

Identification of Trends in Papers for Digital Printing

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ABSTRACT

A survey of digital print providers in the U.S was conducted to identify constraints and potential solutions for improved performance and quality of digitally printed papers. In printers' decisions about which paper to purchase, the key factors were identified as runnability and print quality. The leading paper characteristics considered when making a purchase were found to be toner/ink adhesion, accurate sheet dimensions, dimensional stability, and moisture level. Performance- and runnability-related factors were found to be more important than appearance-related factors. Overall, the price of papers charged by manufacturers to print producers was not a leading factor in the paper selection process; in particular, a company (printer) that makes the paper purchase decision together with the customer (print purchaser) is less likely to put high emphasis on price. Digital print providers are most interested in an extended product range, with more sizes, finishes, and basis weights available for their digital presses.

INTRODUCTION

A survey of U.S. print providers currently using production electrophotographic digital printing technology was conducted to assess the relative importance of the different properties of digital papers. The survey explored the reasons why certain grades are selected by print providers, and assessed gaps in currently-available digital grades. This study is directed towards the production segment of electrophotographic digital printing, and does not include the SOHO (small office and home office) and graphic arts inkjet markets. A full analysis of the survey results is published in a Printing Industry Center Report [1].

The Market for Digital Paper

Mirroring the growth of digital presses is the development of papers manufactured specifically to meet digital press requirements. Paper for digital presses is now the fastest growing category in paper manufacturing [2, 3]. In response to these market dynamics, paper manufacturers have launched new digital paper lines and expanded existing lines. Both printers and print specifiers are increasingly demanding a wider and more diverse selection of papers qualified for digital presses and an expansion of other media for use with these technologies (for example, self-adhesive labels, envelopes, identity cards, synthetic substrates, etc.).

In order to produce high quality images and good on-press runnability, electrophotographic papers require good dimensional stability and surface smoothness, small, evenly distributed additives and fillers, more tightly controlled and uniform moisture levels, controlled conductivity levels, and uniform charging characteristics for toner transfer efficiency. The chemical composition, spatial distribution of components, and thickness uniformity of paper are therefore more critical than in traditional printing papers. Thus, the design and production of high quality digital papers requires significant expertise. In addition to these technical factors, to fully exploit the fast turnaround capabilities of Print on Demand, printers may need to carry a significant inventory of papers. This poses challenges in an environment in which space and cash flow are at a premium. Where several print technologies are functioning within one print operation, a universal paper has significant economic advantages. In general, however, robust runnability and image quality require papers designed specifically for electrophotographic applications [4].

RESEARCH METHODOLOGY

A telephone survey of digital print providers in 2005 elicited 103 responses from print companies in the U.S. and Canada based on the Rochester Institute of Technology database. Following an exploration of company demographics, questions were asked to understand how and why different papers are selected for digital printing jobs. The following categories were explored:

- Paper grades commonly used for digital printing jobs
- Number of brands used and companies' relationships with suppliers
- Factors which affect brand decisions
- Relative importance of different paper properties and characteristics
- Paper characteristics needing improvement
- Limitations imposed by digital press design, and
- Paper cost changes in recent years

RESULTS

Respondent Company Demographics

The 103 respondent print companies have been in business from 3 to 197 years, with a median of 28 years; more than 30% have been in business for over 50 years. More than 50% of companies had fewer than 20 employees in 2004, with only 14% above 100. The median annual revenue for 2004 was approximately \$1M, with 68% below \$3M. This confirms the predominance of small- and medium-sized enterprises in the printing industry [5]. By the end of 2004, 28% of respondents owned one digital press, 19% had two presses and 16% had three presses. Only 20% own only digital printing technology; 72 have sheetfed offset presses, 14 have web offset presses, 13 have inkjet equipment, and 3 have flexographic presses.

Digital Printing Applications

Respondents identified the types of jobs produced with digital printing; the leading categories ranked as a "major portion" of the business were Marketing and Promotional Materials, Quick Printing Applications, and Direct Mail. When asked to indicate only one predominant job type, the leading application is again Marketing and Promotional Materials (24%), followed by Direct Mail (21%), Manuals and Documents (19%), and Quick Printing Applications (14%) (Figure 1). The outlook for Manuals and Documents, and Quick Printing Applications is diminishing, which may be due to the growing proportion of competing electronic document forms.

