Digital Technology Application Among Malaysian Value-added Wood Products Manufacturers

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The application of digital technologies (DT) has been on the increase within the manufacturing industries since a decade ago. It has been widely suggested that the onset of the COVID-19 pandemic has accelerated the adoption of DT in manufacturing industries worldwide, as countries have tried to contain and mitigate the spread of infection through lockdowns and stringent standard operating procedures (SOPs). Hence, a study was undertaken to evaluate this trend in the Malaysian wood products industry, and to identify the key DT used. A questionnaire-based survey was implemented and targeted at the furniture, moldings, and builder's joinery and carpentry sub-sectors, with the assistance of the relevant trade associations. A total of 477 responses were obtained, and it was found that digital technologies, such as computer aided design (CAD), computer numerical control (CNC), digital communication, digital marketing, and enterprise resources planning (ERP) systems, were highly adopted, but they did not significantly differ in terms of company size or product type. However, the rate of adoption was not uniform, as 5% of the respondent companies did not adopt any digital technologies. The study revealed that wood products companies adopted digital technologies that boosted their production and marketing, while those with limited DT adoption were more severely impacted during the pandemic.

Keywords: Digital technology; Wood products; Covid-19; Labour intensive; Marketing; CAD; CNC

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INTRODUCTION

The focus on and appreciation of digital technologies (DT) has been on the rise since the late decade. The need for greater productivity growth, rather than incremental inputs to fuel growth in the resource-based industries remain to be a topic for discussion among many in the research and industry fraternity. Even policy makers in many developing countries have been looking for avenues to boost industrial growth, as globalization affected the relative competitiveness of many industries worldwide (Ratnasingam and Teoh 2021). In fact, the adoption and application of DT has not been uniform throughout the manufacturing sector, with automotive, electrical & electronics, and metal working industries appearing to be more receptive to DT. On the other hand, traditional industries, such as wood, appear to be the laggard in adopting DT, primarily due to the lack of investment in DT, as most of the players were small and medium enterprises (SMEs) who were operating with tight financial budgets. Further, as these traditional

industries have been dependent of low-cost foreign contract workers, the benefits to transform towards the application DT has not been fully realized.

The onset of COVID-19 pandemic has impacted the wood products industry globally throughout 2020, and the arising uncertainty in 2021 still lingers. The lockdowns implemented in many countries throughout the world to contain and mitigate the spread of the infection has curtailed economic activities severely. Some sectors, such as tourism and hospitality, suffer the most, while the impact on others including manufacturing was significant but not catastrophic. Only essential services, such as health, utilities, food and beverages, law enforcement, *etc.*, could operate normally to maintain a basic standard of living. As fatalities from the COVID-19 infections rose steadily in many countries, many governments found it extremely difficult to find a balance between life and livelihood (Ratnasingam *et al.* 2020a, 2021).

As working remotely or better known as working from home, became the norm in many countries, the concept of a home office picked up pace, and inevitably, demand for such furniture and related products has grown strong. According to the Malaysian Timber Industry Board (MTIB), exports of value-added wood products from Malaysia have been steady in 2020, despite the global pandemic. Although trade volume for several types of wood products registered a reduction, others, especially furniture, moldings, and builders' carpentry and joinery (BCJ), did show an improvement, compensating for the losses in the other sub-sectors in the global market (MTIB 2021). Similarly, the other furniture and wood products exporting nations in the ASEAN region, such as Vietnam, Indonesia, and Thailand, registered steady performance during this period, debunking the sluggish business climate throughout the world (Ratnasingam *et al.* 2021). To remain competitive in the value-added wood products industry, quick turn-around of new designs into prototypes and production pieces was recognized as a necessary component of a successful business strategy (Schuler and Buehlmann 2003). Further, Bumgardner *et al.* (2004) reported that factors, such as timely delivery to customers, better control over manufacturing, and closer interaction between marketing/design and manufacturing, are important success factors in the highly competitive global furniture market. In fact, shortened lead times and DT investment have been specifically and repeatedly cited as important competitive factors, especially when dealing with customers who sell their products through online platforms and mail-order catalogues (Grushecky *et al.* 2006).

From another perspective, the COVID-19 pandemic has also been a game-changer for Malaysian wood products sector, which had traditionally considered a large workforce to be indispensable and has challenged this perception (Ratnasingam *et al.* 2021). In fact, it has been noted that the factories that had adopted some DT found themselves in a position of advantage, as they were able to run their operations even with a significantly reduced number of workers. Against the background of the strict movement control orders (MCOs) and standard operating procedures (SOPs) implemented by the government to contain and mitigate the spread of infections, the industry was forced to relook at strategies of working under conditions of minimal workforce, while maintaining production levels (MTIB 2020). One such strategy is the increased adoption of digital technologies within the work environment, which as an initiative has been around for more than a decade. However, the benefits of DT appear to have gained attention when the government became adamant in reducing the number of foreign contract workers employed in the manufacturing sector since late 2018 and insisted on greater adoption of DT through the implementation of the National Industry 4.0 Framework (MITI 2018).

