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Feasibility and Marketing Channels of a Smartphone Application that Brings Nondestructive Techniques to Job Sites

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Feasibility and marketing channels of a smartphone application

that brings nondestructive techniques to job sites

By

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This work conducted market research on the use of smartphones and smartphone applications in the forest products industry and academia. This research also attempted to project how likely the industry would be to use an app that measures stiffness of wood. After the review of scholarly literature and existing apps, data was collected via an online survey. Participants were individuals who work with wood or wood-based products. Out of 1,221 invitations, 311 were returned at the response rate of 27.2 percent. Data was analyzed using SPSS statistics. Nearly all of the respondents (95.7%) had smartphones, and over half of them were iOS users (52.3%). More respondents had paid apps experiences (45.2%) than in-app purchases (28.5%). Regarding responses' perceptions toward the app, the respondents expressed that the app could be useful, and were interested in the app. Millennials showed a higher interest level in the app than other generations.

DEDICATION

To my supportive family and for my loving husband,

Lee, Juhyeong

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CHAPTER I

INTRODUCTION & OBJECTIVES

Introduction

Smartphones are heavily used among the general population in the U.S. As the perception toward smartphones becomes more acceptable, the smartphone usage diversifies, and the popularity continues to grow. In forest products, however, there are not many smartphone applications (app), so smartphone usage is limited. Wood products, such as lumber and plywood, are commonly used in home construction in the U.S. Certain wood species or products are preferred due to their strength. Wood strength property measuring devices currently available in the market lack convenience and affordability for general usage at building sites. For instance, one piece of non-destructive testing (NDT) equipment known as the “timber clear specimen test equipment”, marketed by TestResources, Inc., weighs 33,750lb, and another device, the Metriguard 312, weighs 3,000lb and costs $5,250 (Metriguard, 2017). One of the lightest devices marketed by Metriguard still weighs 32lb and is difficult for one person to use properly due to its weight. As a result, the Department of Sustainable Bioproducts at Mississippi State University is developing a smartphone app that can measure the stiffness property of lumber using smartphones without purchasing expensive NDT devices. The app will utilize the built-in microphone and/or accelerometer of the smartphone to perform the measuring process.

Objectives

This work proposes to 1) conduct market research in the relevant industrial and academic sectors and 2) project how well the app would be used on job sites. This study provides justification of the app development and benefits the job sites where the quality of wood materials, namely stiffness, should be confirmed to ensure high quality construction and safety. Ultimately, the app makes structures safer by possibly avoiding materials that are inclined to deflection (sag). The research on potential users' attitudes toward the utilization of the new smartphone app in the Forest Products (FP) industry will enable new marketing techniques to be adoptable on its job sites. Accordingly, it will stimulate business transactions on a relatively new platform, the app stores, for the FP sector. The overall FP market can operate more effectively and efficiently with the use of this new technology.

The research also aimed to identify which areas of industry, business, and professional markets that may use the app. Lumber that is stress rated is not generally available to the do-it-yourself (DIY) market or to small contractors. The big box stores do not normally stock Machine Stress Rated (MSR) or Machine Evaluated Lumber (MEL). This technology would provide widespread use of techniques to identify candidate lumber stock for critical applications where high stiffness is required.

CHAPTER II

LITERATURE REVIEW

Smartphone use in the U.S.

Theoharidoe *et al*. defined a smartphone as a cell phone that is accessible to application repositories, such as app markets to install third party applications with advanced hardware that enables it to process sophisticated works through the device. According to the definition, it should also provide "multiple and fast connectivity capabilities" including Wireless Fidelity (Wi-Fi) or High Speed Downlink Packet Access (HSDPA) (Theoharidou, Mylonas, & Gritzalis, 2012). Even though the first smartphone opening the market was the BlackBerry, Apple realized the mass marketing of smartphones in early 2007 (Park, Lee, Suh, & Kim, 2012). Park *et al*. provided a simpler definition of a smartphone that is "a mobile phone equipped with computing power similar to that of a PC." It also enable customers to have "computing experience" with mobility. Examples include availability to check e-mail, browse the internet, and watch streaming videos (Park et al., 2012). As indicated, it not only provides the fundamental functions of a mobile phone, such as voice calls or text messages, but is also readily perceived as a multifunctional gadget that people can use for work and entertainment. Other functions include personal time and schedule management, the internet content access, document editing, and location directions (Osman, Talib, Sanusi, Shiang-Yen, & Alwi, 2012). Specifically, the internet accessibility of the smartphone enables users to interact with each other at no additional costs (Ho, Lu, & Lin, 2013). The number of smartphone users has dramatically increased over the last several years from 62.6 million in 2010 to 207 million in 2016 by 231% in the U.S. (Statista, 2017). This growth trend is expected to continue as listed in Table 2.1.

The significance of the smartphone can be gleaned from the ownership rates of which show that over 60% percent of U.S. population had smartphones in 2016, and ownership is estimated to grow to 75% by 2019. This increase has been in double digits from 2010 through 2016 (Table 2.1).

Table 2.1 Smartphone users in the U.S.

Year	Number of users (millions)	Yearly increase	U.S. population (millions)	Smartphone ownership rate
2010	62.6	N/A	309	20%
2011	92.8	48%	312*	30%
2012	122	31%	314*	39%
2013	144.5	18%	316*	46%
2014	171	18%	319*	54%
2015	190.5	11%	321*	59%
2016	207.1	10%	323*	64%
2017*	222.9	8%	325*	68%
2018*	236.3	6%	328*	72%
2019*	247.5	5%	330*	75%

* Estimates (Bureau, 2016; Statista, 2017)

The user ratio according to the different age groups, Millennials (1978-1994) were the heaviest smartphone user group in the second quarter of 2014 (Figure 2.1) (Nielsen, 2014). Whereas, Baby Boomers (1946-1964) and Generation X (1965-1977) represent the two largest workforces in the U.S. These groups have started to retire and will continue to exit the workforce in the next several years (Beutell & Wittig-Berman, 2008; Ponder, 2013). The heaviest smartphone user group, Millennials, is predicted to become the largest workforce in the U.S. Accordingly, it is assumed that FP job sites are influenced by such changes. A survey conducted by the Engineered Wood Journal also indicates the generational changes in the FP industry work force; nearly 60% of the survey respondents responded that 6-20% of positions will be replaced due to retirements by 2021 (Caim, 2017).

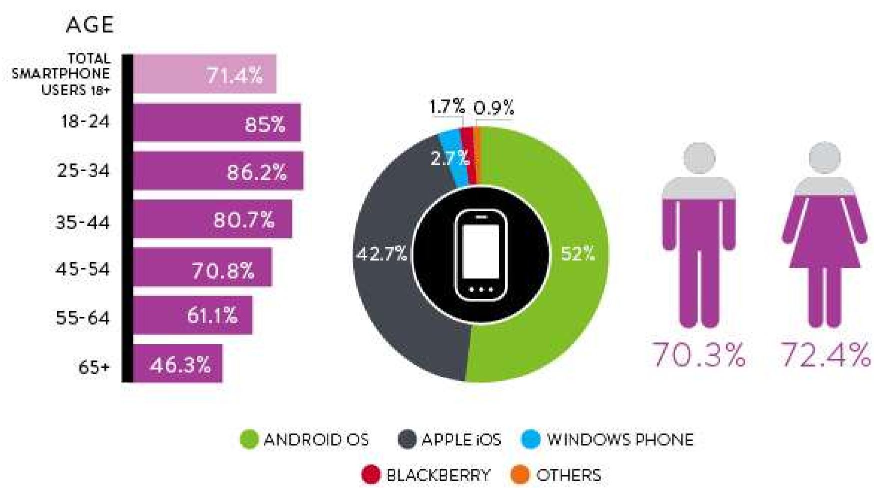

Figure 2.1 US smartphone market share by age, operating systems, and gender. The second quarter of 2014 (Nielsen, 2014).

In the U.S., the main companies in the smartphone market in terms of the number of subscribers include Apple, Samsung, LG, Motorola, and HTC. These five companies had 89.9% of the combined market share (Table 2.2) (ComScore, 2016). According to this data, Apple had the highest number of U.S. smartphone subscribers (43.6% of the market share), followed by Samsung (28.5% of the market share). In contrast, the smartphone operating systems were dominated by Android, with the market share of 52.8% and Apple, with a market share of 43.6% in early 2016 (Table 2.3) (ComScore, 2016). This research focused on the iPhone and Apple iPhone app store (the App Store), as it was ranked first as a single brand in the size of subscribers in the U.S. Android has a different operating system for apps; thus, Android markets will be examined in a separate study in the future.

Table 2.2 Top smartphone Original Equipment Manufacturers (OEM)

Brands	Share of subscribers
Apple	43.6%
Samsung	28.5%
LG	9.6%
Motorola	5.0%
HTC	3.2%
Others	9.6%
Total	100%

Source: (ComScore, 2016)

Table 2.3 Top smartphone operating systems

Platforms	Share of subscribers
Android	52.8%
Apple	43.6%
Microsoft	2.7%
Blackberry	0.8%
Total	99.9%

Source: (ComScore, 2016)

Mobile phone app

The Cambridge Dictionary defines a mobile app as a “software program that runs on a mobile phone” (Cambridge, 2017), which is commonly abbreviated to an “app.”

Apps provide limited functions, do not occupy a large space in terms of size on a storage drive, and act as individual units. Other terms, such as web app, online app, iPhone app, or smartphone app, are also used to describe mobile applications (herein after a "smartphone app") (Techopedia, 2014).

Smartphone in FP

Smartphone usage in the FP sector is difficult to document. There are a few studies involving smartphones; Geographic Information System (GIS) technology embedded in the smartphone is used to collect data for forest management (Kennedy, 2012). It substitutes tools that are traditionally used for the data collection, such as Global Positioning System (GPS) devises, maps, paper forms, and cameras. "Smart Measure" and "Measure Height" are smartphone apps that are used to measure tree height to make field determination easy, fast, and accurate (Bijak & Sarzyński, 2015). Land-holders use smartphone apps for managing plantation forestry in Chile (Harris-Pascal, 2015). Itoh *et al*. developed an iPhone app to measure tree height using an accelerometer function (Itoh, Eizawa, Yano, Matsue, & Naito, 2010). A number of studies examined the accuracy of other built-in smartphone functions used in the apps including GeoTrees, Smart tools, and Trestima. These apps collect information only using smartphones; "GeoTrees" is a tool for inventory management that collects attributes including tree location, species, height, and diameters (Fauzi et al., 2016). When used in height and slope modes, "Smart Tools" use the image on the camera screen and lines on the phone case to measure tree height (Villasante & Fernandez, 2014). "Trestima" is an app that measures and reports tree positions, species, and width and length of each sample using a smartphone camera (FordaqSA, 2017). Land- holders use a smartphone app, "iBitterlich", to aid in managing plantation forestry in Chile (Harris-Pascal, 2015). This app can measure the basal area of a stand using the camera on a smartphone (Taakkumn, 2012). The same developer that created “iBitterlich”, also developed “iHypsometer,” which measures tree height, stand basal area, and stand volume (Taakkumn, 2012).