Paper Grades for Digital Printing Applications

Paper grade categories that respondents used for digital printing and their frequency of use were explored using grade descriptions designed to avoid resemblance to brand names or product ranges. Coated gloss is the leading grade, followed by premium uncoated, uncoated calendered, coated matte, uncoated uncalendered, and premium bond [Figure 2]. When printers were asked to select only one grade they used most often, the leader was coated gloss (32%), followed by premium bond (15%), and uncoated uncalendered (12%). The combination of gloss grades (coated and coated high-gloss) accounted for about 38% of grades used most frequently and ranked as very or somewhat frequently used by 82% and 59% respectively. This heavy usage of coated gloss correlated with the Marketing and Promotional Materials as the most important application. Most of the digital presses used by respondents in this survey are sheetfed. Eighty-five percent of survey respondents do not use webfed media at all, and 5% use webfed media only.

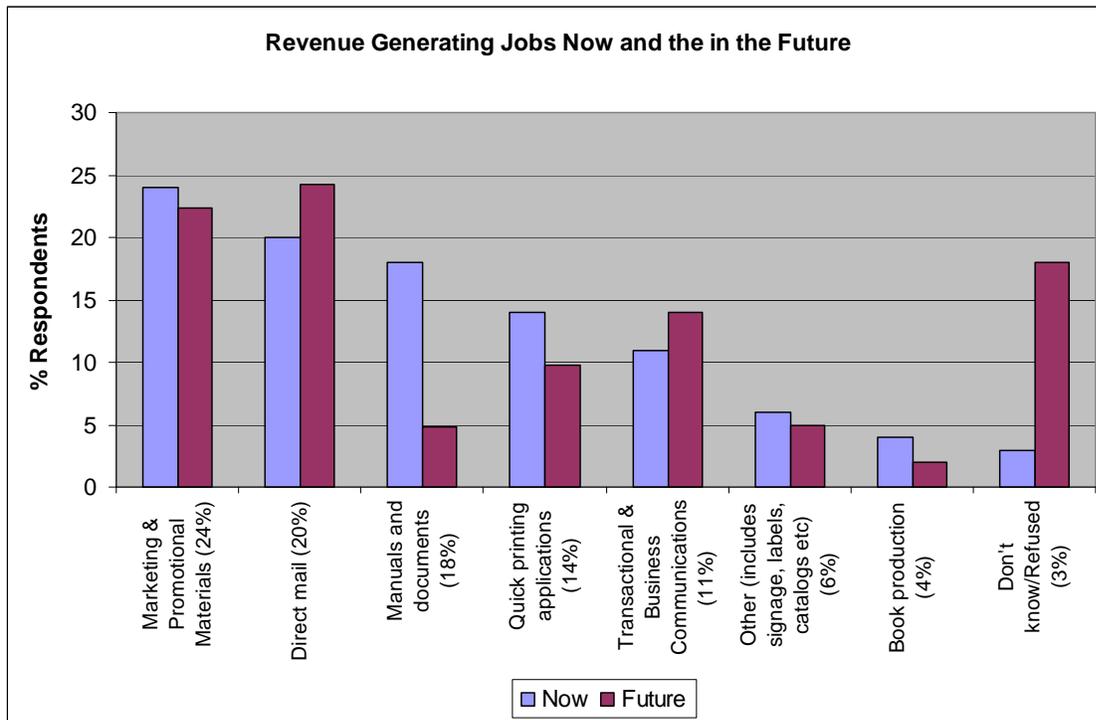


Figure 1 Predicted revenue generating jobs now and in the future.

