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How do micro-psychological and macro-socioeconomic factors influence construction safety knowledge sharing? Insights from a mixed-AI approach

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ABSTRACT

Construction safety knowledge-sharing is beneficial for construction accident reduction. This study explores the relationship between micro-psychological and macro-socioeconomic factors influencing engineering workers' motivations to share construction safety knowledge via surveys and microblogs. The quantitative results found that better-perceived organisational support in sound economic regions and longer services significantly raised workers' willingness to share construction safety information. The qualitative results of 3701 microblogs and 8200 comments echoed the survey's findings that workers in wealthier regions actively share more construction safety knowledge. Besides, governments were key opinion leaders in engineering and construction knowledge sharing. These findings differed from those of overseas social media, where most key opinion leaders were individuals or private companies, and knowledge-sharing motivations came from individuals. This paper extended the knowledge-sharing theory by uncovering the interactions between economic and psychological factors that motivate knowledge-sharing in engineering and construction safety. It is the first to study microblog engineering and construction safety knowledge-sharing. Second, it contributes to the methodological foci by employing the white box H2O Driverless AI model. Third, it offers managerial implications to construction practitioners. This study provides a novel approach to analysing social media data; however, it is limited by the location of the study and social media types.

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KEYWORDS
Construction safety; innovative knowledge management; safety information sharing; AI modelling; big data text analytics; human resource management

1. Introduction

According to the National Bureau of Statistics of China, there were 88,074 construction enterprises in 2020. The construction industry is a leading sector that employs 1,451.8 million people (Statista 2021). However, the industry has a high accident rate. Many

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accidents happen because workers are ignorant of situation awareness, security devices, skill level, etc. All these heighten the importance of safety knowledge sharing.

The foundation of an enterprise information system relies on stakeholders' efforts to share information and related knowledge. The employees' knowledge-sharing motivations are critical to engineering management (Bhatti et al. 2021). As smart tools become essential for knowledge sharing when face-to-face communication is impossible during COVID-19 (Comite et al. 2020), it accelerates rapid communication technologies development, such as X (Twitter), which offers innovative knowledge sharing (Yao et al. 2021). While there is an increase in the popularity of knowledge-sharing tools in China, such as Web 2.0 (which allows individuals to read and write on websites), mobile apps and the Internet of Things (IoT), most of these are well-known for entertainment. Research on the interplay between micro-psychological macro and macro-socioeconomic factors that motivate construction industry practitioners to use them for construction safety knowledge sharing is scarce. This research aims to fill this research void.

This study provides information to construction practitioners, workers, construction companies, and local governments regarding the area of knowledge shared most and key opinion leaders' backgrounds, indirectly reflecting the knowledge-sharing motives. For example, if most of these are construction safety training companies, the motivation may come from businesses' profit increments via online advertisements. Thus, this study includes qualitative research on individuals and groups that share construction safety knowledge via Weibo.

This study's research objectives are twofold: 1) to explore the interplay between micro psychological and macro-socioeconomic factors that affect people's willingness to share construction safety knowledge; 2) to study the Weibo's main foci, which indirectly reflect the the factors that power practitioners to share safety knowledge in the construction field.

In the next section, this paper reviews knowledge-sharing literature about the construction safety knowledge-sharing process and articulates the research hypothesis. Section 3 is the research method, and section 4 shows quantitative results. Section 5 is the qualitative text mining results of microblogs. Section 6 is the conclusion, providing critical research findings, implications, and conclusions.

2. Literature review

2.1. Construction safety knowledge-sharing process

Knowledge sharing provides task information and know-how to develop new ideas, collaborate with others and solve problems (Bhatti et al. 2021). It is an innovative process of interpersonal interaction between groups, departments, or divisions. Traditional knowledge sharing requires experts to share their knowledge via written documents and face-to-face communications. The digital age broadens the knowledge-sharing channels to Information Communication Technologies (ICTs) and virtual communities that are more interactive and convenient in construction and engineering (Huang et al. 2020).

Tech-based knowledge sharing lowers the barriers among workers and enlarges information access (Kamalipoor et al. 2023). Sometimes, knowledge-sharing benefits more from a technology-aided context than a face-to-face approach. Individuals might

prefer to engage in online discussions of cocreating and exchanging knowledge. Workers share knowledge on a virtual platform via online communities, contributing to the organisation (Luo et al. 2021). To facilitate knowledge sharing in virtual communities, it is critical to understand why people share or receive knowledge from others.

Construction workers' knowledge-sharing activities raise site safety awareness (Ishdorj et al. 2024). While the development and application of digital tools for knowledge-sharing require investment which may be limited by the availability of construction companies' funds, construction companies may share construction safety knowledge via a free tool like Twitter (Yao et al. 2021). Chinese construction practitioners primarily use microblogs (Weibo), which share similar functions to Twitter, for knowledge sharing. Extensive research indicated that Chinese users share safety knowledge regarding disaster management (Shan et al. 2019), travel safety (Oliveira et al. 2020). Previous research also studied people's movements based on Weibo data. However, applying microblogs to share construction safety knowledge still needs to be explored in research.

2.2. Tech-based safety knowledge sharing under psychological concepts

The social capital theory underpins trust, norms, and obligations in an organisation's relationship between workers and the organisation's intellectual capital exchange (Nahapiet and Ghoshal 1998). Knowledge sharing in a social exchange process between workers and teams allows companies to exploit knowledge-based resources. In the digital online environment, workers share knowledge through social ties in virtual public and professional communities (Jain et al. 2021).

