Innovations in Business Process Digitalisation in the Forest-Wood Sector In Slovenia

Ana Slavec
InnoRenew CoE, Slovenia
Michael Burnard
InnoRenew CoE, Slovenia
Andrej Marušič Institute, University of Primorska, Slovenia
Faculty of Agriculture and Forestry, University of Helsinki, Finland

Abstract

Digital technology can help businesses automate and streamline various processes to optimise resource use, improve efficiency, and reduce costs. This paper aims to study digitalisation in Slovenia's forest-wood sector, which is essential to the country's smart specialisation strategy. Based on a survey we conducted among 294 enterprises in this sector, we study a subsample of innovators that were asked if they introduced or are planning to introduce innovations in business process digitalisation such as collaboration with IT or data experts, implementation of sensor technologies, digital modelling and simulation, collaborative platforms, and other technologies that can help the sector to improve manufacturing and production processes, logistics and sales. The results show that adopting digital technologies is correlated with enterprise strategy, investments in R&D, collaboration with universities and research institutes, the share of employees with a tertiary degree and in RDI positions, and enterprise size.

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Introduction

Advances in information technology are a source of competitive advantage for enterprises (Porter & Millar, 1985), and the ability to redesign business processes around information technology is a powerful tool (Davenport & Short, 1990). However, the association between information management and firm performance is mediated by organisational capabilities (Mithas et al., 2011).

In the context of the forest industry, business process digitalisation is still in an early stage and is under-researched (Kortelainen et al., 2020). A US study reviewed several technologies in forest and fire management but found only a few examples of the Internet of Things (IoT), location-based services, and big data (Keefe et al., 2019). In Europe, a survey of sawmill representatives in Austria confirmed that the level of digitalisation in this sector is low and identified a lack of IT skills in addition to data protection and security challenges and high costs as the main challenges of digitalisation (Ranacher et al., 2023).

Nevertheless, there are several examples of different aspects of digitalisation in the forest-wood sector. For instance, there are cases of using automation in furniture production, such as scanning logs with computed tomography (Fredriksson, 2015) and using optical methods to examine and check the development of plywood panels (Burnard et al., 2018). Even deep learning can have applications in the automation of furniture manufacturing, but it still needs to be implemented in real-time industrial processes (Chen et al., 2022).

Internet of Things (IoT) was applied in forestry for tree monitoring (Matasov et al., 2020; Tomelleri et al., 2022; Yang et al., 2021) and forest and fire management (Keefe et al., 2019). Sensors were also used in lean forest management to make better and faster decisions based on data (Rautio et al., 2023), and remote sensing technology was used for forest resource assessment and monitoring (Calders et al., 2020), and data-driven wildfire management (Hogland et al., 2021).

Wildfires were also analysed based on data from virtual reality technology (Fiore et al., 2009), which has also been used to visualise avalanche protection by forest (Olschewski et al., 2012). In addition, an online survey among Finish Forest owners indicated an interest in applying virtual reality tools in forest management (Holopainen et al., 2020).

Another study in Finland focused on the digital transformation of forest services and identified the need for agile software tools studies (Kankaanhuhta et al., 2021). In Finland, innovation in this sector is also supported by an online platform developed by the government, but it does not have the same potential for all users (Pynnönen et al., 2021). Similarly, in New Zealand, a citizen science ICT platform was constructed to collect data on forest species (Grant et al., 2019).

In this paper, we study the occurrence of business process digitalisation in the forest-wood sector in Slovenia, which has not been covered in previous research. Moreover, we evaluate its association with enterprise characteristics, strategies, innovation activities, and collaboration with other organisations.

Methodology

The results are based on responses from a self-administered cross-sectional survey that was conducted in 2019 among 294 Slovenian enterprises in the forest-wood sector that can be accessed through the Slovenian Socia Science Data Archive (Slavec & Burnard, 2021). A mixed-mode approach combining postal and online data collection was used.

The questionnaire is based on the basic definition in the Oslo Manual (OECD/Eurostat, 2018) and was mostly composed of selected questions from the Community Innovation Survey (CIS). However, unlike the CIS, it included enterprises of all sizes, including micro-enterprises, as they can be at least as innovative as small and medium enterprises (Slavec, 2022).