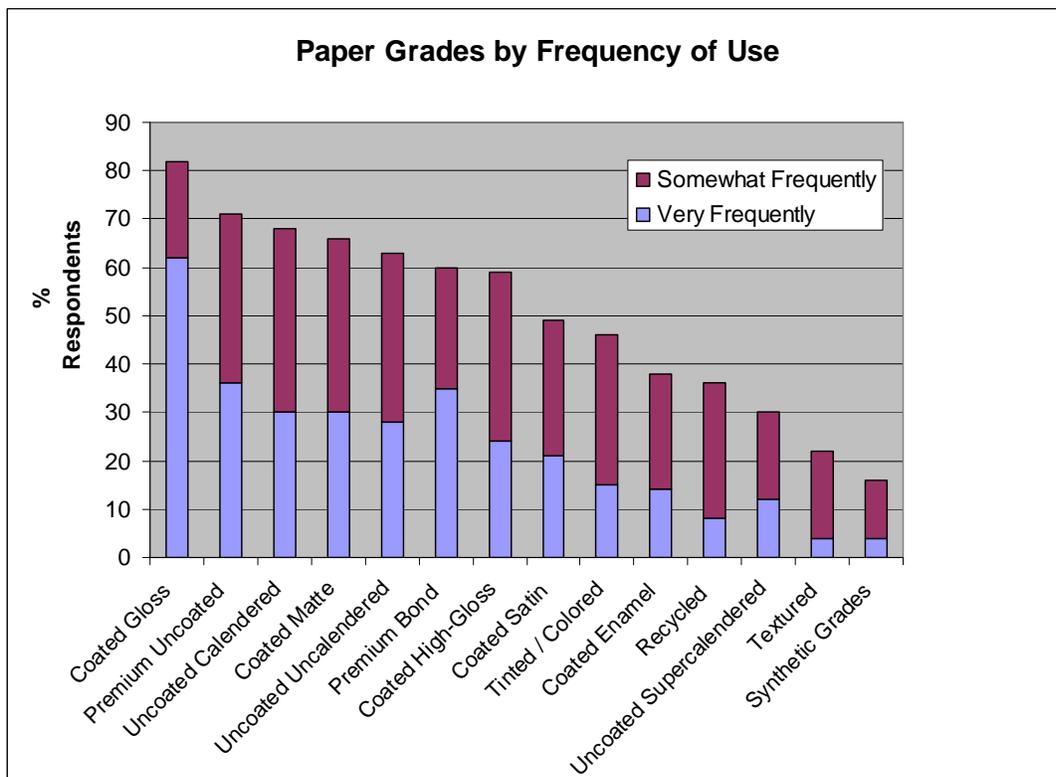


Figure 2 Frequency of use of paper grades for digital printing

The Paper Selection Decision

A degree of brand loyalty was evident, with the median number of brands at 5. 28% of respondents are limited to one brand of paper. Respondents were asked to rank factors relating to the paper purchase decision on an importance scale. “Runnability” was used in the context of no misfeeds or web breaks during a press run; “appearance characteristics” included brightness, whiteness, finish type, etc.; “product range” included weight, size, finish, etc; “availability of grade” referred to acceptable turnaround on ordering; and “multipurpose application across different printing technologies” refers to papers qualified for electrophotography as well as offset lithography or other technologies.

Runnability and print quality were ranked as having the most importance and were statistically equivalent (Figure 3). Price was found not to be a leading factor in the purchase decision for these digital grades in this survey. The difference between brands on the basis of these factors was investigated; about one third of respondents indicated that various brands showed major differences in runnability, availability, and print quality.