This observation was prevalent among the small and medium enterprises (SMEs) that predominate the wood products manufacturing sector as reported previously by Ratnasingam *et al.* (2020a), and such transformation was necessary for the businesses to remain viable. In this context, it is of interest to investigate whether the COVID-19 pandemic had influenced, if not accelerated the adoption of digital technologies (DT) in the wood products sector, or whether the increased adoption of DT in the wood products industry was merely coincidental. DT have been shown to assist in product design, manufacturing, and marketing across all wood products manufacturing sectors, and many manufacturing enterprises have realized increased design and production efficiencies (*i.e.*, streamlined production) after becoming proficient with DT (Ratnasingam *et al.* 2021).

Digital Technologies in Wood Products Manufacturing

In a recent analysis of best manufacturing practices used by the value-added wood products manufacturers in the ASEAN region indicated that several DT were linked to top-performing companies (Ratnasingam *et al.* 2019). In fact, the types of DT that were most prevalent among the ASEAN wood products manufacturers include computer-aided design (CAD), computer numerical control (CNC) workstation, digital marketing, computer-aided manufacturing (CAM), enterprise resources planning (ERP), automated machine monitoring, in-line quality assessment, and digital communication. The study highlighted the fact that these eight technologies made up almost 96% of the DT available currently employed in the wood products sector. As reported in a previous paper by Ratnasingam *et al.* (2019), the degree of application of automated technologies in the Malaysian furniture industry is relatively small and its readiness to adopt technologies of Industry 4.0 is also limited. Nevertheless, the study also highlighted that adoption of automated and digital technologies were more prominent among larger value-added wood products manufacturers, who were keen on increasing production volume to meet the higher demand for their products. Unfortunately, not much of DT is used for improving production flexibility and product diversity (Ratnasingam *et al.* 2019). However, Dorns *et al.* (1995) examined the relationships among technology adoption, firm demographics, and productivity, and it supports the view that technologies that streamline the production processes often lead to significant improvements in the wood products manufacturing firm's competitive position. Higher growth rates and lower failure rates were also reported among manufacturing plants that adopted a larger number of advanced technologies, and higher labor productivity rates were associated with plants that used such technologies (McGuckin *et al.* 1996). In another study, it was shown that the latest DT were more likely to be adopted by larger companies compared to SMEs, due to the latter's limited financial resources (Dunne 1994). However, Ratnasingam *et al.* (2021) showed that with a steady reduction in prices of these technologies, uptake of DT among SMEs has also improved over the years. This is also supported by the survey conducted by the Malaysian Productivity Corporation (MPC) in 2019, who reported that computer-aided manufacturing (CAM), in which CAD and CNC workstations have become more prevalent in the woodworking industry since the mid-1990s in Malaysia. Nevertheless, the adoption of DT including automation in the overall manufacturing sector in Malaysia is relatively low, as it has been reported that the country's manufacturing sector deployed only 40 units of industrial robots per 10,000 employees in 2018, almost 55% below the global average of 85 units (FMM 2019).

The manufacturing sector, comprising 98.5% of Malaysian SMEs, serves as a major contributor to the country's economy. In 2018, the sector contributed 22.4% of the gross

domestic product (GDP) at about USD 84 billion, and the sector stands to reap growth in productivity gains of up to USD 30 billion over the next decade through the adoption of DT as well as Industry 4.0 (MTIB 2019). In this context, the Malaysian wood products manufacturing sector is also predominated by SMEs, and any change in its 'modus operandi' of the SMEs will have an implication on the wood products sector as well.

One of the major challenges faced by the Malaysian wood products manufacturing industry is the heavy reliance on foreign-contract workers, who make up almost 69% of the total workforce in the industry (MTIB 2019). The large numbers of foreign-contract workers, who are paid the minimum salary of USD 300 per month, has kept wages low, inevitably contributing to the prevailing low-wage economy. In hindsight, it has contributed to increased unemployment among local workforce, a large outflow of funds to the workers' country of origin, social ills, and most importantly, it has stifled the need for the adoption of technology to move along further the manufacturing value-chain (Ratnasingam *et al*. 2019). In essence, the formulation of the National Timber Industry Plan (NATIP) in 2009 and the National Industry 4.0 Framework in 2018 were primarily aimed at reversing this trend, while encouraging the industry to move towards technology-oriented, high value-added sectors (MITI 2018). DT is expected to transform the wood products industry into a more productivity industry, with lesser dependence on labour. Nevertheless, it must be recognized that some of the large wood products manufacturers have embarked on such transformation, increasingly adopting DT, to boost productivity and move along further the value-chain. Although it has been argued that the larger manufacturers have larger financial muscle to invest into DT and are more receptive to such technologies, SMEs with limited funds are laggards in this respect.

In recognizing the financial constraints faced by the SMEs, the government had initially allocated USD 1.5 billion for this transformation in the form of financial subsidies for purchase of DT, tax breaks, trainings, *etc.*, to encourage the overall manufacturing sector to move towards the adoption of DT, and a further USD 1.5 billion was recently announced to further assist the manufacturing sector due to the new challenges arising from the COVID-19 pandemic. Against the background of a limited number of workers allowed work during COVID-19 period, and the availability of incentives to acquire DT, it was expected that the manufacturing sector, including the wood products sector, would capitalize on these developments and accelerate the transformation through the adoption of DT. Whether the onset of the COVID-19 pandemic had indeed influenced, if not accelerated the DT adoption in the manufacturing sector warrants immediate research attention. Further, for the value-added wood products industry, which is labour intensive and poorly invested in terms of technology (MTIB 2020), to what extent DT has been adopted is worthy of a study.