Overall, these apps are concentrated on forestry inventory and management areas. Measuring tree height and tree positions with smartphone apps appeared to be acceptable because there were studies regarding such apps throughout publications. However, other examples for apps were not found, such as usages in the lumber or flooring industry. The lack of antecedent studies on smartphones or smartphone apps in the forest products sector limited the scope of the literature review. Therefore, eBusiness in the FP sector was chosen to discover how the advanced technology would be perceived by job sites focusing on the general use of eBusiness from the users’ perspectives.

eBusiness in FP

eBusiness

eBusiness is a way of conducting business via the internet. eBusiness can vary and cover a wide range of business transactions depending on the firms that engage in using the technology. eBusiness tools, mainly e-mail and the World Wide Web (www or the Web), are used for contacting customers and vendors, webpage, marketing and promotion activities, and product/price inquiries, according to a survey conducted in 1999 (Vlosky, 1999). Steven R. Shook *et al*. provided examples of eBusiness applications that include “purchasing, selling, vendor-managed inventory, production management, logistics, communication and support services such as on-line training and recruiting (Shook, Zhang, Braden, & Baldridge, 2002).” Vlosky and Youn listed more functions of the internet that include providing a platform for both suppliers and customers, scheduling production, troubleshooting, and compensating employees (Vlosky & Youn, 2002). The later uses of eBusiness described by Shook, Vlosky, and Youn were considered more sophisticated. Vlosky and Smith described the degree of the technology with two terms, lower-order and higher-order functions; the lower-order functions include communications via e-mail, marketing and promotion, and having a static website. Whereas, higher-order functions enable a business to check an order status, track an order, perform transactions via e-mail, and manage inventory and logistics (Vlosky & Smith, 2003).

eBusiness primarily depends on the use of computers; however, smartphones can be substituted for computers in performing various functions of eBusiness. A smartphone's ability to perform eBusiness is a major reason why this study reviewed the eBusiness of the FP industry. It was done to gain a better understanding of the FP industry.

Richard P. Vlosky was the first researcher who conducted a study regarding eBusiness in the FP sector using a survey. The status of internet usage among Forest Products Society (FPS) members was reviewed to derive what the FPS could offer for the community. The survey indicated that 59% of the respondents used the internet. Amid the respondents who use the internet for their business, e-mail (58%) and the Web (46%) were the most frequently used tools (Vlosky & Gazo, 1996). A number of studies show that applications of eBusiness in the FP industry are predominantly e-mail and the Web (Arano, 2008; Dupuy & Vlosky, 2000; Hewitt, Sowlati, & Paradi, 2011; Holmes, Vlosky, & Carlson, 2004; Karuranga, Frayret, & D'Amours, 2005; Kozak, 2002; I. Montague, Gazal, Wiedenbeck, & Shepherd, 2016; I. B. Montague & Wiedenbeck, 2012; Pitis & Vlosky, 2000; Shook, Vlosky, & Kallioranta, 2004; Shook et al., 2002; Smith & Olah, 2000; Vlosky, 1999, 2001; Vlosky & Fontenot, 1997; Vlosky & Gazo, 1996; Vlosky & Pitis, 2001; Vlosky & Smith, 2003; Vlosky & Westbrook, 2001; Vlosky & Westbrook, 2002; Vlosky & Youn, 2002). Table 2.4 lists the adoption status of eBusiness in FP industries and communities.

Table 2.4 The adoption status of eBusiness in FP industries and communities

Author	Year*	Title	eBusiness usage
Vlosky & Gazo	1996	The Internet and the forest products community: The role of the FPS	E-mail (58%) and the Web (46%): higher use in university & government than industry
Vlosky & Fontenot	1997	The Internet and the FP industry: Current status and projected trends	The Internet (52.2%) & webpage (28.3%): product/price inquires
Vlosky	1999	eBusiness in FP industry	The Internet (40%): customer contact (47%), homepage (45%), marketing (44%), vendor contact (33%), promotion (32%), product/price inquiry (31%)
Pitis and Vlosky	2000	FP exporting and the Internet: current use figures and implementation issues	The Internet (81.7%): e-mail (94.1%) and the Web (81.0%), web page (55.9%)
Dupuy &Vlosky	2000	Status of EDI in the FP industry	Current adoption (16%) and planned adoption by 2002 (28%)
Smith *et al.*	2000	Marketing for wood products companies	N/A
Vlosky & Pitis	2001	eBusiness in the FP industry: A comparison of the United States and Canada (in 1999)	The Internet (54%): e-mail (75%), customer contacts (32%), web page (28%), marketing (27%), promotion (20%), product inquiry (20%)
Vlosky	2001	eBusiness in the U.S. FP industry in the year 2000	The Internet (34%): customer contacts, website publishing, marketing, vendor contacts, product/price inquiry, promotion, sales

Table 2.4 (Continued)

Vlosky & Westbrook	2001	The state of FP industry e-business	The Internet (34%), e-commerce (20%)
Vlosky and Youn	2002	A cross-national study of Internet adoption in the FP industry in the U.S. and South Korea	The Internet (34%): customer/vendor contacts by e-mail, home page, marketing, product/price inquiry
Kozak	2002	Internet readiness and eBusiness adoption of Canadian value-added wood producers	The Internet (88%): online research, exchange documents. with partners, customer e-mail, obtaining product and business information. Web sites (51.5%)
Shook *et al.*	2002	The use of eBusiness in the pacific northwest secondary FP industry	Web site (32%), e-mail (53%)
Vlosky *et al.*	2002	An exploratory study of Internet adoption by primary wood products manufacturers in the western U.S.	Websites (61%): promotion/Advertising (Ads) (93%), customer service (7%), sales via e-mail (18%)
Vlosky & Westbrook	2002	eBusiness exchange between homecenter buyers and wood products suppliers	The Internet for FP purchase (24%), website (78%): promotion/Ads (91%), customer service (31%), operational functions (11%), eCommerce (7%)
Vlosky and Smith	2003	eBusiness in the U.S. hardwood lumber	The Internet (90%): e-mail communication, marketing/promotion, website, website (55%)
Shook *et al.*	2004	Why did forest industry dot. Coms fail?	Low adoption rate of eMarketplace
Holmes *et al.*	2004	An exploratory comparison of Internet use by small wood products manufacturers in the North Adirondack Region of NY and LA	The Internet: Ads, sales. Website in NY (44%) and LA (36%): product/price inquires , sales
Karuranga *et al.*	2005	eBusiness in the Quebec FP industry: perceptions, current uses and intentions to adopt	In 1999, the Internet (32.8%), e-mail (28.7%), ecommerce (1.1%). Later, webpage (62.9%), eMarketplace (18.6%), accounting (83.9%)

Table 2.4 (Continued)

Arano	2008	Electronic commerce adoption in West Virginia's primary and secondary hardwood industries: preliminary results	E-commerce (46%): e-mail (100%), purchase supplies (85%), website (81%), orders (77%), banking (46%), Ads/promotion (42%)
Hewitt *et al.*	2011	Information technology adoption in US and Canadian FP industries	Lack of using advanced IT: companies, the Internet: e-mail, static websites, and research on the Web.
Montague & Wiedenbeck	2012	Cultivating connections in 2012-web strategies used by FP business in the southern U.S.	Website (23.5%): product info. and customer service. Social media (27%) and Facebook (25%). Online sales (2.4%)
Montague *et al.*	2016	FP industry in a digital age: A look at e-commerce and social media	Website (96.4%), e-mail (97%): e-Commerce. banking (59.6%), sales (27.1%), social media (58%): Facebook and LinkedIn

* The years refer to years of publications; studies were mostly conducted one or two years prior to the publications.

The internet and Information Technology (IT)

A study conducted in 2001 revealed that only 34% of the survey participants used the internet in their business. The usage drivers were peer (competitors) pressure and downstream users' necessity (Vlosky, 2001). This indicates that if end users demand, or competitors start using new technologies, the industry will adopt them in order to stay competitive in the market. However, it is clear that the FP industry is not fully open or ready for eBusiness. The FP industry's unreadiness for eBusiness opens an opportunity for individuals or companies, whomever initiates business using the new technologies, to claim the pioneer title. The IT adoption rate in FP industry was reviewed in 2011 by Hewitt. IT is the base of eBusiness as it provides the fundamental platform for it to function, which includes software, hardware, and network. Hewitt also pointed out that the production oriented tendency opposed to market orientation is one of the reasons why the FP industry is a slow adopter of IT (Hewitt et al., 2011).

E-mail

The use of e-mail in the FP industry has been observed since 1996 (Vlosky & Gazo, 1996). Most literature reviewed in this study included the certain level of e-mail use in business. The most common use of e-mail was communication that includes customer and vendor contacts, product and price inquiries, and informational queries. E-commerce was still not common in the FP industry, but a few studies showed that it used e-mail as means of e-commerce practice by placing and receiving orders. One should note that it was difficult to read from the studies' results one by one. For example, comparing the rate of e-mail use in one study conducted in 2002 with another study conducted in 2012 would not be adequate. This was because each study took different sample frame and sample size, and was under a different research context. However, the most recent study conducted by Montague in 2016 indicated a very high rate (96.4%) of e-mail use in business. Based on literature, e-mail became ubiquitous in the FP industry even though the level of adoption was inconsistent owing to various research circumstances throughout the last two decades. These studies also indicated a laggard tendency of the FP industry in adopting to a new environment.

Website

Several terms are interchangeably used for a website, including a webpage or a home page. Most websites appear to be in a static format: a website consists of web pages containing advertisements (Ads) and company and product information. A dynamic site is an opposite concept that has more functions that enable online transactions, interactive data access, and information exchange. Data is stored separately from the content in a dynamic site (Ricca & Tonella, 2003). The adoption rate of a website has been inconsistent even within the FP industry. One study showed a 45% adoption rate in 1999 (Vlosky, 1999) which was increased to over 55% in 2000 according to the study by Pitis and Vlosky. However, a 28% adoption rate was again observed in another study conducted in 2001 (Vlosky & Pitis, 2001). The adoption rates in other studies from 2001 to 2016 ranged from the mid-20% (23.5%) to nearly 100% (96.4%). The wide variance may have occurred due to the various research contexts of each study as explained in the e-mail section; one study surveyed hardwood industry, whereas another study focused on certain regions such as the State of Louisiana and another on the North Adirondack region of New York. The highest adoption rate in the FP industry (96.4%) was found in the most recent research in 2016 (I. Montague et al., 2016). Compared to the study conducted in 2012 (23.5%), the adoption of a website increased over approximately 4 years. This may explain two phenomena in the FP industry, including the fact that the adoption rate actually increased from 2012 to 2016, or the difference of the adoption rates between each sample (population of interest) taken by the researchers varied considerably. The industry used websites for various purposes; however, the most frequently observed functions included the presentation of company contact information, product information, promotion, marketing, advertising, and product and price inquiries. Beginning in the late 2000's, e-commerce started to appear as one of the functions of a website.

Third party platform: eMarketplace

The eMarketplaces for FP were once actively promoted; however, in a 2004's study by Shook, the FP industry was reluctant to adopt this eBusiness solution (Shook et al., 2004). The reason was that potential customers lacked an understanding of the benefits of adopting eBusiness over the traditional ways of conducting business in terms of time and cost savings. In addition, the stakeholders of the market, especially buyers and sellers, did not make a full use of the platform with their limited capabilities. One of the biggest reasons for the failure was pointed out to be inexperienced managements (Shook et al., 2004). Moreover, the study conducted by Vlosky and Smith indicated that the companies in hardwood industry did not trust third party eBusiness intermediaries to allow them to connect systematically to the firm's network (Vlosky & Smith, 2003).

eCommerce

eCommerce refers to any buying and selling activity performed online. Systemized e-commerce was attempted in the FP industry with eMarketplaces. However, a slow adoption rate of advanced technologies and ineffective business models on the market, such as brokers or agents who operate without inventory, contributed to its failure (Shook et al., 2004). E-mail was the most frequently observed tool used for online sales transactions in the FP industry. Based on the research published in 2002, only 18 % of the company's sales were conducted on the internet, specifically, using e-mail as the method (Vlosky, Westbrook, & Poku, 2002). The study also revealed that promotion/advertising was the single most prevalent usage of such technology among the industries. Thus, the research recognized the slow adoption rate of the FP industry in introducing a new technology in the feasibility study.

Overall trend

Per the survey conducted in 1996, research and trade groups (university, government and trade associations) outnumbered industry on the internet adoption in the FP sector. Again, home center retailers showed a higher adoption rate than that of solid wood firms in 1999 and 2002. One may project that institutions conducting research or working on policies and management of the FP industry have a higher tendency to adopt eBusiness than manufacturers or wholesalers of FP. The retail sector where a close interaction with an end user occurs appears to be a relatively earlier adopter of eBusiness as well within the FP industry. If the same rule can be applied to smartphone apps, these organizations (universities, home centers, etc.) may show an earlier and higher participation rates to use the technology when compared to the remainder of sectors in the FP industry.