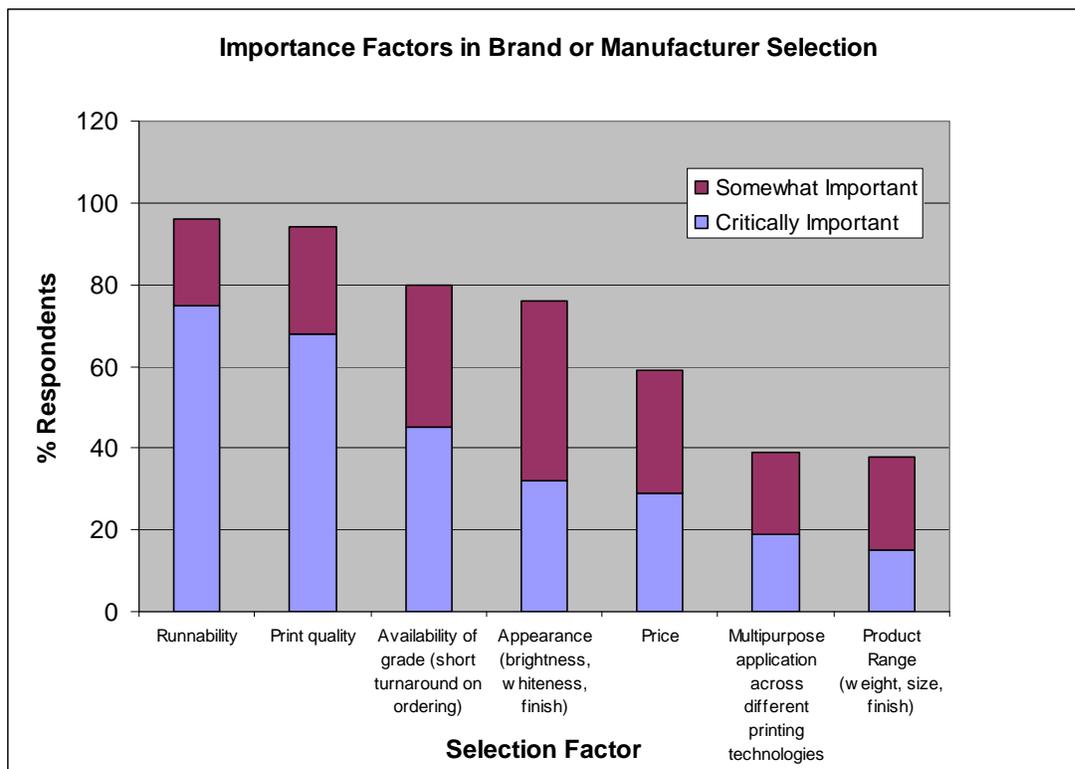


Figure 3 The relative importance of factors used to determine brand or type of paper.

Paper Characteristics

The properties and characteristics of papers that may be considered when selecting a grade were investigated for relative importance (Figure 4). When asked to identify the relative importance of all characteristics in a provided list, the leading characteristics were identified as toner/ink adhesion, uniformity, accurate sheet dimensions, dimensional stability, moisture level, and surface finish. When asked to identify only one characteristic as most important, the top three were the same, but with different weightings; 58 % of respondents identified toner/ink adhesion as most important, followed by accurate sheet dimensions (10%) and uniformity (7%). No respondents identified brightness as the most important characteristic. When parameters were combined, greater importance was attached to performance rather than appearance-related factors: when uniformity, accurate sheet dimensions, dimensional stability, moisture level, basis weight, storage and handling, stiffness, and sheet web strength are

grouped the “critical” rating is 33% compared with 22% for appearance-related factors such as color, opacity, and brightness. Across a wide range of applications, and for all the most important revenue generating jobs, ink/toner adhesion was found to be the most important factor.