In this context, the objectives of this study were to (1) assess whether adoption of DT during the COVID-19 period had accelerated in lieu of the many incentives provided by the government to support such a transformation, (2) evaluate the degree of use of DT by the furniture, moulding, and builders' carpentry and joinery (BCJ) sub-sectors of the industry, (3) determine whether there is a relationship between technology utilization and company-size, and (4) determine the benefits and challenges associated with the application of different digital DT. The results of this study will provide insights into the extent of digital technologies application by the most prominent value-added wood products sub-sectors in the country and will form the basis on which policy makers could modify or introduce measures to accelerate the expected industrial transformation in this industry.

EXPERIMENTAL

A questionnaire-based survey assessing the application of DT in the furniture, molding, and builders' carpentry and joinery sub-sectors, was developed, reviewed, pilot tested, and implemented through the Google Form. The link to the questionnaire survey was emailed to 1,500 respondent companies, who had consented to participate in the study. The respondent companies were identified by the Malaysian Furniture Council (MFC) and the Malaysian Wood Mouldings and Joinery Council (MWMJC), as being active members that represented the three type of products. The survey population represented large-, medium-, and small-sized companies, which have in operation between 5 to 25 years and more. Face-to-face interviews of the respondents were not possible due to the movement control order (MCO) implemented in the country during the study period. Further, the survey was conducted for a period of one month only due to limited financial resources. For this reason, early and late responders could not be distinguished, thus it was not feasible to conduct a non-response bias test.

The survey included several demographic questions to identify the type of product produced by the respondent's company, years in operation, workforce size, and year on year sales volume between 2018 and 2020. Information on the trends in adoption of DT were assessed through the information on technology investment (*i.e*., amount of investment, types of technologies acquired, application purpose), made between 2018 and 2020 by the respondent companies. This was followed by collecting information on current DT (*i.e*., types of DT used and in which section) used in the factories. In this study, the DT were those commonly applicable to the wood products industry, such as CAD, CNC, CAM, digital communication, digital marketing, ERP, in-line quality assessment, and machine monitoring. These technologies were chosen on the basis of their wide application and relevance to the wood products industry as suggested by industry experts spoken to and also from previous research reports (Ratnasingam and Teoh 2021). This was followed by a set of questions focused on CNC technology use and impacts. A 5-point Likert scale was used to elicit feedback on a series of statements related to CNC implementation. Questions on the impacts of CAD followed (again, a 5-point Likert scale). Questions on the application of ERP followed using the 5-point Likert scale to obtain feedbacks on a series of related statements. A similar approach was taken to gather information on the extent of digital communication and digital marketing application in the industry. Finally, three open-ended questions were posed to elicit free-form feedback on DT used and the challenges within the industry.

Survey responses were captured as a spreadsheet, then imported into the SPSS version 10.1 statistical analysis software (IBM Corp., Armonk, NY, USA). Proportional response rates were calculated for each of the demographic variables. Statistical tests were evaluated using a significance level of $P < 0.10$, as this significance level is used to allow trends to be identified in market surveys (Luppold and Bumgardner 2007). Chi-square tests of independence were conducted to ascertain whether the two independent variables of product type manufactured and company-size were independently distributed. Responding firm size was categorized based on total number of employees at a given operating facility: large-sized companies (more than 200 employees), medium-sized companies (75 to 200 employees), and small-sized companies (5 to 75 employees). The chi-square test also was used to examine whether the sales volume change responses (more than doubled, increased but not doubled, about the same, and smaller) were independent of company-size (small, medium, and large). Overall mean response values were calculated for several questions

including the five series of Likert scale-based questions concerning CNC, CAD, digital communication, ERP, and digital marketing technologies. A factorial analysis of variance (ANOVA) was then conducted on the mean, and separation of means was performed using the Tukey studentized range test at a significance level of $P < 0.10$. To determine if type of product produced and size influenced the attitudes of respondents about CNC and CAD technologies, two multiple ANOVAs (MANOVAs) were performed on the Likert scale-based responses at a significance level of $P < 0.01$.

RESULTS AND DISCUSSION

The response rate for this questionnaire-based survey was 31.8% or 477 usable responses from the targeted 1500 respondents. The demographic profile of the respondents is shown in Figs. 1 through 4.