Perceived Organisation Support (POS) shapes workers' attitudes and behaviours and the relationship between the workers and employers (Eisenberger et al. 2001, 566). It captures a worker's belief regarding how much the organisation value their contributions (Eisenberger et al. 2002). The individual's motivation for sharing knowledge depends on the organisation. Workers with positive perceptions of the perceived organisation engage in extra-role activities beyond formal requirements. On the contrary, workers who feel an organisation is insufficient POS may refrain from engaging in outside work, such as knowledge sharing (Wickramasinghe and Perera 2014).

Perceived organisation offers a solid theoretical basis for examining workers' motivation to share knowledge. Although new technology accelerates knowledge sharing, managers and leaders must create and maintain an open environment favourable for sharing knowledge. Supportive corporate culture, leadership, and practice must motivate people to share knowledge (De Long and Fahey 2000).

Given the above, perceived organisational (POS) shapes employees' willingness to share knowledge. We posit:

H1: Perceived organisation positively enhances workers' motivation to share technology-enabled safety knowledge in engineering and construction companies.

Leader-member exchange is a multidimensional construct (Dienesch and Liden 1986). It promotes organisational (Scandura 1999), job satisfaction, performance, engagement, etc. (Bauer and Erdogan 2015). While leader-member exchange positively leads to the above outcomes, the leadership-member exchange depends on trust. A lower level of trust in

the organisation is associated with less knowledge sharing among co-workers (Liao et al. 2024; Rutten et al. 2016).

P. Pinjani and Palvia (2013) found that higher mutual trust among global virtual teams may be associated with more IT than face-to-face interaction. However, lacking trust discouraged workers' openness to share knowledge in the virtual environment. For example, Chinese employees were unlikely to share information like workplace mistakes (Zheng and Davison 2022). Similarly, Caruso (2018) found that employees were unwilling to accept colleague criticism due to information security, confidentiality, openness, and sensitivity. To further examine the relationship between leader membership exchange and technology-enabled safety knowledge sharing, we propose:

H2: Workers with better-perceived leader membership exchange positively enhance the motivation to perform technology-enabled safety knowledge sharing in engineering and construction companies.

2.3. Individual-level personal benefits and technology-enabled safety knowledge sharing

Social exchange theory suggests that individuals evaluated the perceived ratio of benefits to costs in the social interaction: they expected rewards such as respect, reputation, and tangible incentives as results of their actions (Cropanzano and Mitchell 2005). The social dilemmas (Kollock 1998) identified personal payoff determined the individual's motivation and unwillingness to accept organisational tasks. Workers were concerned about the results of knowledge sharing in the community, such as criticism and misleading information (Muhammed and Mathew 2022). On the other hand, Javernick-Will (2012) identified the power of social motivations in motivating knowledge sharing in engineering and construction companies. Personal benefits have different impacts on motivating knowledge sharing. Osterloh and Frey (2000) uncovered intrinsic and extrinsic knowledge-sharing motivations. They found that intrinsic motives (internal or emotional rewards) increase knowledge sharing. In contrast, extrinsic (outcomes of performances, such as earned money) were less potent (David et al. 2020). Some organisations share knowledge as an indicator of measuring employee performance in innovation. Others found that incentives like promotion, bonuses, and a higher salary increased workers' contributions to sharing knowledge and their frequency (Singh et al. 2021). Conversely, workers need to see the personal benefits of their act to be motivated to share knowledge. They did not even understand why knowledge sharing would be essential for themselves or their organisation.

Regarding social-emotional benefits, Nguyen et al. (2021) have found that moral obligation and community interest considerations stimulate knowledge exchange instead of narrow self-interest. Previous research found that online knowledge sharing was related to increased job satisfaction (Kucharska and Erickson 2020). For instance, knowledge-sharing outcomes enhanced their professional reputations. However, knowledge sharing was confined to highly competitive industries or professional communities (Wasko and Faraj 2005). This phenomenon assumed that the motivation of knowledge sharing in open-access online virtual communities could decrease without directly benefiting contributors (Wasko and Faraj 2005). Also, free riders only acquired others'

knowledge from virtual communities without any contributions (Hergueux et al. 2023). Given the above, this study proposes:

H3: Workers with better perceived personal benefits positively enhance workers' motivation for technology-enabled construction safety knowledge sharing.

2.4. Macroeconomics and technology-enabled safety knowledge sharing

A social capital theory suggests that social and economic development is the basis for a fair society functioning (Deller et al. 2018). Economic development is essential for promoting social progress (Song et al. 2019) and a material basis for knowledge sharing (Bogoviz et al. 2018). The knowledge formed by different economic conditions has different contents and characteristics, resulting in various ways of knowledge-sharing behaviour (Ahmed et al. 2019). Wealthier nations can afford to buy smartphones for knowledge sharing via mobile apps, and more money to receive IT education-related tools. Therefore, we posit:

H4: Workers in wealthier regions positively affect workers' willingness to share construction safety knowledge via IoT, Web 2.0 and mobile apps.

The literature review shows that the micro-level perceived organisational support, leader membership exchange, and individual-level perceived personal benefits had not been linked to economic conditions. Yet, economic conditions affect technology usage, so it is reasonable to consider micro-psychological and macro-socioeconomic factors when examining knowledge sharing. This study proposed the following hypotheses:

H5a: Workers with better-perceived organization support in areas with a better economy are more willing to engage in technology-enabled safety knowledge sharing.