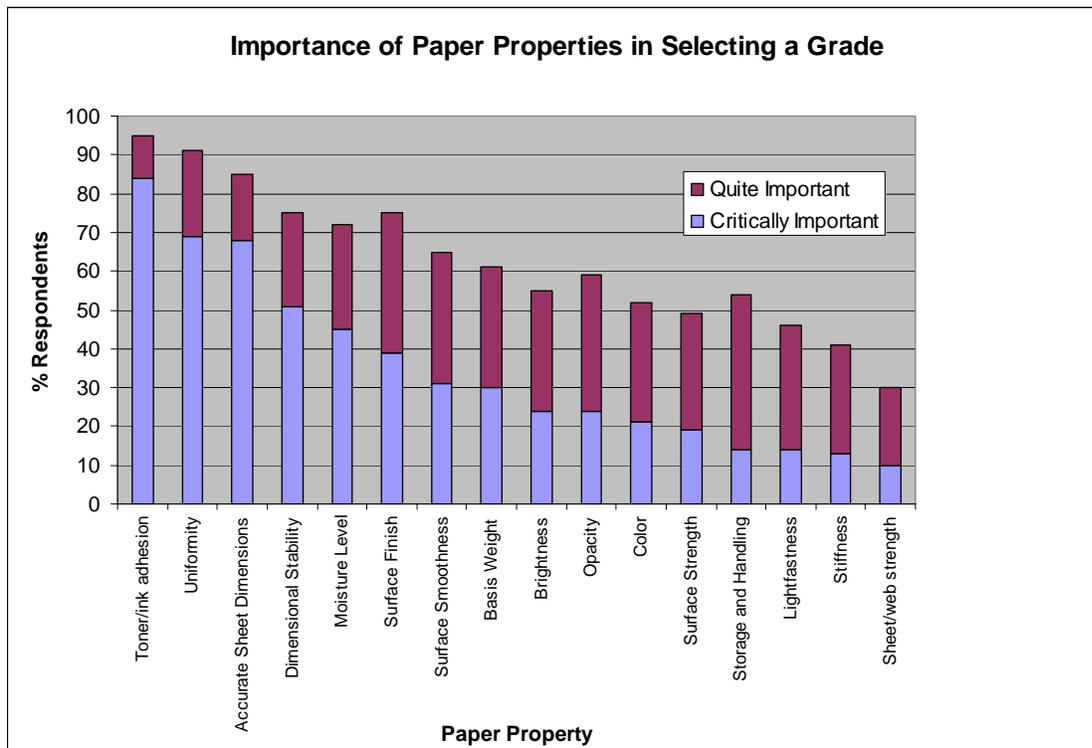


Figure 4 The relative importance of paper characteristics and properties in selecting a grade.

Desired Improvements

In an open question, forty four respondents reported that current product ranges are not sufficient at this time to meet all needs for digital document production, with specific comments calling for a wider range of sizes (10), more colors, a wider range of caliper/thickness and basis weights, and the ability to print on the same stock across different technologies. A range of comments related to the adhesion of toner or ink onto the substrate. Details of the comments on desired improvements are reported elsewhere [1].

When asked about limitations imposed by the digital press design, the leading limiting factors relate to product range: twenty respondents felt that they are limited in basis weight due to press limitations, but only one at the low end: fifteen are limited to sizes imposed by the press, and ten are limited by thickness. Adhesion and substrate pre-treatment was called out by fifteen respondents.

Statistical Analysis of Purchase Decision

This section attempts to understand the paper purchase decision of digital printing firms using statistical methods. An underlying idea is to link firms’ paper purchase decisions to their characteristics. This will shed light on which aspects or parameters of the printing paper the surveyed printing companies put emphasis in their purchase decisions.

In particular the importance of price and runnability in the paper purchase decision were considered in the analysis. [Figure 1] provides motivation to look at these two aspects of the paper purchase decision. A majority of the

respondents considers runnability important, but somewhat surprisingly the price does not seem to play a key role in their purchase decisions.

The discrete nature of the data obtained by the survey makes the use of a standard linear regression model impossible. Due to discreteness of dependent variables the logit model is used. The probability of a respondent choosing an answer is

$$\Pr(y = 1 | \mathbf{x}) = \frac{\exp(\mathbf{x}\boldsymbol{\beta})}{1 + \exp(\mathbf{x}\boldsymbol{\beta})},$$

where \mathbf{x} is the respondent's characteristics and $\boldsymbol{\beta}$ is a vector of the estimated coefficients.

The data set used in the analysis includes 93 companies. Ten companies had to be deleted from the data set due to missing values. Summary statistics are provided elsewhere [6].

Several sets of explanatory variables reflecting the firms' characteristics were created using the information provided by the survey. They include:

- Firms' demographics like the number of employees, the age, the revenue, etc.,
- Different printing jobs done by the set of printers in the firm (in particular the percentage of digital printers)
- Whether the firms do Digital Asset Management and/or Variable Data Printing
- Paper selection in the firm as well as possible restrictions imposed by the presses used in the firm.

Results for the Importance of Price

Starting with a full model insignificant variables were eliminated one after another until arriving at the final model shown in [Table 1] in the appendix. When interpreting the coefficients it is important to keep in mind that this is a nonlinear model. The coefficients do not represent the marginal effects on the probability of higher price sensitivity. However, the sign of the coefficients reflects the direction of change in the probability, allowing an intuitive interpretation.

