs

	Complexity	1	2
1	Difficult to use and understand	–	
2	Requires an advanced workforce	0.729	–

Table G4

Correlation matrix within trialability constructs

	Trialability	1	2
1	Availability of trials	–	
2	Trials to test potential	0.792	–

Table G5

Correlation matrix within observability constructs

	Observability	1	2
1	Support from suppliers	–	
2	Customer pressure	0.721	–

Table G6

Correlation matrix within PEU constructs

	PEU	1	2
1	Easy to understand	–	
2	Easy to become skillful at	0.728	–

Table G7

Correlation matrix within PU constructs

	PU	1	2
1	Accomplish task quickly	–	
2	Increase productivity	0.594	–

Vita

Vita

Akshat Pardiwala is a graduate student in the Print Media program at Rochester Institute of Technology. Born in Mumbai, India on May 19, 1993, he has a Bachelors of Engineering degree in Electronics and Telecommunications from the University of Mumbai. While his family's supply and services company, Nippon Color, serves the Indian printing industry, his personal interests in digital printing and entrepreneurship motivate him towards expanding the family business. He picked RIT to avail the opportunity of learning the fundamentals of the graphic communications industry, understanding the printing technologies, and at the same time acquiring knowledge on business and management through the electives. His career goal is to promote production digital printing technologies in India to create new business opportunities which current print service providers may be missing out on. With this thesis and Akshat's published book entitled *The New Print Industry: Trends and Opportunities*, he aspires to achieve his goal of attaining a high level of adoption of production digital printing technologies. You can reach him at akshat@nipponcolor.com

Find out more about Akshat at www.akshatpardiwala.com