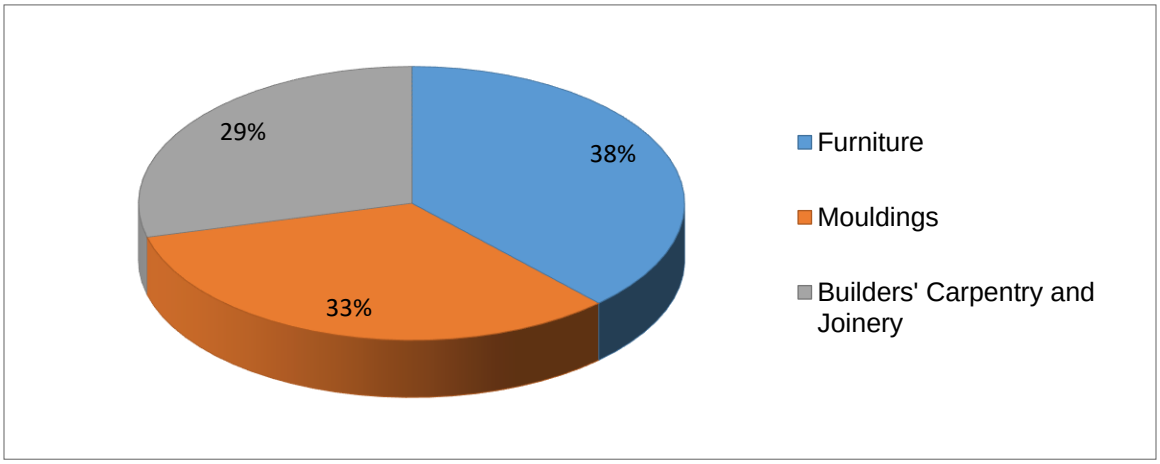

Fig. 1. Distribution of respondents by product type

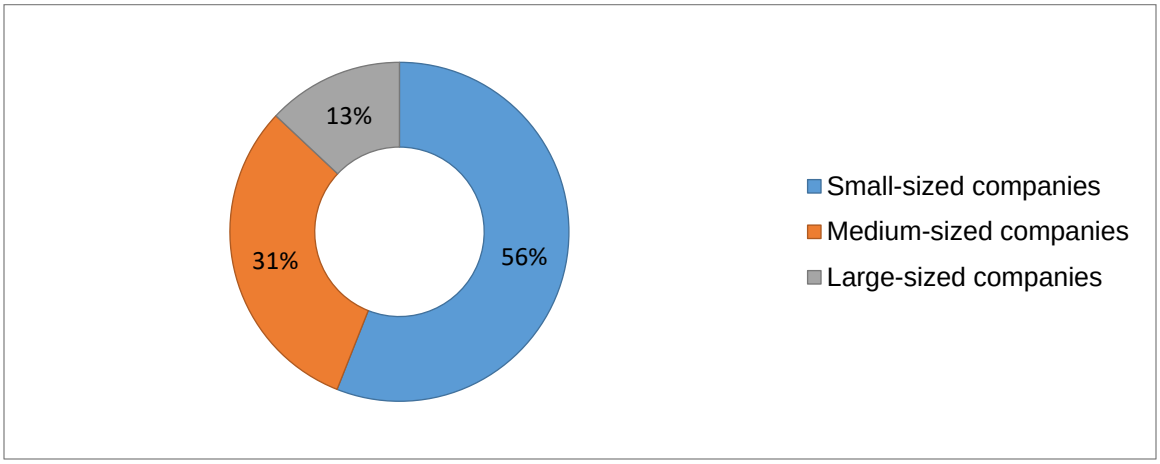

Fig. 2. Distribution of respondents by company size

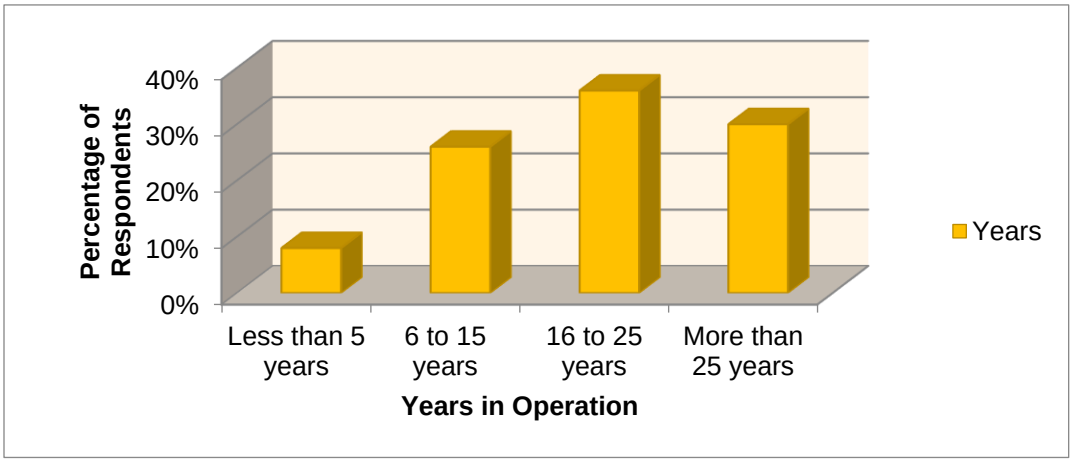

Fig. 3. Year production started

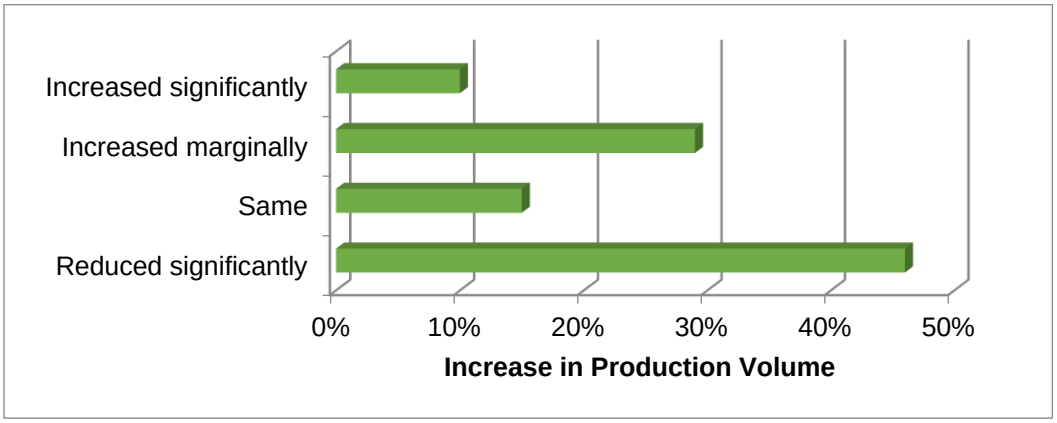

Fig. 4. Annual production volume in 2020 against 2018

The results of the survey showed that investments in DT did not spike during the COVID-19 pandemic, even though there were opportunities for subsidies and incentives from the government (Fig. 5).

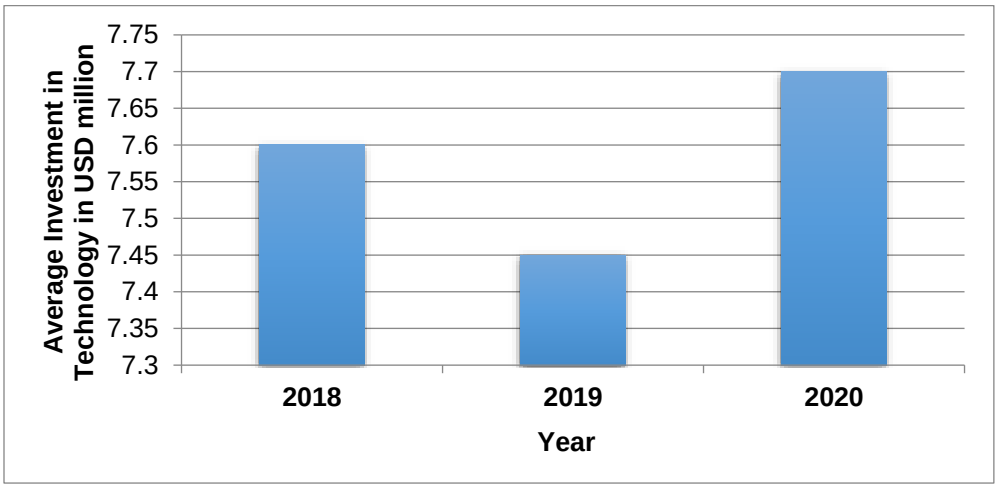

Fig. 5. Trend in technology investments among respondent companies, 2018 to 2020

However, DT related to communication and marketing were notably increased, but they did not involve significant investments among the respondent companies. This finding is contrary to common perception that the COVID-19 would have significantly accelerated the adoption of DT, as the companies would have taken steps to reduce their dependency on manual workers, without sacrificing production volume. It was noted that the uncertainty in the marketplace did not necessitate production volume ramp-up, and the availability of foreign workers on contract also means that they could be deployed, should demand pick-up. Therefore, this study clearly reveals that the existing foreign workers employment eased the pressure on manufacturers of wood products to adopt digital technologies, and inevitably, it is a loss opportunity to transform the wood products industry through technology and facilitate its move along further the value-chain.