Overall, the FP industry still appears to be in its infancy in adopting internet-based technologies. Vlosky and Smith categorized eBusiness activities into eCommunication, eSupport, eOperations, and eTransactions. Examples of each category are listed in Table 2.5 (Vlosky & Smith, 2003). According to the studies available as of May 2017, the FP industry has adopted eCommunication and eSupport functions that are mostly lower-order applications of eBusiness, however, higher-order applications categorized as eOperations and eTransactions are rarely found. Regardless of the current adoption status of eBusiness in the FP industry, the importance and usage of smartphones and apps should not be undervalued considering smartphone ownership rate in the U.S. and the untapped potential.

Table 2.5 eBusiness categorization

Classification	eCommunication	eSupport	eOperations	eTransactions
Examples	The use of e-mail and websites to promote & marketing	Products & price inquiries, shipping notice, order status, order tracking	Inventory management, logistics	Online sales & purchases
Stakeholders	Customers, suppliers, vendors	Customers	Employees	Customers & suppliers

Source: eBusiness in the U.S. hardwood lumber industry (Vlosky & Smith, 2003)

Smartphone app store and apps

Smartphone app store

Market research for the app market was conducted to learn the market's behavior, which could aid in strategy formulation. The app store is a platform where apps are traded; app developers list their apps, and consumers can download them. As of January 2017, Apple made over 2.2 million apps available on its app store, known as the App Store. The number of apps was increased by more than 20% from the previous year (Apple, 2017b). However, Apple does not provide the number of downloads of each app, or how the ranks of apps are computed. The apps are classified into 24 different categories to describe the apps. A category that can be applicable to the present study may be "utilities" enabling users to complete a specific task, such as measurement or unit conversion. Other categories include books, education, entertainment, music, games, and social networking (Apple, 2017c).

The apps can be downloaded with two options: free (usually with advertisements included in the app) or paid (usually non-advertisement). Marketers can decide whether to charge for their apps, and there are advantages as well as disadvantages for both free and paid apps. Paid apps can generate sales revenue for developers with revenue-sharing terms, and app downloaders tend to use it more often since they have paid for it (Talyor, 2016). However, the clients are reluctant to pay for apps that have not proven to be useful for them. Apps' reviews can aid in eliminating uncertainty about the apps' usefulness, but building up reviews is another task for app marketers. Free apps, on the other hand, have no barriers in downloading in terms of monetary sacrifices. Thus, it has more potential to increase the number of downloads even though more downloads do not guarantee the revenue generation. Free apps with advertisements are more common, as it can generate revenues for developers. In-app purchase functions can also provide the developers a source of income to compensate for their work.

Smartphone apps

The App Store was examined using keywords related to FP. The search was conducted only up to 100 because apps that are not ranked on the top chart are considered less successful. Apps on the top chart encourage further downloads from users, as the number of downloads can be as high as 2.3 times or more than apps not appearing on the top chart (Ansar, 2009). This is the reason why app developers strive to get on the 100 ranking lists to promote further downloads, which generates income in the case of paid apps. However, it is notable that the top ranked paid apps are not necessarily receiving high customer ratings (Lee & Raghu, 2014). This can also affect the number of future downloads.

Table 2.6 App search with three keywords

Key-words	Forest products	Wood	Lumber
Classes	Business, reference…	Games, catalog, reference, lifestyle, productivity	Games, business, utilities(U), productivity(P), photo, reference(R), entertainment, education, lifestyle, social networking, navigation
Apps	Horizon FP web track, FP Machinery & Equipment Expo, SMARTPLY AR BBOS Mobile–Lumber	DIY wood pallet projects, Wood beam calculator	U: Home builder pro Calcs, Home improvement, Lumber calculator pro, Floor finder, and Moisture calculator, P: Timber plus lumber collection, Jasper lumber, R: Woodworking basics, AFP logs and lumber, Cecobois, I.D. Wood…

Source: (Apple, 2017a) searched from http://itunes.apple.com.

On the first stage, three keywords, “forest products”, “wood”, and “lumber” were used to learn about the current market situation. The list of the apps examined in this study may not be exhaustive of all the apps relevant to the FP industry due to variety of search terms. Often times, names or descriptions of apps do not match with search terms.

With the first keyword “forest products”, there were only five apps available in the App Store that were business or reference apps, such as “Horizon Forest Products Web Track” that enables users to access to a corporate system, or “Forest Products Expo” that provides a program guide for attendees and exhibitors of the exposition.

The next keyword “wood” generated more varieties than “forest products”. However, among the top 100 apps with the keyword, only a few apps provided functional apps (utility or productivity) than for entertainment purposes (games). The categories to the keyword included Games, Productivity, Reference, Lifestyle, Education, and Catalog. Apps within the productivity category contained information about wood working skills that were “Wood Turning Skills”, “Wood Carving”, and “Carpentry Basics” that are shown as Figure 2.2. Those three apps were all available at a price of $2.99 each.

Figure 2.2 Productivity apps identified with the keyword “Wood”

Searched the App Store on iTunes with the keyword “wood”: Wood Turning Skills (Apps, 2015); Wood Carving (Applications, 2015); Carpentry Basics (Walsh, 2015), Retrieved from http://itunes.apple.com.

The keyword “lumber” demonstrated more relevant apps that included wood beam calculators, DIY wood working ideas, and furniture building guides. However, games and business apps again dominantly comprised the list. Of the utility apps found with the keyword, “Home Builder Pro Cals”, available for purchase for $4.99 provided over 200 calculators including 20 for wood and materials. “Home Improvement Cals”, available for purchase for at $1.99 and “Lumber Calculator Pro”, for free with advertisements were available offering information for lumber and materials by providing lumber dimensions and board feet information. “Moisture Calculator Lite” that measures moisture contents using green and dry sample weights was listed to promote a paid version that contains the save function. “Woodcraft” was the most expensive, available for purchase for $19.99, and appeared to be the most sophisticated app that was designed for professionals who mainly work on dimensional lumber projects. This app was one of a few apps that displayed quotes from previous users as a form of review to increase the credibility. Further, its continuing updates from the date of publication (August 2012) to the recent time (May 2017) may make the app more reliable. One can learn that the app names and app keywords are critical to improve visibility of apps. Therefore, the app can be listed out when a potential user searches the exact or similar terms.

In order to provide a better understanding about the app market, a comparison between the App Store and the Google Play was made with the third keyword "Lumber." The Google Play operated by Google provided the different options than the App Store by Apple that some apps, such as "wood beam design construction" and "wood beam calculations" were only available on the Google Play, which costs \$ 3.99 and \$ 1.00 respectively as of January 25, 2017.

This happens because developers can decide where to display their apps on any app market platform. According to Taylor, the decision depends on targeting demographics and marketing strategies (Taylor, 2016). His article further revealed that iPhone users have more spending power than Android users. Therefore, an app can be displayed on the App Store if a developer charges for the app. A finding that an app charged more on the App Store than the Google Play supported this claim; it was interesting to observe that the price for "Timber Engineering Calculator" was more expensive on the App Store than on the Google Play by \$1.00. Android gadgets, on the other hand, such as tablets are more welcomed by children due to its affordability from parents' perspectives. Accordingly, if an app targets at children, then Google Play appears to be a better fit (Taylor, 2016). There was also a clear distinction between paid and free apps that apps for professionals were mostly paid apps, whereas, the majority of apps targeting DIYs were free. The number of installs also indicated that free apps were downloaded significantly more compared to paid apps. For example, a free app “DIY wood pallet projects” that provides craft ideas, was installed at between 50,000 to 100,000 times. However, the number of installation of “wood beam calculator” containing information such as Modulus of Elasticity (MOE) ranged from 100 to 500 even though it only cost $1.00. Note that the number of downloads, even rough data, are only displayed on the Google Play. In addition, considering more apps that have free trial versions ranked on the top paid apps than the apps without the free trial version, this can be considered for as a marketing strategy (Chen & Liu, 2011).

In the process of search optimization, the researcher found apps that provide similar functions of the one this study investigated; those included “wood beam design construction” and “Timber Engineering Calculator” on the Google Play and “Timber Engineering Calculator”, “all beam designer”, “TraviGo”, and “A-beam (lite and full versions)” on the App Store. Only the later five apps were reviewed in the study as it focused on the App Store (Apple).

First, the “Timber Engineering Calculator” contains 55 calculators for timber and wood-works (Figure 2.3). Values obtainable with this app include area of section, maximum fiber stress, tension, MOE, volume factor, and total allowable lateral load. There was one review (posted on Jan. 28, 2017) by a user who rated one star out of five (one for negative and five for positive) and expressed some concerns about its advertisement for other related apps. However, it was hard to generalize attitudes toward the app with only one review. The most recent available version was version 4.0, which was updated in April, 2016. The app was first published on May 2013. The range of installs was not displayed on the App Store, so the popularity of the app was unknown. Whereas, the number of installs of the app (version 1.0) on the Google Play ranged from 10 to 50 as of May 2017. It is assumed that the excessive amount of information the app provides could have been overwhelming to the users. There is also the possibility that users are not familiar with the terms and/or how to read (or interpret) the results. The app was available on The App Store at a higher price ($3.99) compared to $2.92 on the Google Play.

Figure 2.3 Timber Engineering Calculator ($3.99)

Pugazhenthi, V. (2016). Timber Engineering Calculator. (Version 4.0). Retrieved from http://itunes.apple.com (Pugazhenthi, 2016)

"All beam designer" (Figure 2.4) calculates cross section area, second moment of area, section modulus, and other different sections properties for steel, aluminum, grey iron, and wood. There was no rating or review of the app. This app was one of the apps that are sold as a package of "Engineering Apps" that includes "Bolt Torque" along with this app for $10.99. This app was available at $9.99 and was not listed on the Google Play.

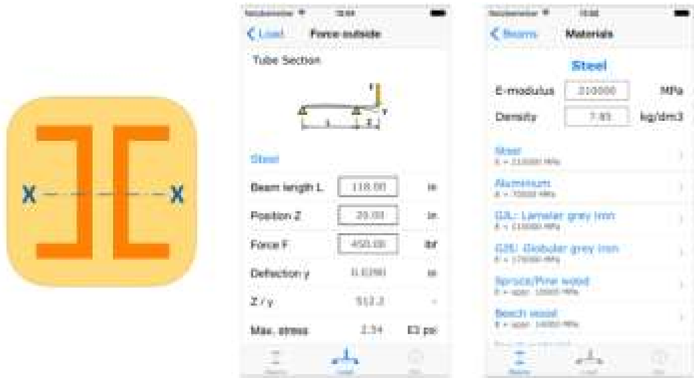

Figure 2.4 All beam designer ($9.99)

Autrata, J. (2015). All Beam Designer. (Version 1.1). Retrieved from http://itunes.apple.com. (Autrata, 2015)

"TraviGo" provides shear force and a bending moment diagram calculated for concrete, steel, and wood beams (Figure 2.5). It emphasizes ease of use, and is recommended to use for educational purposes only. The first publication was on Sep 2013, and the recent update was on July 2015 for the version 2.0. No customer ratings or reviews were posted as of May 2017, and this app was only available in the App Store.

Figure 2.5 TraviGo ($4.99)

Bellu, G. (2015). TraviGo. (Version 2.0). Retrieved from http://itunes.apple.com. (Bellu, 2015)

The app “A-Beam Lite” calculates reaction forces, shear forces, bending moments, and deflection of beams due to an applied load (Figure 2.6). One can input length of the beam, loading location and load, and other basic information for calculating deflection or stiffness of the beam. For example, “stiffness” sheet includes simulated values with corresponding equations used. This app shows how to obtain solutions. The results can be emailed or converted to PDF format. However, since it is a lite version, the limitation exists that only one span beam can be created for a trial purpose. The full version is available at $5.99 as displayed in Figure 2.7. There were no reviews or ratings for this app. The recent version was 4.0 and updated on December, 2016, and the first version 1.0 was listed on March 2012.