In this analysis, we only analyse five questions from CIS: strategies (Q2), innovation activities (Q8), cooperation with other enterprises and organisations (Q10), turnover (Q21) and average number of employees (Q24). Moreover, we also developed original questions, including a question about business process digitalisation innovations with 12 items (Q15) and characteristics of enterprises such as the number of employees with tertiary education (Q25a) and in research, development, and innovation (RDI) position (Q25b). We also used the year of registration as one of the characteristics known from the sample frame, which was the bizi.si registry of Slovenian businesses.

For this paper, we focused only on the subsample of 198 enterprises that had any product, process, organisational or marketing innovations in the three years between 2016 and 2018, as only those responded to Q15. Data was analysed using the SPSS statistical program (Version 29), except for charts drawn using Microsoft Excel. The association between selected variables and enterprise size (grouped in three categories) was examined by computing Spearman's Rank Correlation Coefficients.

Results

The results first present the distribution of responses and descriptive statistics for control variables (characteristics of enterprises, strategies, engaging in innovation activities, and cooperation with other enterprises or organisations).

Characteristics of enterprises

In total, about two-thirds of enterprises (75%) had a turnover of less than half a million Euros, three-quarters had less than a million Euros, and only 8% had a turnover of over 5 million Euros. However, when limiting the analysis to only 198 enterprises that had any innovations, 72% had a turnover of less than a million, and only 11% had over 5 million.

More than three quarters (77%) of the 294 respondents were micro-enterprises (less than 10 employees), while small enterprises (10-49 employees) account for 15% of the sample, medium 9% and large enterprises 1% of the sample. Among innovators, 73% were microenterprises, and 24% had 10 or more employees.

Between 2016 and 2018, more than two-thirds of respondents reported that their enterprise had at least one employee with a tertiary degree (69%), and more than a third (36%) had at least one employee in an RDI position. Considering only innovators, the percentages are slightly higher: 73% had at least one employee with tertiary education, and 45% had at least one in an RDI position.

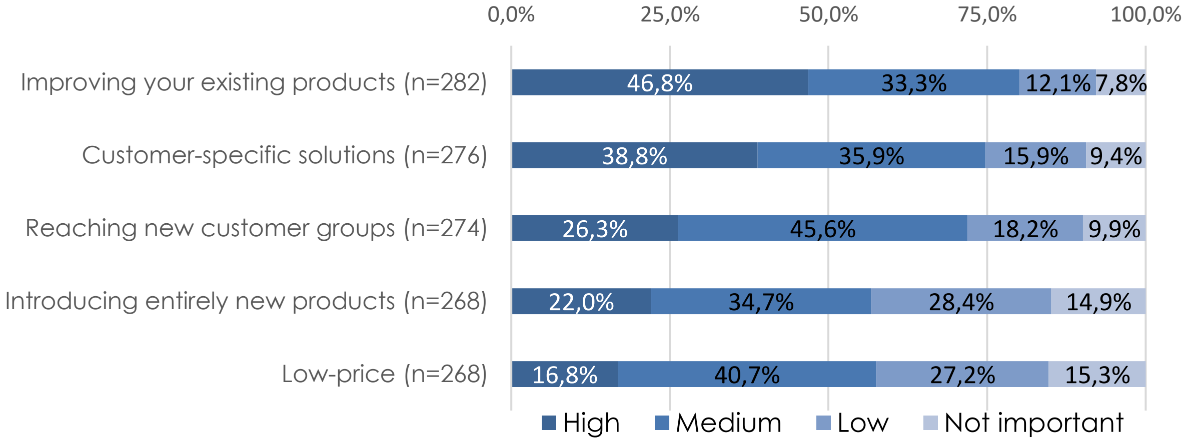
Another characteristic of enterprises that we included is the year of registration, based on which we computed their length of activity. As per the participation condition, the minimum was four years, while on both the median and the average, they were active for about 16 years (Std. Deviation 9.36).