The results of the survey revealed that the DT adoption rates of the eight types of advanced digital technologies listed in the survey were mixed, and the mean number of types of technologies used by the 477 responding companies were 3.8. It was found that 97 of the responding companies used all eight of the DT, while 23 of the responding companies were not using any of the DT. Overall, the five types of digital technologies that are most widely used were CAD (78%), Digital communications (62%), CNC (71%), Digital Marketing (51%), and ERP (31%) (Fig. 6).

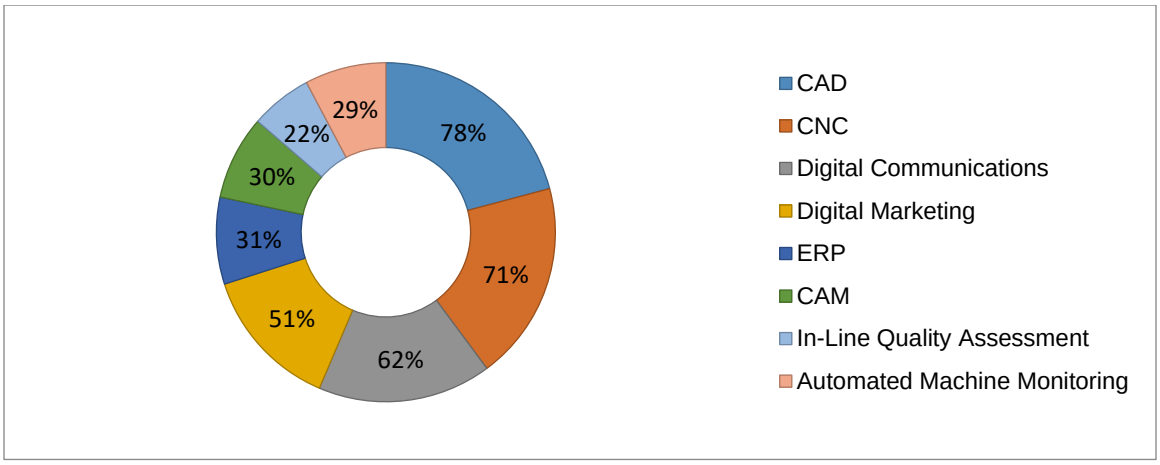

Fig. 6. Common digital technologies applied

Considering that 454 firms adopted digital technologies, these companies use, on average, 4.1 different types of technologies. The relative order of adoption of the different types of technology is shown in Table 1. It is apparent that companies adopted CAD, CNC, and digital communication, before moving on to the more advanced DT, which requires a systematic approach. This is most likely due to the incentives available to manufacturers to purchase such technologies, and skills required to manage such DT is also easily acquired (Ratnasingam *et al*. 2019).