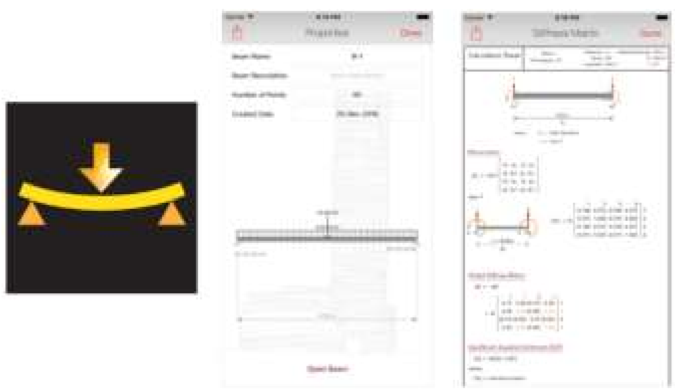

Figure 2.6 A-Beam Lite (Free)

Pimsen, S. (2016). A-Beam Lite. (version 4.0) Retrieved from http://itunes.apple.com. (Pimsen, 2016)

The full version, “A-Beam,” that supports testing multiple number of beams was available from December 2011. Over 20 updates were made throughout to 2017. The last update was on April 2017 as version 4.4 for fixing minor bugs. Again, the different pricing strategy was observed that “A-Beam” and its free trial version “A-Beam Lite” were available on the Google Play at the lower price ($3.99). A total of 71 reviews averaging 3.8 stars (one for negative, five for positive) with the number of installs ranging from 1,000-5,000 indicated that this app potentially performed better than other apps that were reviewed in this study. Thus, it can be benchmarked in the development and marketing of similar apps.

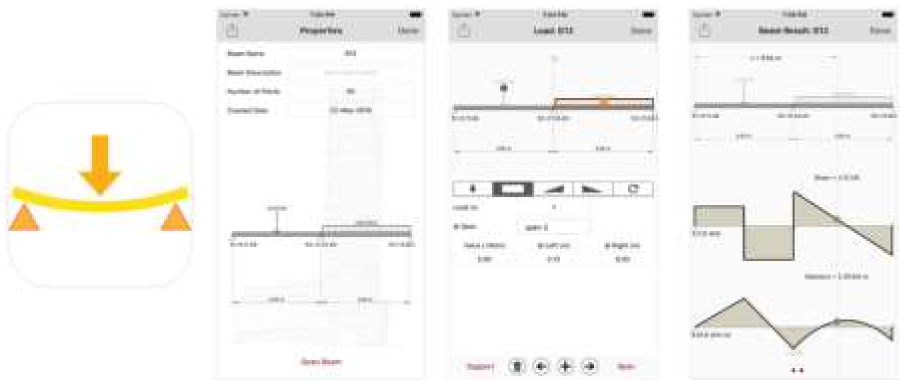

Figure 2.7 A-Beam ($5.99)

Pimsen, S. (2016). A-Beam. (version 4.0) Retrieved from http://itunes.apple.com. (Pimsen, 2017)

Even though those apps provide measurement results, they were still one-dimensional. In other words, they only provided a way of calculating functions that use information inserted by users. In the engineering world, the use of smartphones in testing products and equipment has emerged. When engineering apps were introduced, smartphones and apps became an actual tool, thanks to sensors added to smartphones (Alexander, 2015). These sensors include accelerometers, ambient temperature sensors, gravity sensors, gyroscopes, light sensors, linear acceleration sensors, magnetometers, barometers, proximity sensors, and humidity sensors (Su, Tong, & Ji, 2014). There are several apps using one or multiple types of these sensors to measure the information that engineers needed; Gaia Consulting developed an app "Zephyrus Wind Meter" that measures air speed using the sound of passing air to smartphones. Another app "Ridgid Digital Bubble Level" can provide information that enables a user to level equipment by placing the smartphone on a surface or using a camera. "Physics Toolbox Sensor Suite" is an example of using multiple sensors to provide various information. There are even apps that are able to measure humidity (Alexander, 2015). These examples of apps that utilize such sensors embodied in smartphones make the app that measures stiffness more feasible to develop.

Other uses of smartphone apps by firms were found. Several industrial firms had developed apps to provide general company profiles (contact and location) and product (pricing, new and top products, stock) information. The apps were also used for promotion, event updates, and even reward programs. While conducting the research of currently available apps on the market, some keywords such as timber, span, board, engineering, design, and beam became available for the name and keywords of the app.

Based on the findings in the literature and objectives of the study, it will test hypotheses as listed below.

H_1: The frequency of one's use of smartphone apps will affect his or her intention to use the app.

H_2: Individuals who had purchased a paid app will more likely to buy the app.

H_3: Value is added to the job sites if the app demonstrates usefulness.

H_4: Different age groups differ in interest level toward the app.

H_5: Academia and industry differ in interest level toward the app.

CHAPTER III

MATERIALS AND METHODS

An online survey was conducted to collect data. Among various survey methods, such as in-person interview, phone, mail, and e-mail, an online survey via an e-mail invitation was chosen due to advantages including cost efficiency, quick data collection, and accurate data entry (Gosling, Vazire, Srivastava, & John, 2004). Gosling *et al*. addressed that an online survey's benefit will be justified based on the quality of the data (Gosling et al., 2004). Even with the possible disadvantages in terms of data quality, an online survey is an effective tool of collecting opinions of targeting population owing to the heavy use of the internet in the U.S. According to the survey conducted by Pew Research, 84% of American adults use the internet in the U.S. (PewResearch, 2016). This survey was developed using Tailored Design Method by Don A. Dillman (Dillman, Smyth, & Melani, 2011).

Participants

Participants were individuals who work with wood or wood-based products in an organization or individually, which were also the population of interest in this research. DIYs were excluded from the sample frame due to the limitation in identifying the population. Because of the specificity and limitations of identifying the whole population of interest, the research used the convenience sampling method.

The sample frame was specified combining the number of the FP researchers including faculty, staff, and students in universities, researchers at laboratories, and employees in the FP industries including lumber mills, lumber wholesale and retail stores, contractors, and architects. The sample, then, was categorized into two different groups that are academia and industry; the academia group encompasses researchers including faculty, staff, and students at universities or colleges, and individuals who work at research centers. The industry group is made up of lumber mills and wholesalers in the southern region which includes Alabama, Arkansas, Florida, Georgia, Louisiana, Maryland, North Carolina, South Caroline, Tennessee, Texas, and Virginia. The southern region was defined by Random Lengths (Random Lengths Publications, 2017). Import and export companies throughout the U.S. were also included in the industry group.

A sample was compiled from publically available online sources, online directories, and print of the Big Book by Random Length (a FP business directory). The online directories were obtained from the FPS that publishes the Forest Products Journal. The Forest Products Journal is one of the few recognized journals in the U.S. focusing on forest products' materials science and marketing-related topics (Rank, 2017). The members of the FPS were believed to be working on wood or wood-based materials for their jobs, thus, included in the sample.

As far as the FP industry is concerned, the Big Book version 2017 provides the most comprehensive and complete directories that covers all states in the U.S. It also include contacts of mills, distributors, and exporters of the wood products. The list of the sample contained the names, the names of companies, emails, the positions within the organizations that are likely working with FP directly. Each respondent from the Big

Book was selected primarily if only one e-mail was provided with the identification. If there were several contacts, a respondent was decided according to the following order: the one who was 1) in charge of quality control, 2) holding the second highest ranks at each company, such as vice president, 3) a branch manager, 4) a general, sales, or operation manager, or 5) an associate or assistant. After the first list-up, there were companies that did not provide their e-mails to the Big Book. Accordingly, more effort was made to determine the unlisted contacts or contacts that were more relevant by visiting the companies' websites when official websites were available. In order to select right subjects, the general role of each position was briefly reviewed on recruitment websites, such as LinkedIn, Monster, and Indeed. For cases that a person held multiple positions (e.g. President and Sales Manager), the one with a higher position or rank represented the person. If no websites of certain firms were available on the Big Book, Google was used to confirm the availability. For example, there were 347 wholesalers in the southern region where 149 e-mails were provided in the book. After online research, 31 additional e-mails were found and added to the list. When the websites did not list e-mail contacts on their websites, those were left unfilled and excluded from the final survey list. The reason was that this study aimed at using only the resources and contacts that were available online in validating the contact information.

Further, part of the members of Stairbuilders and Manufacturers Association (SMA) were included in the sample that the advisor became aware of at 2017 annual SMA conference. The members of SMA are comprised of architects, builders, manufacturers of stairs. For the academic sector, graduate students, faculty, and staff at educational institutes or research centers who likely conducted research in the wood or wood-based material fields were included in the sample frame.

Members of the FPS were selected to represent the academia sector and some of the FP industry (Figure 3.1). Out of total 877 members registered on the website (as of February 17, 2017), 847 emails were refined to be usable. 45% of the e-mail holders, 384 members, were individual members who were either faculty or staff of institutions or representatives of companies. Whereas, approximately 14% of them, 120 members, were student members. Organization members of 121 (14%) and retired members of 85 (10%) were also included in the sample. Developing country members that include both individuals and student members were 5% of the total.

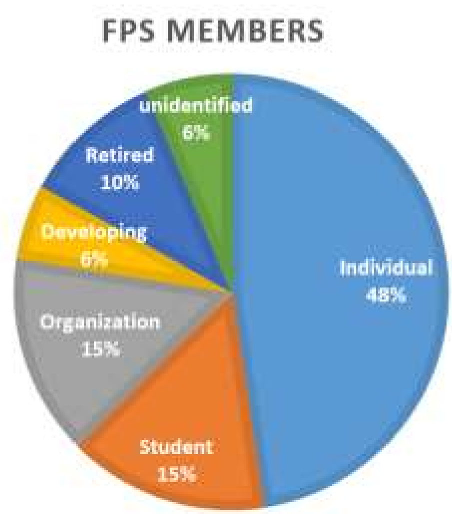

Figure 3.1 FPS member distribution (n=877)

Source: (Society, 2017)

Contacts listed multiple times in the different categories (the Big Book, the FPS, and SMA) were deleted to appear only once on the list. In addition, the collection was aimed at the plant or branch levels. Thus, firms that had multiple locations may participated more than one time. However, if a single person managed multiple branches or plants, it was viewed as a single entity. Thus, only one participation was required. For example, a lumber mill has three offices in Arizona in which of two offices are managed by one production manager. In this case, the production manager will participate for the survey on behalf of two offices.

Survey development

Table 3.2 shows surveys conducted in the FP sector. These studies were more oriented toward eBusiness, such as use of the internet in the business or readiness for eCommerce (Delton Alderman, Duvall, Smith, & Bowe, 2007; D. Alderman, Smith, & Bowe, 2007; Arano, 2008; Fontenot, Vlosky, Wilson, & Wilson, 1997; Shook et al., 2002; Vlosky, 1999; Vlosky & Smith, 2003; Vlosky & Westbrook, 2002; Vlosky et al., 2002; Wilson & Vlosky, 1997). Previous FP studies used mail and phone surveys as means of data collection. The context of an online survey is different from that of mail or phone surveys. Thus, a questionnaire was developed specifically for this study to uncover the status of the use of smartphones and smartphone apps in the FP industry and the attitudes toward a smartphone app that measures stiffness of wood.

Table 3.2 Examples of publications conducting survey in FP

Title of the paper	Author	# of responses	Survey type	Year*
Effect of buyer-seller relationship structure on firm performance	Fontenot, *et al.*	434	Mail	1997
E-business in Forest Products industry	Vlosky	200~	Mail	1999
An exploratory study of internet adoption by Internet adoption by primary wood manufacturers in the western United States	Vlosky, *et al.*	215	Mail	2002
Ebusiness exchange between homecenter buyers and wood products supplies	Vlosky and Westbrook	70	Mail	2002
The use of e-business in secondary wood (telephone)	Shook, *et al.*	780	Phone	2002
eBusiness in the U.S. hardwood lumber industry	Vlosky and Smith	175	Mail	2003
Eastern white pine secondary manufacturers: Consumption, markets, and marketing	Alderman, *et al.*	111	Mail	2007
Eastern white pine: Production, markets, and marketing of primary manufacturers	Alderman, *et al.*	441	Mail	2007
Electronic commerce adoption in West Virginia's primary and secondary hardwood industries: preliminary results	Arano	56	Mail	2009

* The years refer to years of publications, studies were usually conducted one or two years prior before they were published.