Enterprise strategies

At the beginning of the questionnaire, enterprises were presented with a list of five strategies and asked how important each was to their enterprise.

As seen in Figure 1, almost half of respondents (47%) ranked improving existing products highly, followed by customer-specific solutions (39%) and reaching new customer groups (26%). Introducing entirely new products (22%) and low-price (17%) were considered the least important.

Figure 1
Enterprise strategies



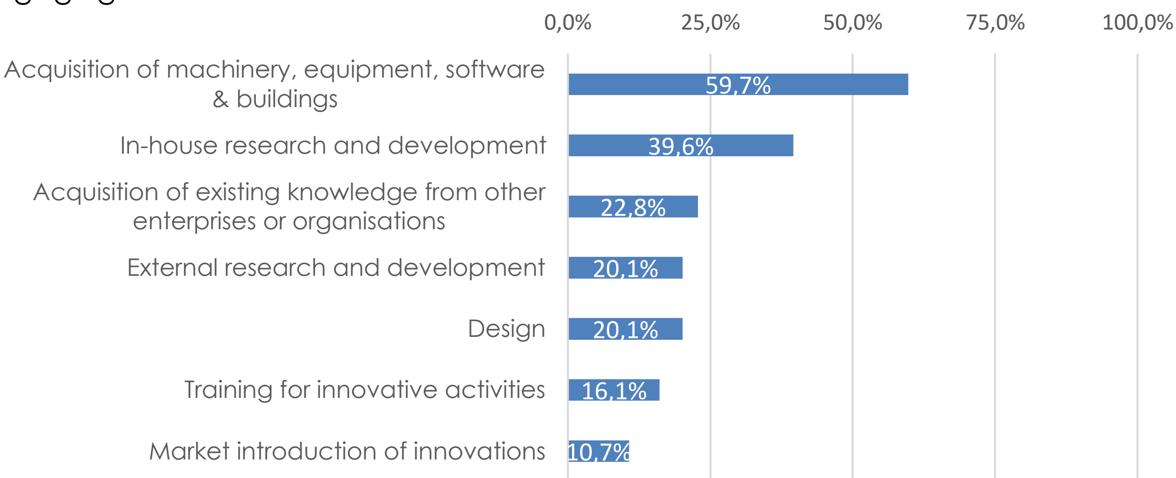
Note: The number of responses is provided in parentheses and varies from 268 to 282.
Source: Author's illustration in Microsoft Excel

Engaging in innovation activities

Enterprises that engaged in innovation activities from 2016 to 2018, even those that did not result in product or process innovations, were asked which innovation activities they engaged in. Nevertheless, the present analysis only includes those where innovations were present (n=149).

As indicated by Figure 2, most engaged in the acquisition of machinery, equipment, software, and buildings (59%), followed by in-house research and development (40%), while external research and development were less popular (20%). A few more than that acquired existing knowledge from other enterprises or organisations (23%), and about the same number engaged in design (20%). A lesser number of enterprises trained in innovative activities (16%), and the lowest percentage was the percentage for market introduction of innovations (11%).