Based on the factorial ANOVA tests conducted, it was found that product type (*i.e.*, furniture, moldings, BCJ, and company size (*i.e.*, large, medium, and small) did not show any significant interaction at $P < 0.001$. In contrast, 46% of the variation in the number of DT adopted could be attributed to the variations in company size. The Tukey separation of means test indicated that the number of technologies adopted by firms was different for all three size classes (Table 2).

Table 1. Types of Digital Technologies Used by Companies

Type of DT	Proportion (%) of Companies Applying Different Types of DT			
	1 Type (n = 34)	2 Types (n = 58)	3 Types (n = 119)	4 Types (n = 138)
CAD	56	51	43	40
CNC	21	26	22	23
Digital Communication	9	11	10	13
Digital Marketing	7	6	9	8
ERP	3	1	4	5
CAM	2	3	5	3
Automated Machine Monitoring	1	1	4	4
In-Line Quality Assessment	1	2	3	4

Table 2. Results of the Tukey HSD Separation of Means Test for Number of Types of Technologies Adopted for Different Levels of the Variable Firm Size

Classification Variable	Levels Compared	Difference Between Means*
Company Size	Large to Medium	1.29
	Medium to Small	1.67
	Large to Small	2.97

*All values significant at P < 0.1 level

Large companies adopted an average of 5.1 types of digital technologies in their operations, while medium-sized companies reported adopting an average of 3.4 types of technology. Small-sized companies had adopted 2.2 types of digital technologies in their manufacturing plants. The results of chi-square analyses to determine whether the rates of adoption of the various types of technologies included in the survey were different for small, medium, and large companies indicated significance. The four types of digital technologies that were most broadly adopted by survey respondents, CAD, CNC, digital communication, and digital marketing, were used by large firms and medium-sized firms significantly more frequently ($P < 0.0001$) than they were by small firms. In fact, all eight of the listed technologies showed significantly different results for rates of adoption based on firm size. Interestingly, none of the variation in the number of technologies adopted between firms was associated with whether the responding firm manufactured furniture, moldings, or BCJ. The overall mean number of technologies adopted for all product sectors was 3.69, clearly ruling out that product types dictated technology adoption.

CAD Adoption

The three statements that targeted users of digital design and drawing software (CAD) each met with, on average, medium to high-level agreement based on 431 responses: (1) Using CAD software has reduced the length of time required for product design, rated a mean score of 4.4, (2) Using CAD software has allowed the production of more complex products, was rated a mean score of 3.9, and (3) Using CAD software has contributed to reduced labor costs during the design process, which obtained a mean score of 3.8, just less than the 4.0 level that indicates agreement with the statement. The MANOVA results indicated that statistical differences were absent in the level of respondent agreement with each of these three statements, *i.e.*, neither product types (P =

0.77) nor company size (P = 0.44), nor the interaction of these two main effects (P = 0.98) had impacted the ratings obtained. It was also found that 78% of the respondent companies indicated they used CAD to perform two or more tasks, especially for developing detailed product renderings (77% of companies using CAD used it for this), and to work on preliminary concept development (67% of users) for customers. Respondents also indicated that CAD was also used less frequently for CNC workstation control (46% of users).

CNC Adoption

Of the 454 responding companies that indicated the use of CNC workstations in their wood products manufacturing operations, 76% were using one or more CNC routers. Panel saws were used by 34% of the respondents, while point-to-point machines were used by 43% of the respondent companies, and 40% used CNC workstation (Fig. 7).