H5b: Workers with better-perceived leader membership exchange in areas with a better economy are more willing to share construction safety knowledge.

H5c: Workers with better perceived personal benefits positively enhance workers' motivation for technology-enabled construction safety knowledge sharing in areas with better economies.

3. Research method

This study used a mixed-method research design for two stages: quantitative H2o.ai modelling in stage one and qualitative text mining in stage two. In stage 1, we collected the opinions of construction and building engineering workers on their willingness to share construction safety knowledge. Similar methods were adopted in other studies. For example, Edwin et al. (2024) utilised a survey to study the relationship between safety and project management in the Norwegian construction industry.

To study the impact of macroeconomy on willingness to share knowledge via Web 2.0, Mobile Apps, and IoT. We conducted a pilot survey before formal data collection. First, we shared the data collection protocol (Appendix) with research experts from three university institutions to gather feedback, enhance the accuracy of measurements, refine research objectives, and improve the theoretical rigour of survey and interview questions. Next, we distributed the Wenjuanxing link in the Chinese Construction Engineer Association WeChat group to recruit pilot respondents. This pilot study, involving 34 participants, allowed us to test the questionnaire's quality, assess reliability and validity, and identify any outliers or errors. After that, this study sent surveys to construction companies in China of different provinces with different GDP per capita via email and WeChat from 2 October 2022 to 27 October 2022. It eliminated invalid survey results such as surveys with lots of missing answers, and the respondents picked the same answers for all the questions, which indicated reckless answers. It eventually retained 400 valid surveys for analysis in 2022.

3.1. Explainable AutoML for predicting tech-based construction safety knowledge willingness

AI algorithms study the various factors that affect sharing of construction safety knowledge. This paper adopted H2O Driverless AI, an explainable AutoML algorithm (a white-box model) for analysis. AutoML minimises adjustments and tunes all parameters automatically according to the embedded algorithms to select the best model based on five machine learning algorithms: XGBoost, distributed random forest, gradient boosting machine, and stacked ensemble. Through the H2O Driverless AI technology platform (automatic machine learning), H2O Driverless AI helps people quickly apply machine learning technology (2022). Thus, we used H2O Driverless AI to automatically select the best model from the many models available and the most relevant variables for the model and exclude irrelevant ones. The same data split used a ratio of 0.75 for the training sets to the original data, with the remaining 0.25 allocated for the test sets. The AUC (Area Under Curve) scored 0.95, which is very close to the actual scenario.

AUC formula:

$$AUC = \frac{\sum_{ins_i \in positive} rank_{ins_i} - M*(M+1)/2}{M*N}$$

The Explainable AutoML Gradient Boosting Decision Tree (GBDT) model uses LightGBM as the framework for implementing the GBDT algorithm. GBDT uses weak classifiers (decision trees) to train the optimal model and yield good training performance. LightGBM supports efficient parallel training, results in faster training, lower memory consumption, and improved accuracy. Extreme gradient boosting (XGBoost) parallel enhances tree growth to reduce time and optimise performance. Each tree is approximated by numerous regression functions fi(x). Feature importance is computed according to the average gain during node splitting. XGBoost's objective function is computed as Obj $(\theta) = \sum_{k=1}^{k} \vartheta(f_k) + \sum_{i=1}^{n} L(y_i, \hat{y}_i)$, where the first part shows the sum of each tree's complexity, the second part illustrates the model's training loss. Tree complexity is estimated as $\vartheta(f_k)$=$\gamma T + 0.5 \quad ||w||^2$, where γ shows the complexity parameter, T represents the leaf nodes number, refers to the fixed coefficient, and $||w||^2$ indicates the l_2-norm of leaf

weight. Accelerating the convergence training process and adding a regularised term to prevent overfitting, XGBoost was used for predicting stock prices (Li et al. 2022).

Gradient boosting machine (GBM) is a homogeneous ensemble learner, with each subsequent tree depending on the results of previous trees. It requires tuning hyperparameters by applying a grid search. A distributed random forest (DRF) generates a forest of regression trees where each tree is built on row and column subsets. Regression averages the predictions from all trees. DRF maps factors in lexicographic order to the Schwarz lookup array using integer indices for a categorical response column (Li et al. 2022). A generalised linear model (GLM) accommodates data that does not follow a normal distribution. It shows a curvilinear relationship between a response variable Y and the explanatory variables x_i: $Y = a_0 + a_1x_1 + a_2x_2 + \ldots . + a_kx_k + \ldots + \varepsilon$, where a_0 refers to the regression coefficient for the intercept and a_k represents the regression coefficients for explanatory variables 1 through k, computed using the training data and explanatory variables x_k. X can be a linear or of a higher power, and ε represents the error term (Li et al. 2022).

A stacked ensemble combines the abovementioned models to raise prediction accuracy. It trains L base learners on the training set, performs k-fold cross-validation on-base learners, and cross-validates the predicted values p1, … pL. The N cross-validated predicted values from each of the L algorithms are combined to create N new rows in the training set, which are then multiplied by L features to form a matrix z. The matrix constitutes the level-one data alongside the original response vector y. The ensemble model consists of L base learning and a meta-learning model by training the meta-learning algorithm on level one data (y=f(z)) (Boehmke and Greenwell 2020). Previous research has shown that a stacked ensemble outperforms multilayer perceptron in PM2.5 levels and stock prices (Li et al. 2022).