Figure 2
Engaging in innovation activities



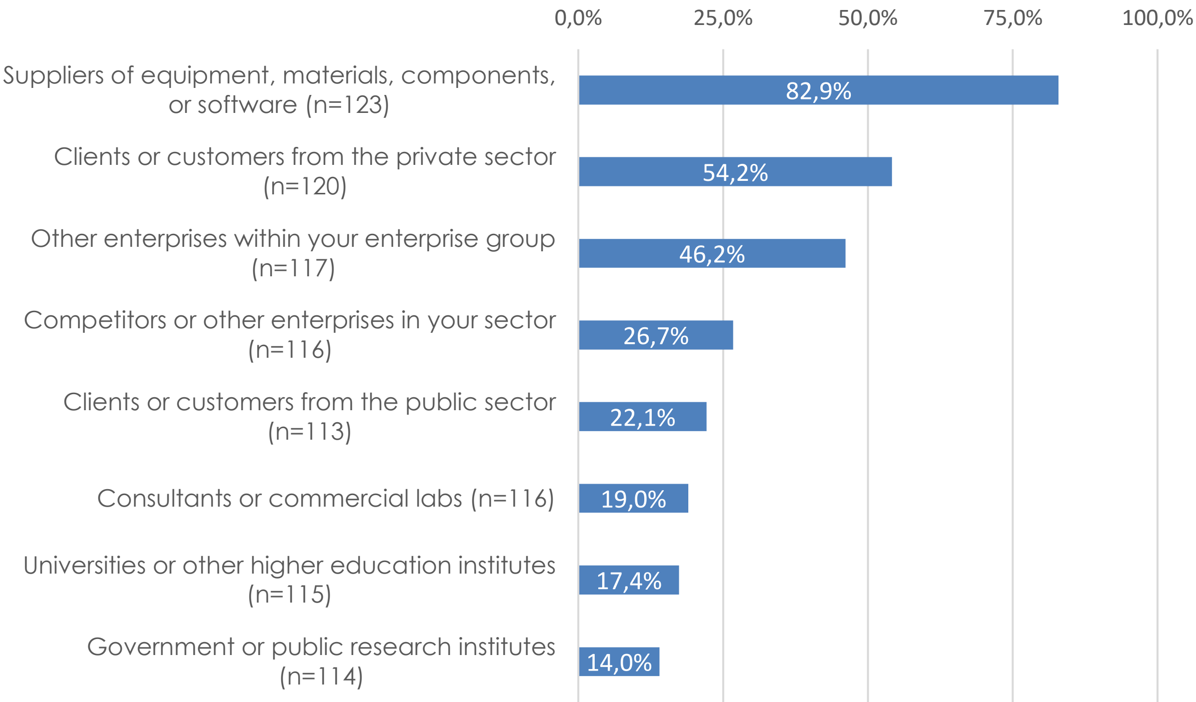
Note: n = 149 enterprises
Source: Author's illustration in Microsoft Excel

Co-operation with other enterprises and organisations

Respondents whose enterprise engaged in any innovation activities (n=123) were asked if they cooperated with any other enterprises or organisations in Slovenia or outside.

Figure 3 shows that when engaging in innovation activities), most enterprises cooperated with suppliers (83%), followed by clients in the private sector (54% co-operate) and other enterprises within the enterprise group (46%). Only 27% collaborated with competitors or other enterprises in their sector, 22% with clients or customers from the public sector, 19% with consultants or commercial labs and 17% with universities or other higher education institutions. The least popular collaborators were research institutes (14%).

Figure 3
Co-operation with other enterprises and organisations



Note: The number of responses is provided in parentheses and varies from 113 to 123.
Source: Author's illustration in Microsoft Excel