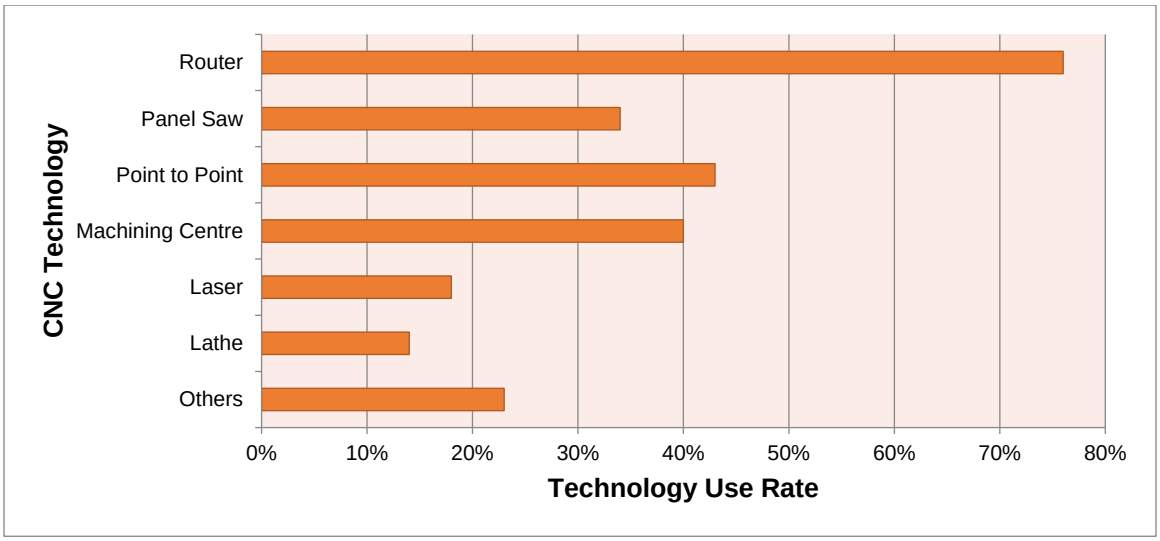

Fig. 7. Types of CNC technology used

Approximately half of the companies using CNC equipment used only one type of CNC machine. A total of 26% of the companies that used CNC machines were using three or more types of CNC machinery, and in many cases, multiple machines of each type were used. The results also revealed that the cycle for adoption of new CNC technologies is approximately 3 to 5 years for companies using more than one type of CNC machinery. Respondents from companies that used CNC technologies indicated their level of agreement with eleven statements about CNC implementation. The three statements that received the strongest endorsement were (1) CNC workstation improved the machining accuracy (mean = 4.7, median = 5.0), (2) CNC workstation improved the ability to perform complex jobs (mean = 4.4, median = 4.7), and (3) CNC workstation improved the manufacturing flexibility (mean = 4.3, median = 4.0). In contrast, the statement that received the weakest level of agreement among respondents was that CNC workstation is easy to learn to operate and program (mean = 3.1, median = 3.4) (Fig. 8). The MANOVA results indicated no statistical differences among firm sizes (P = 0.10), and among product types (P = 0.10). The statements that a CNC workstation is safer to operate than non-CNC machines, CNC workstation has improved the machining accuracy, CNC workstation has improved manufacturing flexibility, and CNC workstation has reduced the set-

up/changeover time, were applicable to all types of companies, regardless of the company-size or product type.

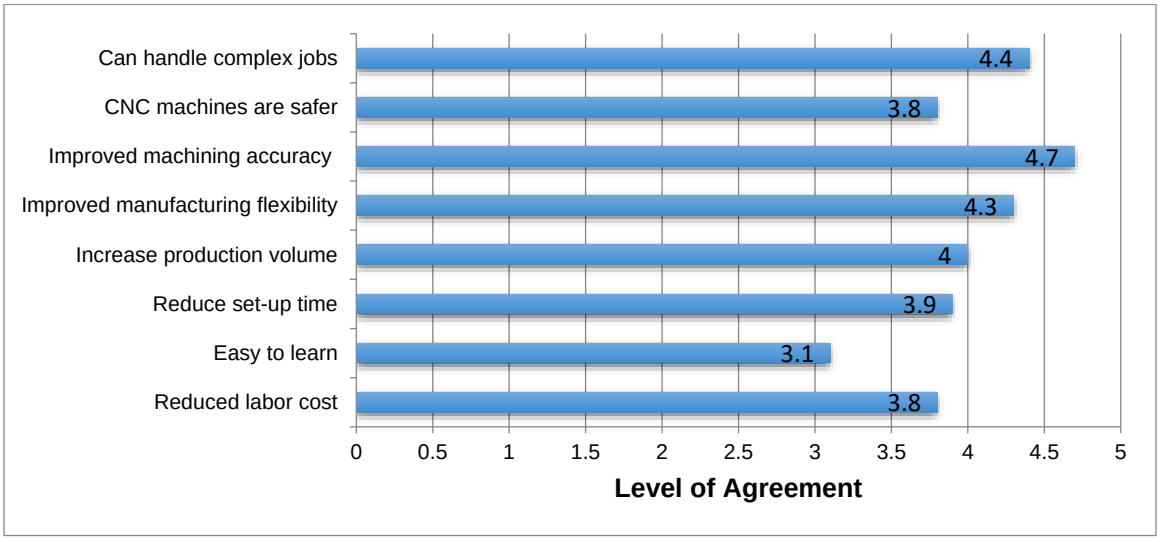

Fig. 8. Levels of agreement to the statements on the benefits of CNC technology

Application of ERP

Enterprise resource planning is the integrated management of main business processes, often in real time and mediated by software and technology. The ERP system provides an integrated and continuously updated view of core business processes using common databases maintained by a database management system (Ratnasingam *et al.* 2018a). The ERP systems track business resources, *i.e.*, cash, raw materials, production capacity, and the status of business commitments, including orders, purchase orders, and payroll. The applications that make up the system share data across various departments (manufacturing, purchasing, sales, accounting, *etc.*) that provide the data. The ERP system facilitates information flow between all business functions and manages connections to outside stakeholders, and thereby enhancing the organization's efficiency. Despite its benefits, the application of ERP systems among the respondents was relatively low at 31%, only used among the large-sized companies. The two main reasons that were cited as being constraints include the need for investments into a variety of computer hardware, network configurations, and a database as an information repository, as well as the lack of skilled and competent workers to operate and manage the system. A similar observation was also reported by the MTIB (2019), who found that computer literacy among the workforce in the wood products industry was relatively low, hence impacting the adoption of DT.