3.2. Validation strategy

H2O Driverless AI automatically splits the training data to determine the performance of the model parameter tuning and feature engineering stages. Using stratified sampling, the data is split into three-fold cross-validation for the experiment. With cross-validation, the whole dataset utilises three models, each trained on a different subset of the training data. Figure 1 shows how cross-validation is utilised on hold-out data, based on cross-validation with five folds. Yet, this experiment creates threefold. The cross-validation process was repeated thrice to ensure the validation metrics were robust since the training data was small (2022).

The result of the Feature Evolution Stage is a set of features to be used in the final model. The top features included in the final model are presented below, ordered by importance. The features in the table are limited to the top 50, specifically those with a relative importance of 0.003 or greater. If no transformer was applied, the feature is an original column.

3.3. Qualitative analysis

After the quantitative analysis, the study verified the people's willingness and motivation for tech-enabled safety knowledge sharing via Web 2.0 by shedding light on data from

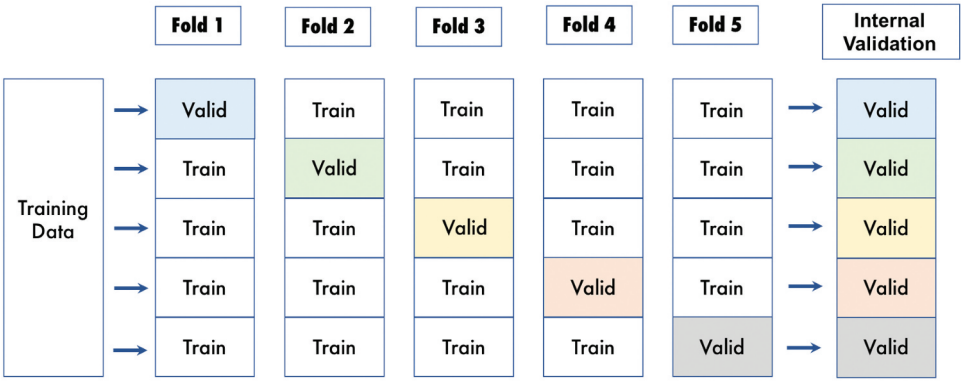

Figure 1. Internal validation of training data (2022).

microblogs. Using Python and MYSQL, it obtained microblog posts from 2011 to 2022 that covered keywords related to construction activities in Chinese (subway, tunnel, dam, irrigation project, power plant, canal, pipeline, construction workers, train station, construction worker, high-speed rail, airport construction, drainage, sewer, road, green building) construction knowledge sharing. It then used the dictionary-based sentiment algorithm of CD Data Science (2023). This dictionary contains words, phrases, common idioms and emoticons. The algorithm analyses each paragraph of text and calculates the overall positive and negative emotion scores based on the text's expression. It does not need training or calibration so it can be used immediately via microblog content (CD Data Science 2023).

4. Qualitative survey results

Table 1 summarises the survey results. On average, participants have 4 years of work experience and reported encountering 1.2 accidents. The Leader-Membership Exchange scales ranged from 0 to 12 based on the scale developed by Liden and Maslyn (1998), where 12 indicates the highest level of leader membership. Of 400 participants, 250, 283, and 317 were willing to share construction safety via IoT, mobile phone apps, and Web 2.0.

Table 1. Survey results.

name	Minimum	mean	Maximum	Standard deviation
Work Years	0.083	4.278	26.000	3.836
POS (Perceived Organisation Support)	0.000	1.538	2.000	0.653
LMX (Leader-Member Exchange)	0.000	9.603	12.000	2.317
Number of accidents over the past two years	0.000	1.227	155.000	10.783
Number of near misses in recent two years	0.000	15.963	3,422.000	205.729
POS * GDP	0.000	76,791.438	241,012.000	45,613.240
LMX * GDP	0.000	474,479.656	1,446,072.000	206,865.271
benefit * GDP	0.000	47,851.889	120,506.000	22,312.103
Age	18.000	34.700	60.000	8.680
Work Experience	0.000	10.041	45.000	8.732
Sex	0.000	0.140	1.000	0.348
Company Size	1.000	3.897	5.000	1.609
Years of Work for Company	0.000	5.243	26.000	4.659
Average GDP	30,389.818	49,921.645	120,506.000	19,564.578

*GDP refers to the GDP of the respondents' city where they have consistently worked over the past 10 years. Similar to other studies, some participants have left some questions blank.

4.1. Factors that affect willingness to share knowledge via Web 2.0

The research results show that the interaction term of perceived organisation and gross domestic product (GDP indicates economic development level) has the most decisive impact on predicting the likelihood of sharing construction safety knowledge. The second most important factor is perceived organisation. All these confirm the importance of companies in sharing construction safety knowledge via IoT. The longer the years of work for the company, the higher leader membership exchange positively impacts the likelihood of sharing construction safety knowledge via IoT. The interaction terms of the reward (Q7) and GDP are positive, indicating that people in wealthy cities with more rewards are more likely to share their knowledge. Nevertheless, the interaction term of leader-member exchange and GDP displays a negative figure, meaning more affluent cities and the excellent leader-membership exchange negatively correlate with the willingness to share construction safety knowledge (Figure 2).