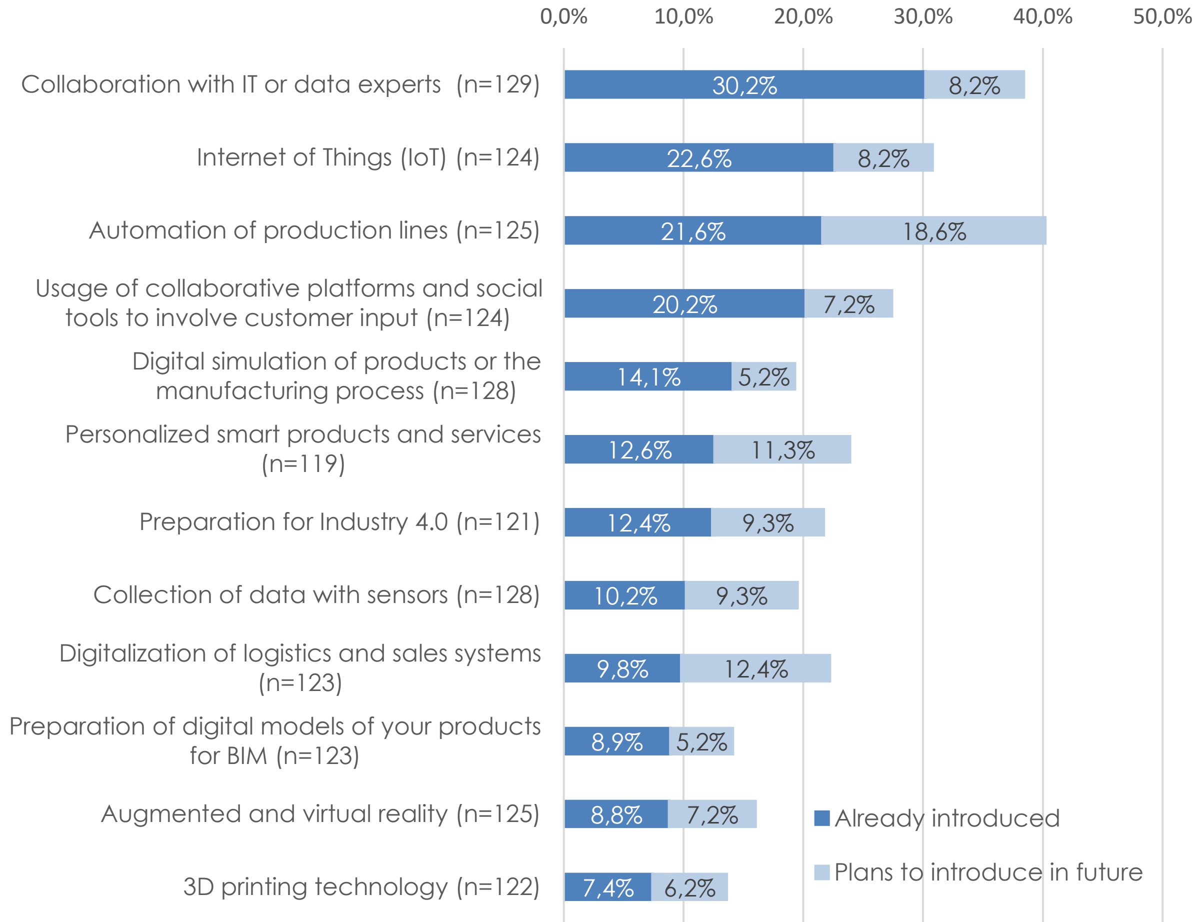
Business process digitalisation

Respondents who reported at least one product, process, organisational or marketing innovation (n=198) were asked about business process digitalisation. In Figure 4, the dark blue bars display actual innovations, while the light blue colour indicates the intention to implement this kind of innovation in the future.

Most, but less than a third of innovators, introduced collaboration with IT or data experts (30%), followed by Internet of Things (23%), automation of production lines (22%) and usage of collaborative platforms and social tools to involve customer input (20%). Less than one in seven enterprises introduced digital simulation of products in the manufacturing process (14%), personalised smart products and services (13%) and preparation for Industry 4.0 (12%), collection of data with sensors (10%) and digitalisation of logistics and sales systems (10%). The least often introduced innovations were 3D printing technology (7%) and the preparation of digital models for Building Information Modelling (9%).

When asked if they plan to introduce any of the business process digitalisation innovations, 65% responded that they did not. The most popular among the listed options was the automation of production lines, which was selected by almost 19% of the respondents, followed by the digitalisation of logistics and sales systems (12%) and personalised smart products and services (11%). Summing up actual and planned innovations, automation of product lines covers 40% of respondents, followed by collaboration with IT or data experts (38%) and the Internet of Things (31%).

Figure 4
Innovations in business process digitalisation



Note: The number of responses is provided in parentheses and varies from 119 to 129.
Source: Author's illustration in Microsoft Excel

To reduce the dimensionality of the data, we computed a count of business process digitalisation as an outcome variable to use in further analysis. We used all 12 items as they correlated strongly with each other, with a good Cronbach's Alpha (0.81).

Table 1 shows the frequency distribution of the count variables. As much as 41% of innovators did not digitalise any business processes, while 21% did at least one, 16% at least two, 5% at least 3, 6% at least 4, 4% at least 5, and the remaining almost 7% did 5 or more. However, the maximum count is 10, and no enterprises have done 11 or all 12 digitalisation types.