The questionnaire consisted of four parts. Part 1 collected demographic information, such as, occupational field, position, age, and work location, while part 2 gathered information about smartphone ownership and the use of smartphones and smartphone apps; part 3 queried regarding usefulness of wood stiffness that the app could provide; part 4 asked about participants' interest levels and acceptable price levels for the app.

The construct "usefulness of the stiffness information of wood material" was defined as "the degree people working on and with wood or wood-based materials are in need of the stiffness property of wood material to enhance their job performance". The majority of the questions were closed-response items, as it could reduce participant's efforts in responding in terms of time and writing (Robert L. Johnson, 2016). The questionnaire had twenty-two questions that were mostly nominal scale (Yes or No), Likert scale (strongly agree to strongly disagree), and a few open-ended questions. Questions related to the demographic were included for analytical purposes. Items regarding attitudes were rated on a five-point scale (Likert scale) that ranged from strongly disagree (1) to strongly agree (5). For the construct "usefulness of the stiffness of wood", multiple questions were developed to capture the attitude because it was a rather abstract idea, which the respondents may or may not have an exact answer for. It also might have required more thought to answer, than other questions that simply asked for "yes" or "no" answers.

The survey implemented several methods to increase the benefits of participation to motivate participants to respond to the survey. Those benefits included providing information about the survey, asking for help, appreciating, and showing support for shared values (Dillman et al., 2011).

Research context was the key factor that the survey needed to be short, straightforward, and easily understandable. The FP industry was known to be conservative and late to adopt new methods, therefore, a low response rate to the survey was a major concern. As a result, the survey was designed to have the minimum number of questions to prioritize a higher response rate. Dillman also indicated that the first objective of good questionnaire is high responses (Dillman et al., 2011). A logo of Mississippi State University was attached at the top of the questionnaire to increase credibility of the survey.

When the items were developed, several revisions were made to avoid ambiguity or confusion. The items used positive wording and sentences that are complete and short to clearly state each question's intent. Further, use of multiple-meaning words or technical terms was avoided to minimize reading demands considering unknown cognitive skills of the respondents.

Neutral point (neither agree nor disagree) was also included to demonstrate audience's indifference in the questionnaire. "Don't know" and "Not applicable (N/A)" options were also included to avoid faulty or fictitious responses. The first question "Do you work with any kind of wood or wood-based products?" was intended to assure the qualification of the respondents. If the response was "No" to the first question, the survey was closed and submitted. The survey was also designed to be mobile phone friendly, so that potential respondents who might take the survey on their mobile phones would find it easy to complete.

Overview of the questionnaire

The questionnaire (Appendix A) was reviewed prior to the execution of the survey by the advisor, committee members, and other experts. They reviewed the wordings, scales, order, and content of the questions. The questionnaire was also reviewed and approved by the Institutional Review Board for the Protection of Human

Subjects in Research (IRB) of Mississippi State University. The questionnaire was pretested with 30 SMA members before distribution.

Procedure

After the sample for the data collection was determined, email invitations that contained a "start survey" button directing readers to the survey were sent to 1,221 participants. SurveyMonkey, an online survey service provider, administrated the survey. SurveyMonkey recorded the data and exported it to an Excel file when the survey was completed. Then, the survey data was subsequently imported to statistical software (SPSS) to perform statistical analyses. The average response rate to an e-mail survey was reported to be approximately 20 percent (Kaplowitz, Hadlock, & Levine, 2004). In the case of a lower response rate, in-depth interviews were scheduled as an alternative.

The participants could take this survey at their convenience. The survey required approximately or less than 5 minutes per participant. This time required to take the survey was considered to decrease the cost of participation in terms of time commitment. One of the biggest concerns in taking survey was known to be the time that requires to complete the survey (Dillman et al., 2011).

The data collection began on May 5, 2017 and closed on May 15, 2017. The first invitation was sent on May 5, 2017. Then, two reminder e-mails were sent to encourage participation to yield a higher response rate. Those email invitations can be found in Appendix B. One study toward undergraduates illustrated that reminders on the web-based survey had a positive impact to the response rates (Wygant, Olsen, Call, & Curtin, 2005). The first reminder was sent 4 days after the first e-mail on May 9, 2017 to those who had not completed the survey; the first reminder yielded a fair amount of additional responses: 92 responses (30% of the total). Thus, the second reminder was sent 3 days after the first reminder on May 12, 2017. However, only up to two reminders were used because there was a concern that more reminders may cause irritation to the potential respondents.

Method of analysis

Data was analyzed using SPSS statistics version 24 mainly for descriptive statistics: frequency and percentage. Additionally, an analysis of variance (ANOVA) table was also used to compare the means of variables. To have clear and straightforward results, age groups (8 different groups) or levels of agreement (5 levels from "strongly disagree" to "strongly agree", were consolidated into a lesser number of categories. For example, age groups were simplified to three generations (Millennials, Generation X, and Baby Boomers), while the level of agreement was reduced to three levels ("disagree", "neutral", and "agree"). Comparison of different groups toward questions was analyzed using one sample t-test, two sample t-test, and ANOVA. The level of significance used in the difference comparison was 0.05.

Response

Out of 1,221 invitations, the total number of valid surveys was 1,144 surveys after considering individuals who opted-out and those who had unreachable accounts. Of the valid survey invitations, 311 responses were returned at the response rate of 27.2 percent. In the FP industry from 2000 to 2015, the median response rate for published works was 26 percent, and the number of responses received was 131.5 (Bumgardner, Montague, & Wiedenbeck, 2017). Compared to the survey average of the FP industry according to the study by Bumgardner, the response rate in this survey was slightly higher. Whereas, the number of responses received was higher than the industry average by nearly 1.4 times. Considering that there was no compensation provided to the respondents, it yielded a satisfactory response rate.

Nonresponse bias

Non-response bias was evaluated by comparing early responses with late responses. Means of early 10 percent and late 10 percent responses were compared using independent sample t-tests at the alpha level of 0.05. No difference was observed between early and late responses for question 15 and 17.

Other bias

The survey took the pretest to minimize measurement error that might occur with questions.

CHAPTER IV

RESULTS AND DISCUSSION

Respondent demographic characteristics

Of each responding group, the FPS and SMA showed the highest responding rates of 31.8 percent and 33.3 percent, respectively. Lumber manufacturers followed at the rate of 15.6 percent, while the responding rates of import and export firms (11.9%) and wholesale and retail businesses (9.4%) were below the average (27.3%). Of 311 valid responses, 290 responses were qualified for analyses with a screening question. 21 responses that were disqualified were omitted from the study. Table 4.1 demonstrates demographic characteristics of the survey respondents.

Table 4.1 Demographics of survey respondents

Item	Frequency	Percentage	True percentage*
Age**			**n=274**
18-22	2	0.6%	0.7%
23-30	27	8.7%	9.9%
31-38	35	11.3%	12.8%
39-46	40	12.9%	14.6%
47-54	49	15.8%	17.9%
55-62	63	20.3%	23.0%
63-70	42	13.5%	15.3%
Over 71	16	5.1%	5.8%
Choose not to respond or skipped including not qualified	37	11.9%	-
Total	311	100%	100%
Occupational field			**n=283**
Academia	112	36.0%	39.6%
Industry	113	36.3%	39.9%
Engineering	21	6.8%	7.4%
Government	11	3.5%	3.9%
Consult	7	2.3%	2.5%
Other	19	6.1%	6.7%
Skipped including not qualified	28	9.0%	-
Total	311	100%	100%
Business Category			**n=282**
Education & Research	138	44.4%	48.9%
Lumber	59	19.0%	20.9%
Engineered wood	15	3.2%	3.5%
Chemical	10	4.8%	5.3%
Other	60	19.3%	21.3%
Skipped including not qualified	29	9.3%	-
Total	311	100%	100%

*True percentage omitted "not to respond" or "skipped" responses that may include disqualified respondents for this survey. The sample sizes differ for true percentages.
**represents age when the survey data was collected.

The age group including 55 to 62 years olds comprised the biggest portion (23.0%) of the total survey respondents. The age groups were, then, re-categorized to three different generations (Millennials, Generation X, and Baby Boomers) for analyses (Table 4.2). Baby Boomers consisted nearly 45 percent of the respondents, but when respondents over 71 years old were excluded, Baby Boomers actually accounted for 38.3% of respondents. Thus, one third of respondents fell into Generation X, and less than one fourth of respondents were Millennials. Learning from the result, more Generation X and Baby Boomers were surveyed in the FP industry than Millennials.

Table 4.2 Generation categorization of the survey respondents (n=274)

Age	Frequency	Ratio	Generations	Frequency	Ratio
18-22	2	0.7%	Millennials (1978-1994)	64	23.4%
23-30	27	9.9%			
31-38	35	12.8%			
39-46	40	14.6%	Generation X (1963-1977)	89	32.5%
47-54	49	17.9%			
55-62	63	23.0%	Baby Boomers (1946-1962)	121	44.2%
63-70	42	15.3%			
Over 71	16	5.8%			

* The years for generations differ by studies, thus, redefined for this study.

When the respondents were classified according to their occupational fields, two-fifths (39.6%) of the total respondents were in academic fields while nearly the same percentage (39.9%) of the respondents worked in industry. For analysis purposes, the classification was consolidated into two groups: academia (academia and government) and industry (industry and the rest) as displayed in Table 4.3.

Table 4.3 Occupational field re-categorization of the survey respondents (n=283)

<table>
<tr><th>Items</th><th>Frequency</th><th>Percentage</th><th>Items</th><th>Frequency</th><th>Percentage</th></tr>
<tr><td>Academia</td><td>112</td><td>39.6%</td><td rowspan="2">Academia & Research</td><td rowspan="2">123</td><td rowspan="2">43.5%</td></tr>
<tr><td>Government</td><td>11</td><td>3.9%</td></tr>
<tr><td>Industry</td><td>113</td><td>39.9%</td><td rowspan="4">Industry</td><td rowspan="4">160</td><td rowspan="4">56.5%</td></tr>
<tr><td>Engineering</td><td>21</td><td>7.4%</td></tr>
<tr><td>Consulting</td><td>7</td><td>2.5%</td></tr>
<tr><td>Other</td><td>19</td><td>6.7%</td></tr>
</table>

Of the 283 respondents who responded to the occupational field question, 43.5 percent (frequency=123) were reclassified as academia and research adding the number of respondents who work at governmental organizations to academic occupants. The remainder of respondents who identified themselves as working in industry, engineering, consulting, and other fields were classified as industry for the purpose of analyses. The governmental and consulting occupations were not listed in the original questionnaire. However, these two occupations were later added due to its high number of responses.

After posing the question, “Which category best represents your organization or you?” 48.9 percent of respondents indicated that they worked in education and for a research business out of 282 valid responses. One fifth of respondents (20.9%) were engaged in lumber, followed by chemical (5.3%) and engineered wood (3.5%) businesses.

Of the 269 responses to the question of organization location by state, 51 respondents were from non-U.S. locations that constituted the highest proportion (19%) of the total responses. This might be due to the FPS’s international members.