The sign of the variable *Revenue* is negative. This implies that the higher the revenue of a company, the lower the probability that firms put a high weight on the importance of price in the paper purchase decision. The variable is statistically significant at a 5% significance level.

The variable *Employee_Growth* also has a negative coefficient, implying that a faster growing company puts less weight on the price of paper. This variable was included in the model, although it is statistically insignificant (p-value 0.63). The estimated sign still gives some information and can be contrasted with results on the importance of runnability.

Companies that print marketing materials put less emphasis on the price. Firms that print marketing materials actually care more about runnability. This suggests that while overall costs play an important role, companies are willing to purchase relatively more costly paper if this paper proves to have high runnability, which may reduce the actual production cost. On the contrary, if a company is involved in printing catalogs the company is likely to put higher weight on price. The coefficient is statistically significant at a 5% significance level.

The variable *together* shows the strongest economic significance. This variable indicates whether a firm makes the paper purchase decision individually or in collaboration with the customer. If the firm collaborates with the customer, the likelihood of putting high weight on the price of paper decreases. Thus, a firm that communicates with customers more might be able to pass on cost increases more easily.

The data set includes information on the ability of a firm to pass on cost increases to the customer information. This information is used to analyze a firm's price sensitivity further. The variable *Passon_percent* indicates the percent of the cost increase in paper a company is able to pass on. However, a large number of firms did not reveal this information. To account for this, a dummy variable was created, taking on the value 1 if the firm did not reveal its ability to pass on cost increases to the customer. [Table 2] in the appendix shows the results.

The overall fit is quite good with a likelihood ratio test of all coefficients zero yielding a p-value of 0.1033. The coefficient for *Passon_Percent* is negative indicating that firms that are able to pass on cost increases to the customer are less likely to put high emphasis on the price. If a firm does not have to bear the full effect of a cost increase, then attention will shift from price to other factors like quality/appearance. The coefficient is statistically significant at a 10% significance level.

Interestingly the dummy variable *Passon_NA* turns out to be significant, both economically and statistically. Additionally the sign turns out to be negative. A possible interpretation is that those companies who do not reveal their pass on ability belong to those companies that are able to pass on a high percentage of their cost increases.

This result supports the initial interpretation of the coefficient of the variable *Together*. Firms that make their paper purchase decision together with the customer seem to be able to communicate that increase to the customer and then pass parts (or all) of the cost increase on to the customer. This explains why firms that make the decision together with the customer tend to care less about the paper price.

Results for the Importance of Runnability

While both the price and the runnability of the paper affect the production cost, the fact that almost all the respondents ranked runnability as an important factor in the paper purchase decision suggests that overall runnability has a much stronger impact on the production cost. Note that only about 60% ranked price as such. Another interesting observation is that the correlation of the importance of runnability with the importance of price across firms is -19.7%. This suggests that firms who care about runnability care less about price and vice versa. Again, a full model is estimated and insignificant variables are eliminated leading to the final model reported in [table 3] (appendix). The model fits well. The likelihood ratio test is rejected with a p-value of 0.0020.

The only variable from the set of demographic variables that turns out to be somewhat significant is *Revenue_Growth*. Although the p-value signals a rather low significance the implication is quite interesting. The faster a firm's revenue grows, the more the firm emphasizes runnability. Companies printing marketing materials are more likely to emphasize runnability whereas it was found earlier that they tend to care less about the price of the paper. This is in line with Evans and LeMaire (2005) who report that there is a "trend towards short run, variable data electrophotographic printing for targeted marketing applications [requiring] robust paper runnability".

As expected, the sign for *dig_printer_perc* is positive. The more a firm is involved in digital printing, the more it emphasizes the runnability of paper. Similarly *DigitalAsset* shows a positive sign. Evans and LeMaire (2005) argue: "Compared with many offset requirements, sheet properties for digital printing must be more stringently controlled ... in order to meet the jam-free requirements of complex high-speed paper paths." The coefficient on *dig_printer_perc* is rather large indicating the central importance of the variable. Consequently a firm that has progressed further towards the digital printing is more likely to emphasize runnability in the paper purchase decision.