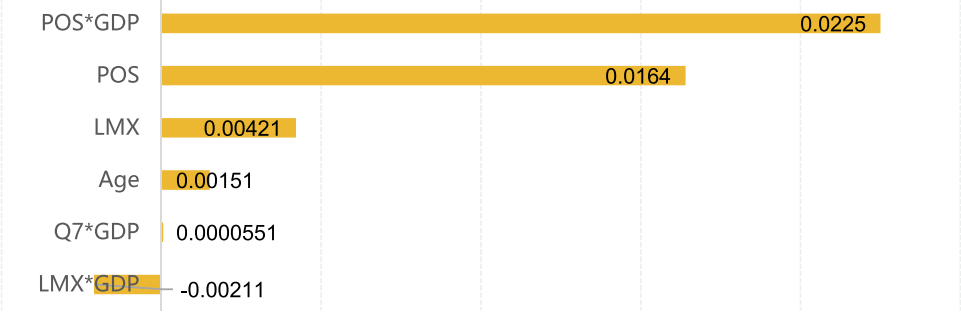

Figure 2. Willingness to share construction safety knowledge via IoT prediction model.

4.2. Factors that affect willingness to share knowledge via mobile apps

In mobile apps, average GDP, better leader membership exchange, higher GDP, and more awards coupled with higher GDP are associated with increased willingness to share construction safety knowledge via mobile apps (Figure 3). As app development and the purchase of smartphones require a monetary expenditure, the wealthiest cities are more likely to share construction safety knowledge via mobile apps. An increase in work and experience is associated with sharing construction safety knowledge. More experienced workers have more confidence in sharing construction safety knowledge. A similar rationale applies to someone who has worked in the same company for a long time. It also shows that building and civil engineering work have no clear difference, which affects people's likelihood of sharing construction safety knowledge.

Figure 3 Willingnessillingness to share construction safety knowledge via mobile apps prediction model

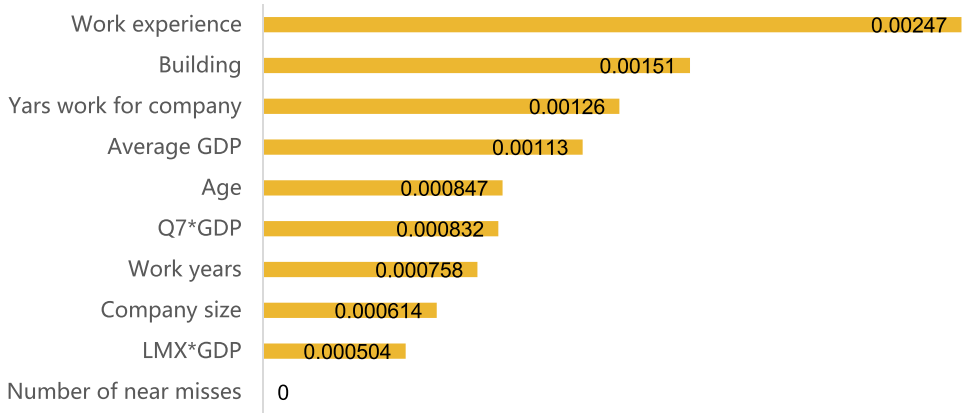

Figure 3. Willingness to share construction safety knowledge via mobile apps prediction model.

4.3. Factors that affect willingness to share knowledge via Web 2.0

In Web 2.0, the average city's GDP where the workers work and more awards associated with wealthier cities are associated with a higher likelihood of sharing knowledge in the prediction modelling. Perceived organisation support is the most important factor affecting people's willingness to share knowledge about construction safety. People who work on building sites are more willing to share construction safety knowledge than civil engineering and non-building workers. More extended work experience and age positively affect the likelihood of sharing construction safety knowledge Figure 4.

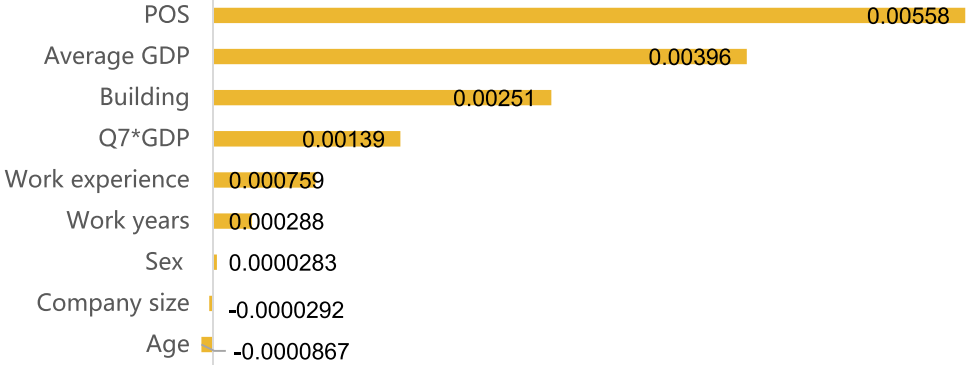

Figure 4. Willingness to share construction safety knowledge via Web 2.0 prediction model.

4.4. Comparison between the motivation to share construction safety knowledge sharing via IoT, Web 2.0 and mobile apps in China

This research found that perceived organisation support under better economic development (POS*GDP), perceived organisation support and years of work for the companies are the top three most important factors that affect willingness to share construction

Table 2. Results of H2O Driverless AI.