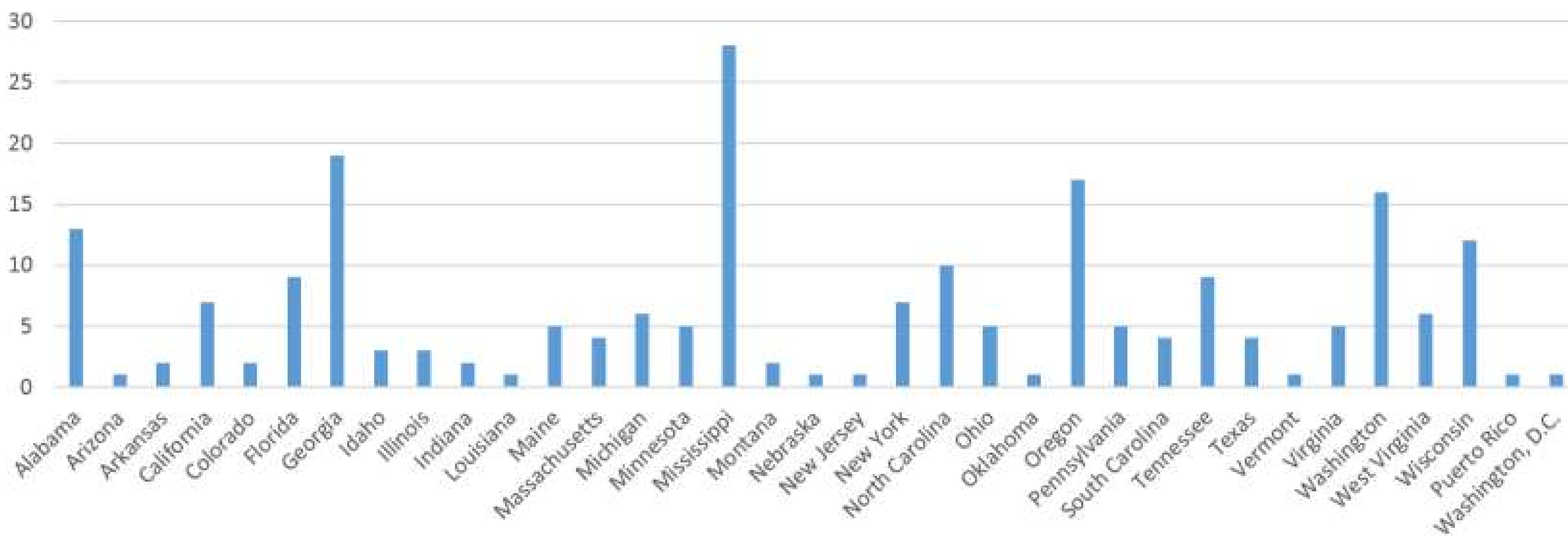

Figure 4.1 Frequency of respondents in various states throughout the U.S. Respondents located outside of the U.S. were excluded (n=269).

With 12.8% of 218 respondents, excluding internationals, Mississippi had the largest proportion of respondents in the U.S., followed by Georgia (8.7%), Oregon (7.8%), Washington (7.3%), and Alabama (6.0%) (Figure 4.1). The number was limited to these 35 states, as the study focused on the southern regions of the U.S. for lumber manufacturing, wholesale, and retails listed in the Big Book.

Use of smartphones and smartphone apps

Use of smartphones

Respondents were asked whether they had a smartphone, and 95.7 percent of respondents said that they did have smartphones (n=282), whereas only 68% of the U.S. population in 2016 reported having smartphones (Figure 4.2). This indicated that majority of respondents had access to the internet as well as app markets with their phones, such as the App Store for Apple apps and the Google Play for Android apps. The questionnaire also asked "What platform does your phone use?", and 52.3 percent (or 139 responses) of respondents answered that they used iOS, while only 39.5 percent of respondents said their smartphone platform was Android (n=266). Over half of the respondents appeared to be potential users of the App Store. Some respondents indicated that they used Windows Mobile and Blackberry OS as their mobile operating systems, however, the share (3%) was less noticeable.

Figure 4.2 demonstrates that Apple was the most popular smartphone brand, being utilized by 54.7% of respondents, distantly followed by Samsung (29.4%) (n=265). LG (3.4%), Microsoft (0.8%), blackberry (2.6%), Motorola (3.0%), and other brands constituted the rest of the share.

Figure 4.2 Percentage of respondents regarding smartphone ownership (n=282), operating platforms (n=266), and smartphone brands (n=265).

Use of smartphone apps

To learn how respondents used smartphone apps personally as well as for work, two questions were asked for respondents to indicate frequency of their app uses (1=never; 3=sometimes; 5=always) (Table 4.4).

Table 4.4 Ratings of respondents' smartphone apps uses

Questions	observations	Mean (Std. dev.)
Do you use mobile phone apps for personal use?	n=265	3.84 (0.92)
Do you use mobile phone apps for work?	n=266	3.17 (1.12)

(1=never, 3=sometimes, 5=always)

Of the 265 respondents, 43.8 percent responded that they often used apps personally which was indicated with the mean score (3.84) close to 4 (4=often). Using one sample (two-tail) t-tests, the frequency of apps use (3.84) from never (1=never) was statistically different (p<0.0005).

At least two of the groups amid Millennials, Generation X, and Baby Boomers showed differences in the level toward the personal use of apps, and it was statistically significant ($p<0.0005$). The differences between Millennials and Baby Boomers and also Generation X and Baby Boomers toward the personal use of apps were found to be statistically significant ($p<0.0005$). Respondents of Millennial and Generation X indicated a higher personal use of apps than Baby Boomers. While there was no significant difference between Millennials and Generation X ($p=0.847$). There were significant differences between Millennials and Baby Boomers ($p=0.038$) and also generation X and Baby Boomers ($p=0.002$). The study also analyzed the data to see if the difference between academic and industry groups exists. There was a difference between academia and industry groups in the personal app use ($p=0.012$) at the alpha level of 0.05. Respondents who work in academia indicated more personal use of apps than industry.

The use of apps for work was less frequently observed (mean=3.17) from responses. To compare the mean (3.17) from value of 1 (1=never), the difference was statistically significant ($p<0.0005$). The differences in generations and business types were insignificant for the app use for work. Overall, respondents were found to be using apps for personal means more often than for working purposes.

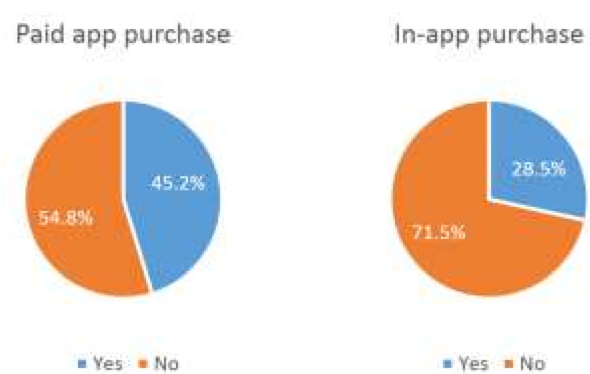

Figure 4.3 Paid app (n=263) and In-app purchase (n=266) experience.

Respondents were then asked if they had purchased a paid app or service while using a free app. As shown in Figure 4.3, slightly over half of the respondents indicated that they had never purchased paid apps (54.8%), whereas, nearly half of respondents (45.2%) had paid-app experience. Apps that respondents paid for included entertainment (music and game), business (scanner and Microsoft office), and utility (unit converter, engineering, and calculator) apps. Of 47 respondents who specified apps they bought, 16 respondents purchased multiple apps for personal as well as business uses.

Compared to the paid-app experience (54.8%), only 28.5 percent of respondents reported that they had purchased service on free apps. The in-app purchases of respondents may be divided into two categories: goods and data. Goods included tangible and intangible (music and e-book) items that can be purchased via online stores. Online stores, such as Amazon and eBay, provide tangible goods. Whereas, data was referred to storage services, for instance iCloud. Across three generations and two business categories (academia and industry), significant differences were not observed at the alpha level of 0.05.

Perception toward the app for doing business

Usefulness of an app

Table 4.5 Analysis for perceived usefulness of the stiffness information of wood by survey respondents

Questions	Observations	Mean (Std. dev.)
Having the ability to measure the stiffness of boards would be useful to me.	n=265	3.34 (1.12)
I need information about the quality of the wood product, namely stiffness, with which I work.	n=264	3.30 (1.09)
The stiffness of board is meaningful information for my work.	n=266	3.40 (1.18)

(1 = strongly disagree, 5 = strongly agree)

Levels of agreement to three questions about usefulness of wood stiffness were obtained from respondents (Table 4.5). A five-point scale ranged from 1=strongly disagree to 5=strongly agree was used. Learning from the mean score of each question, respondents in general implied their opinion either neutral or agreeable to the questions. For all three questions, "agree (4=agree)" was most frequently observed response. After recoding the five-point scale to three-point scale (1=disagree; 2=neutral; 3=agree), the level of agreement became clearer. Approximately 50 percent of respondents agreed (or strongly agreed) that the stiffness information of wood was useful (51.3%, n=265), necessary (48.1%, n=264), and meaningful (54.9%, n=266) for them. Slightly less than one fourth (23.0%, 24.2%, and 22.9% for each question respectively) of respondents disagreed to usefulness of the app.

Current lumber mechanical testers

Table 4.6 Ratings of prices of the current lumber mechanical testers and respondents' purchase intention to the app

Questions	Mean (SD)	Proportion (%)		
		Agree	Disagree	Don't know
Current lumber mechanical testers in the market are too expensive for me (or my company) to purchase. *	3.83 (1.40)	35.8	16.0	17.5
I would purchase an App if it costs less than current testing devices. **	3.48 (1.57)	28.6	21.4	N/A

*n=263, **n=266

17.5 percent of respondents indicated that they had no grounds to respond whether the current mechanical devices for lumber testing were expensive. To the knowledge of respondents who knew the lumber testers' market, the current lumber mechanical test devices appeared to be costly (Table 4.6). 94 respondents (35.8%) either strongly agreed or agreed that current lumber mechanical testers were too expensive (n=263). Of 266 respondents, one-third (28.6%) expressed their willingness to buy an app if it is less expensive than testing devices currently available in the market.

Interest level to the app

Table 4.7 Attitude ratings of interest level toward the app (n=263)

I would be interested in an app to measure lumber quality, such as stiffness, if it is reasonable accurate.	Not at all interested (= 1)				Very interested (= 5)	N/A	Total
Observations	27	34	80	68	48	6	263
Proportion (%)	10.3	12.9	30.4	25.9	18.3	2.3	100

(1 = not at all interested, 3 = somewhat interested, 5 = very interested)

All respondents were asked to rate how much they would be interested in a lumber quality measuring app. 74.6 percent of respondents recorded their level of interest for the app from "somewhat interested" to "very interested" (n=263) (Table 4.7). Within the affirmative responses, the most frequently observed was "somewhat interested (30.4%)", followed by "interested (25.9%)" and "very interested (18.3%). The proportions were indications that the respondents were less enthusiastic about the app. They appeared to be interested because there were no such products available on the market when the survey took place. Whereas, less than one fourth of respondents (23.2%) were either "not at all interested" or "not interested" in the app. The interest levels across the three generations were analyzed using ANOVA for a mean comparison. There were significant differences between at least two out of the three generations for the question (p=0.029). As shown in Figure 4.4, Millennials indicated the highest interest level for the app than Baby Boomers with the difference between generations significant (p=0.032). No significant differences were observed between Millennials and Generation X, and Generation X and Baby Boomers. For different business categories, there was no significant difference (p=0.113).

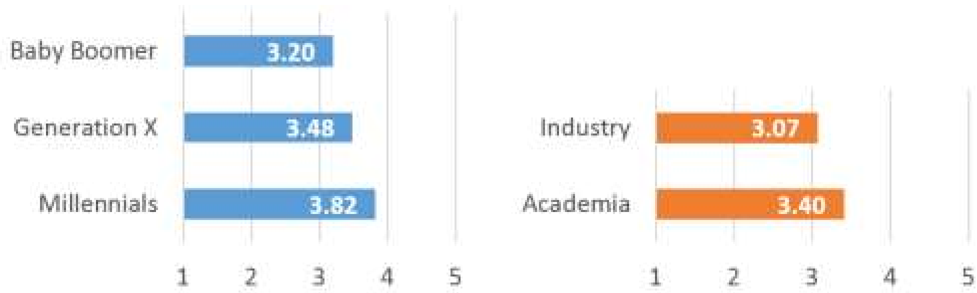

Figure 4.4 Ratings of interest level toward the app by generations and business types

Scale: 1=strongly disagree, 5=strongly agree, number of respondents: Baby Boomer (n=193), Generation X (n=29), and Millennials (n=28); industry (n=83), academia (n=173)

Price of the app

When respondents were asked “I would likely buy an app that measures stiffness of lumber if the price is $____”, the most frequently observed answer was “over 12.” 15.9 percent of respondents selected $4.99 as the second most observed price tag for the app (Table 4.8).