Application of Digital Communication and Marketing

Digital communication involves an organization's online communication efforts. Most organizations today use a wide range of online channels, ranging from website to mobile chat to blogs, to connect with current and prospective customers, employees, and other stakeholders. Of all the different forms of digital communication, the three most popular among the respondents in this study were texts (96%), social media (81%), and video chat (77%). As mentioned previously, digital communication has become an important tool not only for communication but also as a public relation tool to connect and

disseminate timely information to customers and stakeholders, especially during this COVID-19 pandemic, which restricts face-to-face meetings (Ratnasingam *et al.* 2019). The results from this study run parallel to the previous reports (Makkonen 2018; Kropivšek and Grošelj 2020).

Because several types of DT can be integrated into marketing and sales activities, the study investigated the means used by responding companies to sell their wood products. The most common digital marketing platform used was the web-based sales, which was reported by 79% of the respondents. The other platforms that were also being used widely include email-marketing and newsletter, which were used by 70% and 63% of the respondents, respectively. The more sophisticated platforms, such as social media marketing, search engine optimization, Google-Adwords, and Adverts by Google and Facebook, were only minimally used. As reported previously by Murmura and Barvi (2018) and Ratnasingam *et al.* (2018a), the COVID-19 pandemic, which has forced traditional marketing channels to be closed, while encouraging digital marketing, has not seen overwhelming adoption in the value-added wood products marketing in Malaysia. The lack of skilled and digital savvy personnel was highlighted by 96% of the respondents as the main stumbling block to a wider adoption of digital marketing, which was also echoed previously by MITI (2018). In this context, provision of training in digital marketing may be an immediate measure that could be implemented by the relevant agencies, to encourage further application of such technology. In the future, DT in communications and marketing with inputs from artificial intelligence may revolutionize the marketing function in the wood products industry, replacing the traditional marketeer. These however, may take large investments, which under current circumstances may not be amenable to the value-added wood products industry that is highly competitive in terms of pricing rather than value (Ratnasingam and Teoh 2021).

Implications of the Study

An often-cited benefit of DT is an increased ability to develop complex value-added wood products. Large- and medium-sized companies were also deemed to more likely to adopt DT compared to smaller companies (Müller *et al.* 2019). Results from this study reinforces the finding that the adoption of digital technologies has picked up pace, even in the labor intensive and investment starved wood products sector. As shown in this study, the four most widely adopted DT in the wood products sector are CAD, CNC workstation, digital communication, and digital marketing. These latter two technologies appear to supplement and assist in wood products marketing, which cannot be carried out physically during the COVID-19 pandemic. The postponement and cancellation of most trade fairs for wood products throughout the world in 2020 has created a huge vacuum that could be exploited by digital marketing and digital communication. Marketing in the conventional manner is no longer possible, and therefore, manufacturers of wood products are focused on digital communication and digital marketing to remain afloat in this uncertain period. After all, marketing has been one of the weakest links in the Malaysian wood products sector, which exports more than 80% of its production volume (MTIB 2019).

In contrast, the expected increased adoption of DT in the manufacturing activities did not take place in this period of the COVID-19 pandemic, as notable investments in DT for wood products manufacturing were not reported by the Woodworking Machinery Suppliers Association (WMSA) of Malaysia (WMSA 2021). This may be attributed to the sluggish demand for wood products in the global market in the first six months of 2020, but more so, due to the continuous availability of foreign contract workers in the wood

products industry, who are able to ramp up production quickly when the market recovers (Ratnasingam and Teoh 2021). Further, the necessary skilled workers required to operate, and control DT were also not readily available, making it rather cumbersome to adopt such technologies. Therefore, this study reveals that unless the employment of cheap workforce is minimized, any notable adoption of DT to boost manufacturing competitiveness may be seriously stifled. Consequently, the demand for skilled and competent workers for operating and controlling DT may also be limited, further aggravating the prevailing mismatch between the human capital developed through the Wood Science and Technology (WST) curriculums at several universities in the country and the employment opportunities available in the industry (Ratnasingam *et al*. 2018b). In this context, policy makers must take cue from this revelation that encouraging the adoption of DT in labor intensive manufacturing industries, must also be supported with the employment of skilled and competent workforce to manage and support such technologies (Ratnasingam *et al*. 2020b). Such a transformation must however be implemented by first reducing the number of foreign contract workers, who appear to be a restraint on such a transformation.

CONCLUSIONS

1. The study revealed that digital technologies, such as computer aided design (CAD), computer numerical control (CNC), digital communication, digital marketing, and enterprise resources planning (ERP), were mostly used by value-added wood products manufacturers in Malaysia.
2. The rate of adoption of digital technologies did not significantly differ by respondent company size and product types manufactured.
3. Digital communication and digital marketing technologies were regarded important during this period, as physical meeting and marketing activities were limited.
4. The perception that the COVID-19 pandemic would accelerate the adoption of digital technologies to reduce their dependency on workforce was not found to be true from this study.
5. Policy makers must pay greater attention not only to encourage greater adoption of digital technologies but must also simultaneously address the employment of skilled and competent workers to manage such technologies, through a program of reduction of low-waged foreign workers.

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