	Web 2.0			Mobile apps			IoT		
	Feature	Description	Relative Importance	Feature	Description	Relative Importance	Feature	Description	Relative Importance
1	11_POS	POS (Original)	1.0	13_POS * GDP	POS * GDP (Original)	1.0	12_POS	POS (Original)	1.0
2	12_POS * GDP	POS * GDP (Original)	0.5808	17_Work Experience	Work Experience (Original)	0.8441	0_ Years Work for Company	Years of Work for Company (Original)	0.9755
3	4_Company Size	Company Size (Original)	0.5116	12_POS	POS (Original)	0.8086	6_LMX	LMX (Original)	0.8518
4	2_Average GDP	Average GDP (Original)	0.4222	0_ Years Work for Company	Years of Work for Company (Original)	0.7771	13_POS * GDP	POS * GDP (Original)	0.8076
5	0_ Years Work for Company	Years of Work for Company (Original)	0.3897	18_Work Years	Work Years (Original)	0.7359	17_Work Experience	Work Experience (Original)	0.7427
							49_Average GDP	Average GDP (Original)	0.6894
							1_Age	Age (Original)	0.6719
							15_Reward * GDP	Reward * GDP (Original)	0.5708
							18_Work Years	Work Years (Original)	0.5685
							9_Non-building	Non-Building (Original)	0.4022
							11_Number of near misses	Number of near misses (Original)	0.2898
							10_Number of accidents	Number of accidents (Original)	0.2098

safety information via IoT. The importance of perceived organisation support (POS) echoes the results of Web 2.0. Years of work in the same companies are also essential in knowledge sharing via mobile apps, like IoT. Long-service workers know more about their company culture and are more confident in voicing their opinions. This reflects the importance of retaining company employees to enhance a willingness to share knowledge's culture. The results shown in Table 2 echoed the results of Goodbrand et al. (2021) that experienced and new workers' attitudes towards safety knowledge are different, and the economic value they create is not the same. Lastly, economic development impacts people's likelihood to share knowledge. However, the mediating role is mainly reflected in IoT instead.

5. Qualitative microblog results

Among 3,701 microblog posts (after removing duplicates and irrelevant posts), 2014 had the highest number ($n = 789$), and 2019 recorded the lowest number of posts ($n = 102$). From 2011 to 2014, microblog posts increased but decreased to 102 from 2014 to 2019. One hundred and two was the lowest number from 2011 to 2021. After 2019, the number of posts increased. There were 271 posts on microblogs in 2021. The information was analysed (Figure 5).

In Figure 6, construction, safety knowledge, propaganda, question, and construction site were the top five keywords in microblog posts (Figure 6). Figure 7 and 8 shows the forwarded posts with frequently mentioned keywords. Transportation, construction, road, environment protection and quality were the top five most forwarded keywords. Besides, construction, transportation, subway, pipeline, and environmental protection were the top five liked keywords in safety knowledge sharing via microblog Figure 9.

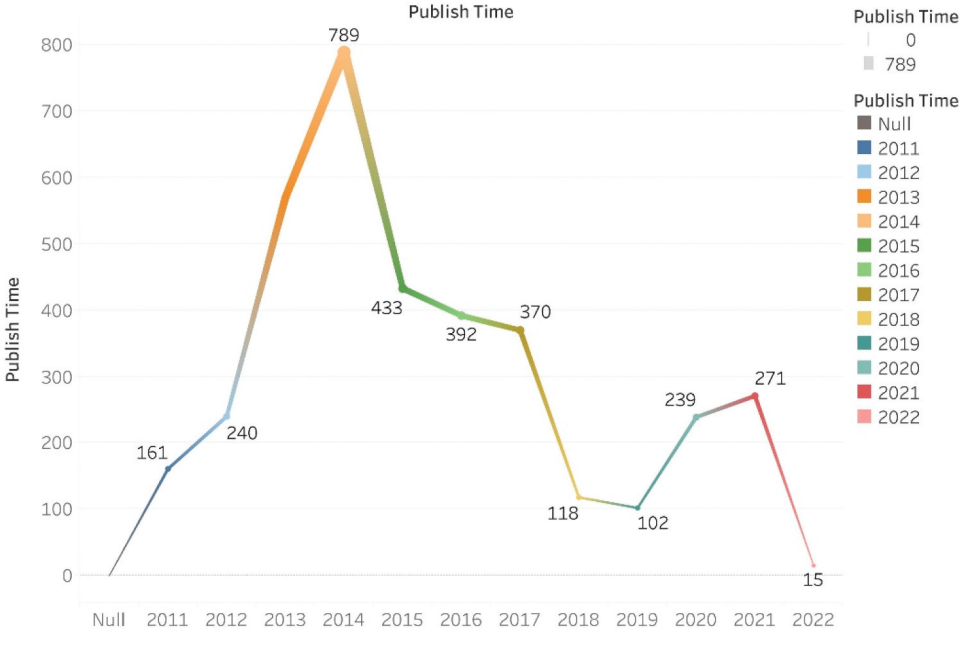

Figure 5. The annual information numbers in safety knowledge sharing from microblog.