Table 1
Frequency distribution of count of business process digitalisation innovations

Count	0	1	2	3	4	5	6	7	8	9	10
Frequency	54	28	21	7	8	6	3	1	1	3	1
Percentage	40.6	21.1	15.8	5.3	6.0	4.5	2.3	0.8	0.8	2.3	0.8

Note: N=133
Source: Authors' computation in SPSS

Relationship between business process digitalisation and other variables

Spearman correlation coefficients were computed for correlations with the number of business process digitalisation and control variables: turnover (n=128), number of employees (n=131), their education (n=100) and position in the company (n=91), year of registration (n=132), engagement in innovation activities (n=116), and cooperation with other organisations (n=104).

The highest turnover (Rho=0.25, p<0.01), number of employees (Rho=0.21, p<0.01), number of employees with tertiary education (Rho=0.31, p<0.01) and in RDI position (Rho=0.51, p<0.01), the more business process digitalisation innovations (Table 2). In contrast, the length of time a company has been active does not have a statistically significant correlation.

Table 2
Relationship between Count of Business Process Digitalisation Innovations and Enterprise Characteristics

Enterprise Characteristics	Spearman's Rho	Sig.	N
Turnover	0.254	0.004	128
Number of employees	0.205	0.002	131
Number of employees with a tertiary degree	0.312	<0.001	100
Number of employees in RDI position	0.508	<0.001	91
Years of activity	0.105	0.230	132

Note: Spearman's rank correlation is in itself a measure of effect size
Source: Authors' computation in SPSS

Giving high importance to customer-specific tasks strategy (Rho=0.32, p<0.01) and improving existing products (Rho=0.23, p<0.01) is associated with the number of digitalisation innovation types. In contrast, when introducing entirely new products, reaching new customer groups, and setting a low price, the correlation is not statistically significant (Table 3).

Table 3
Relationship between Count of digitalisation innovations and strategies

Strategy	Spearman's Rho	Sig.	N
Improving existing products	0.232	0.008	131
Introducing entirely new products	0.145	0.103	128
Reaching new customer groups	0.114	0.202	128
Customer-specific solutions	0.324	0.000	131
Low price	-0.107	0.226	129

Note: Spearman's rank correlation is in itself a measure of effect size
Source: Authors' computation in SPSS

Among different innovation activities, the strongest correlation with the count of digitalisation innovations is found for research and development, both in-house (Rho=0.45, $p<0.01$) and external (Rho=0.38, $p<0.01$), followed by design (Rho=0.28, $p<0.01$), market introduction of innovations (Rho=0.26, $p<0.01$) and training for innovative activities (Rho=0.22, $p<0.05$), while acquisition of neither machinery, equipment and software and buildings nor knowledge from other enterprises or organisations did not a statistically significant correlation (Table 4).

Table 4
Relationship between Count of business process digitalisation and Innovation activities

Innovation activities	Spearman's Rho	Sig.	N
In-house research and development	0.447	<0.001	116
External research and development	0.375	<0.001	116
Acquisition of machinery, equipment, software, buildings	0.085	0.365	116
Acquisition of existing knowledge from other enterprises or organisations	0.111	0.236	116
Training for innovative activities	0.224	0.016	116
Market introduction of innovations	0.263	0.004	116
Design	0.283	0.002	116

Note: Spearman's rank correlation is in itself a measure of effect size
Source: Authors' computation in SPSS

Last, we associated the count of digitalisation innovations with cooperation with different types of organisations and found the strongest correlation with the three least popular ones: universities and other higher education institutes (Rho=0.49, $p<0.01$) and government or public research institutes (Rho=0.36, $p<0.01$), followed by consultants and commercial labs (Rho=0.33, $p<0.01$) and clients and customers from the private sector (Rho=0.26, $p<0.01$), while no significant association was found for clients and customers from the public sector, another group, and suppliers (Table 5).