Table 4.8 Frequency observations of estimated price for the app (n=176)

Amount	Over $12	$4.99	$0.00	$9.99	Other
Frequency	36	28	26	26	60
Proportion (%)	20.5	15.9	14.8	14.8	34.0

The open question asking “I think US$_____ is an appropriate price for the app.” resulted in great variances. The lowest amount that the respondents thought appropriate for the app was $0.00 that the app should be free. The highest price was recorded to be $42769.00, which was considered an outlier. 21.5 percent of respondents reported that

$5.00 was an appropriate price for the app, followed by $10.00 (20.1%), $0.00 (8.6%), and $50.00 and $100.00 (both 5.8%) (Figure 4.5).

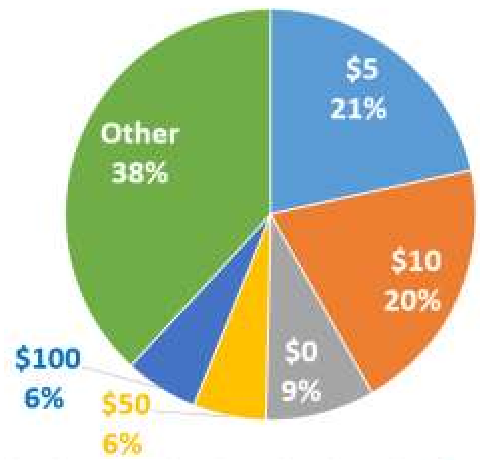

Figure 4.5 Distribution of prices estimations for the app (n=157)

Looking at both questions asking about the price, one closed and the other open-ended question, only 14.5 percent (closed question) and 8.6 percent (open-ended question) of respondents thought that the app should be free. The responses reflected that respondents were willing to pay for such app. A fair number of respondents were willing to pay more than $12 for the app, 20.5 percent and 33.1 percent for closed and open-ended question respectively. Other amounts of the price estimation reported more than one time included $0.99, $1.00, $2.00, $4.00, $4.99, $15.00, $20.00, $25.00, $30.00, and $200.00.

Concerns and suggestions for the app

Concerns about the app

The app is probably the first service in the FP industry that enables potential users to measure the stiffness of wood without additional necessity of devices. The measurement (stiffness of wood) has been obtained by mechanical testing devices that not everyone had access to. Thus, it was assumed that there might be various concerns in regard to function, direction, and results of measurement. Accordingly, the survey asked what would be respondents' concerns about the app; respondents were able to select all concerns that apply to them. The biggest concern was expressed to be "accuracy of the app (80.2%)". Other concerns in descending order were "ease of use (53.0%)", "price (34.8%)", and "speed of the app (27.1%)." Numbers of respondents added their own concerns to the app. One of the biggest concerns that was not listed in the questionnaire was application of the app. Questions were raised regarding applications, such as sizes (thickness, width, and length) and species of wood samples. It was also suggested by several respondents that the direction of use should be clear, and it should be recognized by legitimate agencies or organizations in the FP industry for reliability and accuracy of the results. It was expected that respondents might question security of the app according to the previous studies in eBusiness segment. However, there was only one respondent listed security as one of his/her concerns.

Suggestions for the app

Table 4.9 Classification of suggestions

Category	Design	Workability	Market	Function*	Others**
Observations	23	11	9	4	29
Details	application, function, direction, technology	accuracy, ease of use, and price	industries, target market	moisture content, strength	encourage ment, N/A, no use

Number of responses=76
* Extra functions that respondents needed than the app proposed to provide.
** Others included non-suggestions and other suggestions that were not classified.

The survey included an open-ended question implying its willingness to have suggestions that respondents may have for the app. 76 respondents, which was 26 percent of the valid respondents, specified their suggestions for the app. This great number of suggestions was appreciated to give the research exploratory insights. The suggestions were reclassified to six categories to learn overall concepts from them (Table 4.9). They were categorized to issues of design, workability, market, extra needy functions, and others. Approximately one third of suggestions (34.2%) given by respondents was not actually suggestions. They responded with cheering messages, or statements that the app would not be useful or applicable to them. Next, there were suggestions (30.3%) about the design of the app that included application, function, direction, and technology issues. A number of respondents suggested that the app should indicate what products (lumber or composite panels), species or size of samples could be used in the app. A storage function was suggested to be useful. Another respondent recommended that the app should let users know of the limitation, which further details about the limitation were not specified. A few respondents were aware that weight was necessary information for calculating the result (stiffness). Thus, they encouraged to include how to prepare such numerical inputs in the app. There were also a couple of technology related suggestions. They mentioned uses of microphone or accelerometer built in smartphones to measure frequency or velocity for result calculations. Workability-related suggestions (14.5%) dealt with accuracy, ease of use, and price topics. A few respondents stated that the app should prove the workability, especially accuracy and reliability, by having a trial period or testing with the industry. One response was about the need of verification of the accuracy with available equipment to develop a relationship/correction factor. Some other suggestions regarding workability included user friendliness and simple operation. There were also suggestions about markets or marketing methods (11.8%). One respondent suggested a molded furniture part sector as a potential market. Whereas, a respondent working on export segment discouraged the idea that the exporting market was primarily an appearance grade market. Those suggestions made by respondents can be of useful resources for further research and the app development. The list of the suggestions are displayed in Appendix C.

CHAPTER V

CONCLUSIONS

This study explored how the respondents in the FP industry viewed the use of advanced technology, focusing on smartphones and smartphone apps in their work. The eBusiness sector was examined due to the limited availability of secondary materials for primary research in the smartphone use. Literature indicated that the use of eBusiness was laggard in the FP industry. The reluctance of adopting new systems or programs existed on online communities. However, compared to the early research in the FP industry, there were improvements of IT adoption that majority of companies built websites and used e-mail for business.

Further, some smartphone apps relevant to the FP industry were available. There were a few published literatures on reliability and accuracy of apps that measure tree and wood board attributes including tree species, height, diameter, and a basal area. On the app market, more smartphone apps regarding forest products were observed. Those apps helped users to manage inventory and corporate resources, provided wood working information, and aided in measuring characteristics of forest products.

From the survey, nearly all of the respondents (95.7%) had smartphones, and over half of them were iOS users (52.3%). Respondents used their smartphone apps more personally than for work. Respondents working in academia and research showed a higher apps usage for personal purposes than the industry group, while younger generation (Millennials) indicated more frequent use of smartphone apps than other generations. When responses to the paid app and in-app purchase experience were examined, more respondents purchased paid apps (45.2%) than in-app purchase on free apps (28.5%) by nearly two times. This indicated that nearly half of the respondents might be potential consumers of paid apps. In addition, for the same service, paid apps can be more likely of respondents' interests than in-app purchases.

Responses regarding perceptions toward the app were reviewed. The respondents found that the app could be useful for their work. At the same time, they were interested in the app. The perceived usefulness and a high interest level appeared to give positive signs for the app development. Millennial respondents were more interested in the app than other respondents who were Baby Boomers and Generation X. Therefore, it was assumed that the app can be more attractive to Millennial respondents. There were more respondents who were willing to pay for the app than who wanted the app free of charge. $5 (or $4.99), $10 (or $9.99), or over $12 seemed possible price tags that respondents suggested for the app.

The biggest concern about the app was accuracy, followed by ease of use, price, and speed of the app. A great portion of the suggestions given by the respondents was to confirm the accuracy of the results of the app. Other suggestions included application, function, direction, and technology issues, as well as, ease of use, and price topics.

CHAPTER VI

LIMITATIONS AND FUTURE RESEARCH

The study adopted the convenience sampling method, as opposed to simple random sampling, to conduct the survey. The sampling method had possibly caused sampling error that the findings from this survey may be different from the true values for the population of interest. The survey drew the sample from certain associations (or institutes), such as the FPS, and regions (southern U.S.) that were available to the researcher. Furthermore, the survey mode (online survey via e-mail invitation) may not provide adequate coverage of the population that this study aimed to reach. As mentioned in the previous section, the FP industry is less advanced in the use of the internet and new technologies, however, email survey requires the internet connection in order for participants to have access to the survey. Thus, this study did not attempt to generalize the observations to represent the entire population of interest who work with wood or wood-based materials on their job sites. In order to validate the summary derived from this study, replication of the study with either random sampling or convenience sampling may be necessary. Due to the lack of antecedent research in the FP industry about smartphones or smartphone apps, the study should be considered exploratory.

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APPENDIX A

QUESTIONNAIRE

Part 1. Demographic information

1. Do you work with any kind of wood or wood-based product? (a screening question)
   - Yes
   - No, if the answer is No, please close the survey.
2. What is your occupational field?
   - Academia
   - Industry
   - Engineering
   - Do-It-Yourself
   - Other: please specify
3. What is your title or position?
4. What type of business best represents your organization? (select all that apply)
   - Education & research
   - Manufacturing
   - Wholesale & retail
   - Consulting
   - Contractor
   - Carpentry
   - Other: please specify
5. Which category best represents your organization or you?
   - Education & research
   - Lumber
   - Home-center
   - Hardware
   - Home-deco, floor
   - Do-It-Yourself
   - Other: please specify
6. Which category below includes your age?
   - 18-22
   - 23-30
   - 31-38
   - 39-46
   - 47-54
   - 55-62
   - 63-70
   - Over 71
   - Choose not to respond
7. In what state is your organization located?

Part 2. Smart phone ownership and the use of mobile phone applications

8. Do you have a smartphone? (Primarily business phone if you have more than one.)
   - Yes

- No, if the answer is No, please go to question 15.

9. What platform does your phone use?
    - iOS
    - Android
    - Don't know
    - Other: please specify
10. What is the brand of your phone?
    - Apple
    - Samsung
    - LG
    - Microsoft
    - Other: please specify

The scale for question 11 and 12: 1=Never, 2=rarely, 3=sometimes, 4=often, 5=always

11. Do you use mobile phone apps for personal use?
12. Do you use mobile phone apps for work?
13. Have you ever purchased a paid app?
    - Yes
    - No
    - If yes, what apps?
14. Have you ever purchased services on a free app?
    - Yes
    - No
    - If yes, what apps?
    - Choose not to respond

Part 3. Usefulness of wood stiffness

15. Please select from the following ("Strongly disagree", "Disagree", "Neither agree nor Disagree", "Agree", "Strongly agree.")
    - Having the ability to measure the stiffness of boards would be useful to me.
    - I need information about the quality of the wood product, namely stiffness, with which I work.
    - The stiffness of boards is meaningful information for my work.

Part 4. Interest and acceptable price levels to the App

16. Please select from the following (“Strongly disagree”, “Disagree”, “Neither agree nor Disagree”, “Agree”, “Strongly agree”, Don’t know)
    - Current lumber mechanical testers in the market are too expensive for me (or my company) to purchase.
17. I would be interested in an App to measure lumber quality, such as stiffness, if it is reasonably accurate. (“Not at all interested”, “Not interested”, “Somewhat interested”, “Interested”, “Very interested”, N/A)
18. I would purchase an App if it costs less than current testing devices. (“Strongly disagree”, “Disagree”, “Neither agree nor Disagree”, “Agree”, “Strongly agree”, Don’t know)
19. I think US$___ is an appropriate price for this App.
20. I would likely buy an App that measures stiffness of lumber if the price (US$) is
    - 0
    - 0.99
    - 1.99
    - 2.99
    - 3.99
    - 4.99
    - 5.99
    - 6.99
    - 7.99
    - 8.99
    - 9.99
    - 10.99
    - 11.99
    - Over 12

21. About the App, my concerns are (select all that apply)
    - Accuracy
    - Ease of use
    - Speed of the App
    - Price
    - No concerns
    - Other: specify

21. About the App, my suggestions are

APPENDIX B

THE SURVEY INVITATIONS

The first invitation

From: Han, Songyi
Sent: date, month, year, time
To: name of the participant
Subject: Mississippi State University Research Invitation

Date: May 00, 2017

Department of Sustainable Bioproducts,
Mississippi State University
Box 9820, Mississippi State, MS 39762
Email: sh2350@msstate.edu
Phone: 662-518-0253

Dear First and last name,

Greetings:
I am a graduate student at Mississippi State University, and this is part of my graduate degree program.