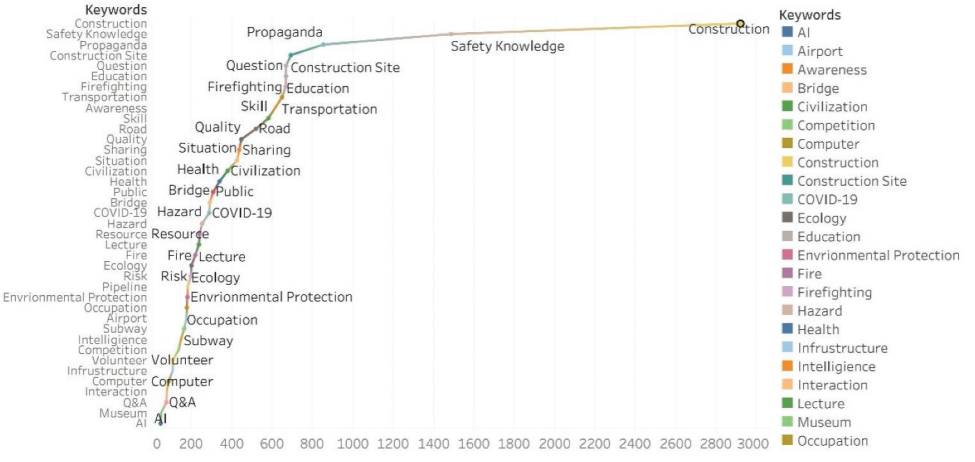

Figure 6. Keywords occurrences in safety knowledge sharing from microblog. Different colours represent different keywords

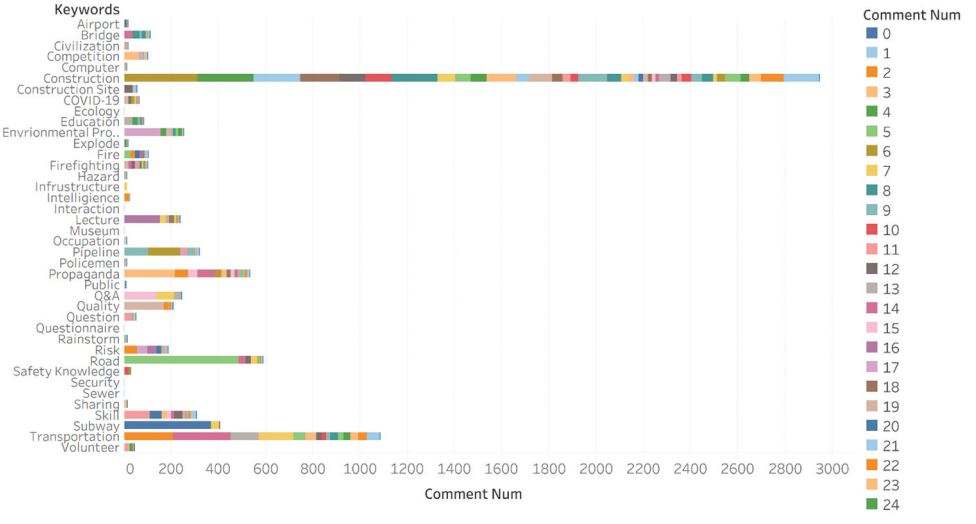

Figure 7. The keywords with comment numbers in safety knowledge sharing from microblogs. Different colours represent different comment numbers

In China, government departments face a considerable challenge because the policy requests that safety production and emergency management combine with digital technology (https://www.mem.gov.cn/index.shtml., 23 January 2022). Figure 10 shows that Guangzhou Emergency Management shared the most posts: 42 in 2013 and 97 in 2014. Figure 11 indicates that Guangzhou Emergency Management, East City of Bureau, Kunming Municipal Bureau of Emergency, Jinzhong Emergency Management, and Shungliu Emergency were the top 5 influential microblog users in safety knowledge sharing from 2011 to 2022.

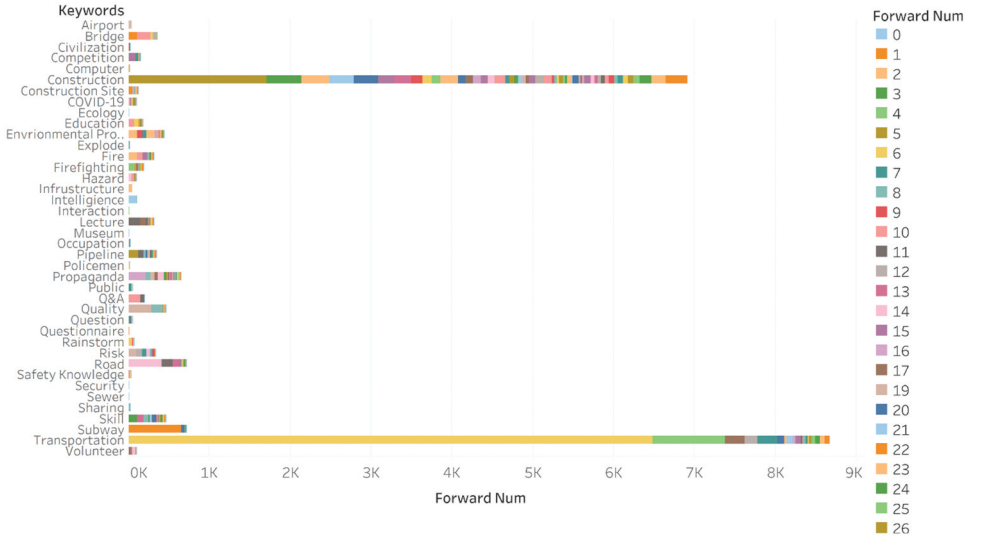

Figure 8. The keywords with the forward number in safety knowledge sharing from microblog. Different colours represent different forward numbers