Portfolio has a negative coefficient indicating that the larger the purchasing portfolio of a firm the less the firm cares about runnability. One interpretation is that these companies care more about price than about runnability. The correlation between the importance of price and the variable *portfolio* is 7.4%, supporting this view.

The variable *Alone_customer* is significant at the 5% level and shows the predicted sign. This supports my claim that if the printing company delegates the paper purchase decision to the customer the emphasis on runnability will be lower. This is intuitive as the customer's main concern is the quality of the end product.

Summary of Statistical Analysis

The statistical analysis of two aspects of the paper purchase decision identified some interesting results about the paper purchasing behavior of digital printing firms. Smaller, slow growing firms tend to put a high weight on the paper price whereas fast growing firms primarily focus on the runnability of paper. Firms that are printing

marketing materials care mostly about runnability. One possible reason is that many are involved in Variable Data Printing which puts higher requirements on runnability, as the loss of one sheet can disrupt the whole print process.

A printing company that makes the paper purchase decision together with its customers is less likely to put emphasis on the price of paper. Evidence was also found that companies able to pass on to the customer a high percentage of cost increases care less about the price. These results suggest that companies who collaborate with their customers on the paper purchase decision are more likely to pass on their cost increases.

The more a company is involved in digital printing, the more it emphasizes the importance of runnability. This makes sense because runnability requirements for digital presses are generally higher. Finally, if a company delegates the paper purchase decision to the customer, the importance of runnability is lower. That is probably because customers put a higher weight on other criteria such as the quality and appearance characteristics of paper.

CONCLUSIONS

The results of this study indicate that paper characteristics and purchasing factors related to efficiency of production predominate over considerations related to appearance and price. In many cases the entire economic viability of a print job depends on the quality of the substrate; poor runnability and low image quality can differentiate between profit and loss in an industry with tight profit margins. The data from this study suggests that production digital printing is not a commodity segment, but is performance- and value-based. Within the On-demand Printing in the digital production segment, there is a lower tolerance for waste (time and materials) and a higher need for productivity, which pressures paper manufacturers to produce more uniform products to higher specifications.

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Appendix:

Table 1: Estimation Results for the Importance of Price regression

Logit Regression			
	Coef.	Std. Error	P-value
Intercept 2	0.3764	0.9761	0.6998
Intercept 1	1.9073	0.9970	0.0558
Revenue	-0.3450	0.1744	0.0479
Employee_Growth	-0.1787	0.3792	0.6375
PJ_Marketing	-0.5555	0.2936	0.0585
PJ_Catalogs	0.6535	0.2870	0.0228
Together	-1.0754	0.4325	0.0129
Score Test		3.89841	0.5641
	Log-likelihood at mean	-405.1	
	Log-likelihood at convergence	-367.7	

Table 2: Estimation Results: Price Importance related to pass on ability

Logit Regression			
	Coef.	Std. Error	P-value
Intercept 5	-0.3877	0.3324	0.2436
Intercept 4	0.9741	0.3468	0.0050
Passon_Percent	-0.8258	0.5008	0.0992
Passon_NA	-1.0130	0.5202	0.0515
Score Test		0.1128	0.9452
	Log-likelihood at mean	-405.1	
	Log-likelihood at convergence	396.0	

¹ Note, this is a chi square statistic.

Table 3: Regression Results for the Variable Importance of Runnability

Binary Logit Regression

	Coef.	Std. Error	P-value
Intercept	0.0318	1.4985	0.9830
Revenue_Growth	0.5187	0.3910	0.1847
PJ_Marketing	0.4898	0.3794	0.1966
PJ_Book	-0.5623	0.3010	0.0618
Dig_Printer_Perc	2.1870	1.0937	0.0455
Dig_Printer_NA	0.2244	1.3726	0.8701
Digital_Asset_Train	1.5284	0.7027	0.0296
Portfolio	-0.7347	0.2924	0.0120
Alone_customer	-1.5976	0.7777	0.0399

Log-likelihood at mean	212.42
Log-likelihood at convergence	163.80