The Sustainable Bioproducts Department at Mississippi State University is conducting research on market attitudes regarding a smartphone App that measures the stiffness of lumber. We are seeking opinions from industry and academia to better understand the market's attitudes toward the technology (the smartphone App).

We are contacting you because we believe you are working with wood or wood-based products. To gather information, we hope you can answer a few questions over the internet.

You can access to the survey by clicking "Begin Survey" button below. Your responses will be completely confidential. To ensure your anonymity, your name will not be attached to any results. You will be able to complete it within 5 minutes or less. Your participation is voluntary, and you can skip questions or discontinue the survey at any point. However, your response is essential to the success of this study and the completion of my graduate degree here at Mississippi State University.

The survey is web-based and conducted by SurveyMonkey. In regard to the privacy policy, please visit "Privacy Policy" and "Security Statement" with the URLs below to learn how SurveyMonkey handles respondent data.

- Privacy Policy by SurveyMonkey: https://www.surveymonkey.com/mp/policy/privacy-policy/
- Security Statement by SurveyMonkey https://www.surveymonkey.com/mp/policy/security/

We appreciate your willingness to participate and share your valuable opinions with us.
Should you have any questions, please contact me by phone at (662) 518- 0253 or e-mail: sh2350@msstate.edu.

Many Thanks,
Songyi "May" Han
Graduate Student
Graduate Research Assistant

The first reminder

From: Han, Songyi
Sent: date, month, year, time
To: name of the participant
Subject: Mississippi State University Research Invitation

Date: May 00, 2017

Department of Sustainable Bioproducts,
Mississippi State University
Box 9820, Mississippi State, MS 39762
Email: sh2350@msstate.edu
Phone: 662-518-0253

Dear First and last name,

Greetings:
This is to encourage you to help our research study on attitudes toward a smartphone App measuring lumber stiffness. We sent the first invitation email 5 days ago.

If you have not yet participated the survey, please click "Begin Survey" button below and answer a few short questions. The survey will only take 5 minutes or less to complete.

Your participation is voluntary, and you can skip questions or discontinue the survey at any point. However, your response is essential to the success of this study and the completion of my graduate degree here at Mississippi State University. Your responses will be completely confidential. To ensure your anonymity, your name will not be attached to any results.

The survey is web-based and conducted by SurveyMonkey. In regard to the privacy policy, please visit "Privacy Policy" and "Security Statement" with the URLs below to learn how SurveyMonkey handles respondent data.

- Privacy Policy by SurveyMonkey: https://www.surveymonkey.com/mp/policy/privacy-policy/
- Security Statement by SurveyMonkey https://www.surveymonkey.com/mp/policy/security/

We appreciate your willingness to participate and share your valuable opinions with us.

Should you have any questions, please contact me by phone at (662) 518- 0253 or e-mail: sh2350@msstate.edu. Thank you so much in advance!

Sincerely,

Songyi "May" Han
Graduate Student
Graduate Research Assistant

The second reminder

From: Han, Songyi
Sent: date, month, year, time
To: name of the participant
Subject: Mississippi State University Research Invitation

Date: May 00, 2017

Department of Sustainable Bioproducts,
Mississippi State University
Box 9820, Mississippi State, MS 39762
Email: sh2350@msstate.edu
Phone: 662-518-0253

Dear First and last name,

Greetings:

This is the second reminder requesting your help in our research study on attitudes toward a smartphone App measuring lumber stiffness. We sent the first invitation on _______ and the second 00days ago.

As your opinions will be tremendous help for us to understand the market, if you have not yet participated the survey, please click the "Begin Survey" button below and answer a few questions. The survey will only take 5 minutes or less to complete.

Your participation is voluntary, and you can skip questions or discontinue the survey at any point. Your responses will be completely confidential. To ensure your anonymity, your name will not be attached to any results.

The survey is web-based and conducted by SurveyMonkey. In regard to the privacy policy, please visit "Privacy Policy" and "Security Statement" with the URLs below to learn how SurveyMonkey handles respondent data.

- Privacy Policy by SurveyMonkey: https://www.surveymonkey.com/mp/policy/privacy-policy/
- Security Statement by SurveyMonkey https://www.surveymonkey.com/mp/policy/security/

We appreciate your willingness to participate and share your valuable opinions with us.

Should you have any questions, please contact me by phone at (662) 518- 0253 or e-mail: sh2350@msstate.edu. Thank you so much in advance!

Sincerely,
Songyi "May" Han
Graduate Student
Graduate Research Assistant

APPENDIX C

SURVEY SUGGESTIONS BY RESPONDENTS

Table C.1 Suggestions for the App from the respondents

Design* (application, functions)	Market	Workability** (accuracy, ease, price)	Other information needed	Others
Species correction	Should be a service of industry for costumers, and therefor for free	Need to make sure that it is accurate.		I don't know enough about the app to provide suggestions
Do not focus on stiffness. Most engineers rely on visual grading, which is more accurate and less complicated than estimating stiffness, then correlating the estimated stiffness with strength.	The export market is primarily an appearance grade market. Not really applicable to what we do, but nice to know that its a possibility.	Have industry experience in showing that it works. Be able to work in a noisy environment if measuring frequency.	Does not seem possible	You would need to provide much more information about how it works and how well it works before I'd want to try or buy.
In my opinion, it should be clear to the user what lumber products the App is intended to be used with. It should also be clear if the App is intended to replace current machines (i.e. bending proof loader) or if the App is only intended to provide supplemental information or quick stiffness readings in the field.	This is simply not relevant to me as an Associate Dean for Research. My technical background is not in wood science, so this is not applicable to me professionally either. Best of luck in developing this app. I am sure others will find it of benefit.	If this type of system cannot perform with the precision and accuracy of existing non-destructive techniques, then it would only be useful as a general informational tool and not relevant to research or building construction application.	Soundness is more important to me than stiffness - decay detection in wood in service is critical.	Not enough info given about how the app would work. Acoustical, optical, other and how it would compensate for MC and how it would calibrate for species. Necessary peripheral equipment?
Use "structural strength of wood" instead of "stiffness". Have the app give values of several different characteristics of the wood and how it would apply to a structural.	Understand your target customer group, their needs and cost of competitive products. It is also important to understand your customers working culture, types of products they produce.	To be useful to me, the App must be accurate within +/- 3% compared to a standardized test such as ASTM D198.	Have no need of a product that measures stiffness, if you could come up with an app that could measure moisture content that would be of interest.	
Up to date	Advertise	User friendly	Could it be used to detect rot?	
Make sure folks know limits	No use for our line of marketing and sales of lumber to export markets	Make it very easy to use.		

* Application, functions, direction, and technology

** Accuracy, ease of use, price

Table C.1 (continued)

Design* (application, functions)	**Market**	**Workability** (accuracy, ease, price)**	**Other information needed**	**Others**
The app will only measure the speed. Where to obtain weight information? Maybe come with a simple scale to measure board weight?	I previously worked in molded furniture parts where stiffness from an app would have been great. But a lot more complex than boards and a small niche market.	Collaborate with manufacturers and or testing facilities to verify accuracy.		
I would like to see it applied to testing composite panels - i.e., particleboard, MDF, OSB - for modulus of rupture and elasticity	To provide some more specific information. Stiffness is a vague concept. What EXACTLY are you after? The use of stiffness seems an odd choice. Wouldn't lumber quality or grading be more important? Are you thinking about hardwoods or is this only softwoods. Remember, a large portion of the US is covered in hardwoods and there is a great need to examine quality.	Keep the operation simple. This industry does not always have the most tech savvy operators. Great idea!		
Stiffness itself is not so useful as strength. If you can include strength prediction from stiffness data, it may be more useful.		A phone app that replaces a multi-thousand dollar machine sounds too good to be true. I suggest you offer a trial period so that users can verify effectiveness.		
It should be designed to text for bending strength along with this and other mechanical tests. I wish you all the best. Professor Ajayi Babatunde Dept of Forestry and Wood Technology Federal University of Technology Akure, Ondo State, Nigeria.	I am not very familiar with NDT for wood/wood product stiffness, but here are some thoughts: I imagine much of its importance regards the evaluation of large lumber members. Would the smart phone app be suitable in these cases? How resistant would industry be to adopting this technology even after proven suitable? Price would seem to be a good reason for partial adoption, but engineers/quality control are often set in their ways (often with good reason). Very cool ideal and best of luck!	Stiffness is one of the important criteria for assessing their lumber quality. This idea will be a brilliant result if it meet three conditional such as Accuracy, Easy to be used, and less expensive. However, I believed that you must consider the accuracy as the first main feature.		
Keep it simple and free if possible as it could have implications in education.		Keeping accuracy within a relatively low tolerance would be more appealing to me than speed. Ease of use is somewhat important.		

* Application, functions, direction, and technology
** Accuracy, ease of use, price

Table C.1 (continued)

<table>
<tr><th colspan="5">Design*</th></tr>
<tr><td>Species database with range of values from Wood Handbook etc. for reference. Adjustments for juvenile wood, etc.</td><td>Most importantly I need to know about in-situ lumber</td><td>Keep improving</td><td>Have ability to store data</td><td>I would need app for measuring stiffness of oak</td></tr>
<tr><td rowspan="2">This is a broad survey and it would be useful if you narrowed down exactly what you are looking at providing. For example, will you provide external hardware that connects via wired/wireless connection to phone? For example, technology that mimics standing tree acoustic velocity with a pitcher/catcher receiver with the data analyzed on a smartphone or tablet. This would be very useful to me. Or will you use the built in microphone of a smartphone/tablet to analyze the resonance frequency of thumps from a hammer? This is less useful to me. In order to predict stiffness, you will need to also have the specimen weight and dimensions in order to measure density/specific gravity. Will the user be required to input this or are you assuming a constant density? All of these types of questions will inform users of what they are willing to pay for an app.</td><td rowspan="2">For me accuracy, versatility, and measurement method are the most important issues for me. The most important things though is to truthfully state what the accuracy and precision of the device is and then the user can decide if it is adequate for their use. Versatility, I work with everything from standing trees, lumber, panel products, etc. Being able to use this app in different products would be useful. Measurement method. Will this be hooked up to a pin meter or use a dielectric field? Having a non-destructive test method for valuable products would be an advantage for me.</td><td rowspan="2">Seems like a great idea. I can think of all kinds of applications, ranging from sorting lumber for building stick frame assembly tests to spot checking MOE for I-joist flange stock. It would be very useful if this could apply to LVL, but that may be asking too much. I realize the app model is low price (but typically not worth much), for professional tools, if accurate, I could see paying $50 - $100, which would be cheap in the long run. Out lab can run dead weight MOE easily, but we don't have a setup dedicated to this, so we sort studs by weight/density.</td><td>It will be difficult to measure the slope of deflection and load with an IPhone.</td><td>Either use accelerometer or sound receiver built in the phone of the measurement of frequency or velocity for calculating MOE</td></tr>
<tr><td>Such a tool could enable detection/culling of premium/marginal components prior to assembly, of buildings, furniture, stairs, practically anything that relies on wood for its structure. The app would need consider the range/scale of such components in size. A builder could choose the best boards for joists in the floor system, a stair builder could choose the best newel post.</td><td>Consider the ability to measure various widths - from 1 1/2" (lumber/LVL) to 4' wide panels. Verify with other available equipment to make sure you are getting the same answer or develop the relationship/correction factor</td></tr>
</table>

* Application, functions, direction, and technology