Table 5
Relationship between Count of business process digitalisation and Co-operators

Co-operators	Spearman's Rho	Sig.	N
Other enterprises within your enterprise group	0.160	0.113	99
Suppliers of equipment, materials, components, or software	0.144	0.145	104
Clients or customers from the private sector	0.263	0.008	102
Clients or customers from the public sector	0.105	0.304	97
Competitors or other enterprises in your sector	0.148	0.146	98
Consultants or commercial labs	0.326	0.001	99
Universities or other higher education institutes	0.488	0.000	99
Government or public research institutes	0.345	0.000	99

Note: Spearman's rank correlation is in itself a measure of effect size
Source: Authors' computation in SPSS

Discussion

The results confirm the findings of previous studies (Keefe et al., 2019; Kortelainen et al., 2020; Rancher et al., 2023) that the digitalisation of the forest-wood sector is low as two in five have not introduced any business process digitalisation innovation. Among those that did, the most popular was collaboration with IT or data experts, but less than a third did it.

The second most frequent digitalisation was the Internet of Things, selected by almost one in four respondents and was also mentioned in several previous studies (Keefe et al., 2019; Matasov et al., 2020; Tomelleri et al., 2022; Yang et al., 2021). Almost the same number reported about the automation of production lines, and there are also several cases of previous applications in literature (Burnard et al., 2018; Chen et al., 2022; Fredriksson, 2015). More than one in five used collaborative platforms and social tools, of which we found only two applications in previous studies (Grant et al., 2019; Pynnönen et al., 2021).

On the one hand, our survey included types of innovations for which we did not find explicitly mentioned in previous studies of the forest-wood sector, such as the digital simulation of products or the manufacturing process, personalised smart products and services, digitalisation of logistics and sales systems, preparation of digital models of products for building information modelling, and 3D printing. On the other hand, preparations for Industry 4.0 (Keefe et al., 2019; Ranacher et al., 2023), collection of data with sensors (Calders et al., 2020; Hogland et al., 2021; Rautio et al., 2023), and virtual reality (Fiore et al., 2009; Holopainen et al., 2020; Olschewski et al., 2012) have been referenced in literature but were reported by one in eight respondents or fewer.

How many business process innovations an enterprise has introduced is strongly associated with the number of employees in an RDI position and moderately with the number of employees with tertiary education, customer-specific solutions strategy, research and development activities, and cooperation with higher education and research institutes and consultants and commercial labs. To a low degree, there is also a correlation with turnover, enterprise size, the strategy of improving existing products, design, market and training innovation activities, and collaboration with clients and customers in the private sector.

The study has three main limitations. First, the response rate of the survey is low, and so is the realised sample, in particular, the subsample of innovators on which the present analysis is based. Thus, the result might contain some bias and not be representative of the studied population. Second, the question on business process digitalisation was constructed by the authors of the questionnaire and is not based on any previous survey or conceptualisation of the term. Some items are too broad, and there is an overlap between some of them, e.g., sensors and the Internet of Things). Further investigations should come up with a more precise operationalisation of the concept. Third, the study is limited to only one country and one sector. Subsequent studies should try to compare results across countries and sectors.

Conclusion

Despite its limitations, this paper is an important contribution to understanding the digitalisation of business processes in the forest-wood sector, which is an understudied topic not only in Slovenia but also globally. The digitalisation level is low, and to improve it, enterprises should employ more skilled employees and place them in RDI positions, invest in research and development and other innovation activities, and co-operate more with universities and research institutes. Future research is needed to improve the conceptualisation and measurement of digitalisation in this and related sectors.

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About the authors

Ana Slavec is a consulting statistician and researcher at the InnoRenew CoE Renewable Materials and Healthy Environments Research and Innovation Centre of Excellence. She obtained a PhD in Statistics from the University of Ljubljana. Her current research interest is survey methods and their use in sustainability research. She has been involved in several domestic and international projects, co-authored scientific publications and presented her work at various conferences. The author can be contacted at **ana.slavec@innorenew.eu**

Michael Burnard is the deputy director of the InnoRenew CoE and an Assistant professor at the University of Primorska. He is also a professor of Practice at the University of Helsinki. His research interests are sustainable construction using renewable materials and human health in the built environment. The author can be contacted at **mike.burnard@innorenew.eu**