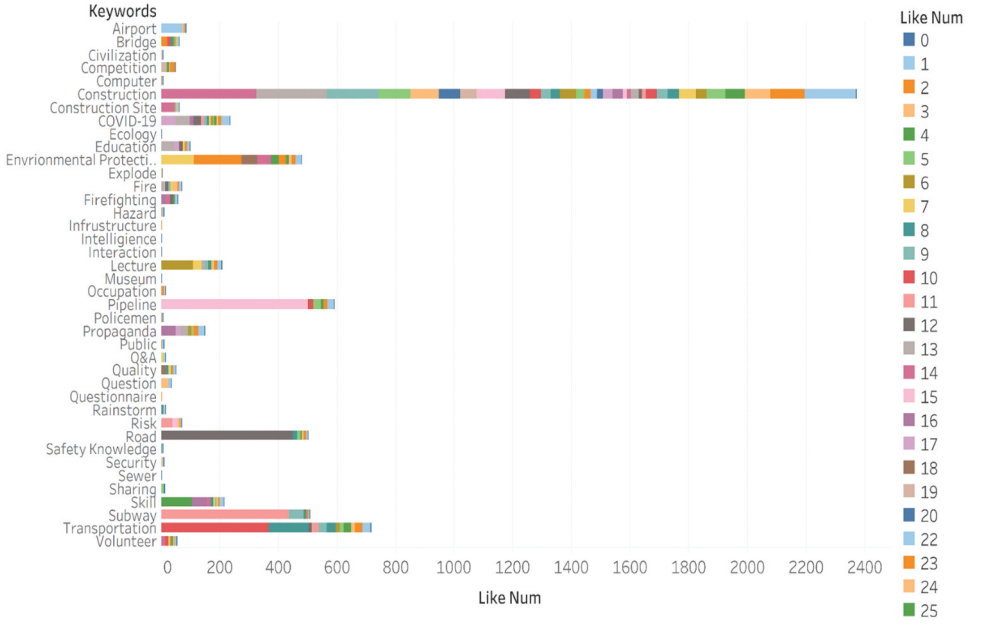

Figure 9. Most forwarded keywords in safety knowledge sharing using microblog. Different colours represent different like numbers

The sentiment results are shown in Figures 13, 14 and 15. When we analysed 701 posts from microblogs in Simply Sentiment (Table 3), 60.9% were positive, and 29.9% were negative (Figure 12). On average, positive posts (566 words) were longer than negative ones (308 words). Thus, microbloggers share more positive information online

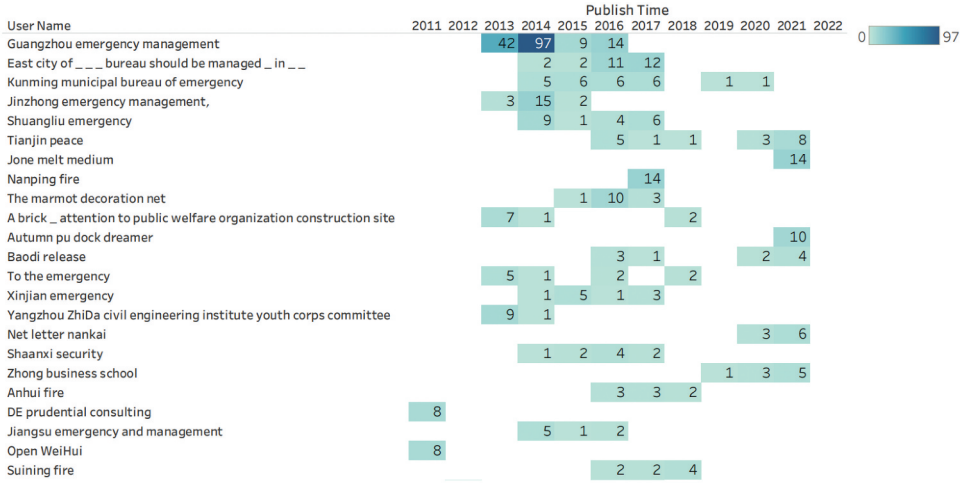

Figure 10. Key opinion leaders in microblogs who share construction safety knowledge (2011–2022).

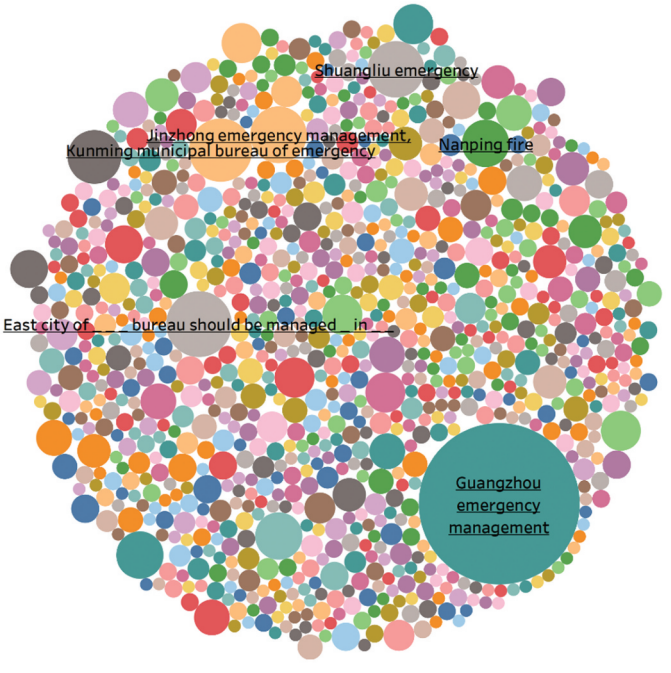

Figure 11. Key opinion leader in safety knowledge sharing through microblog. Different colours represent different opinion leader

than negative ones. The most frequently mentioned words can be found in Figure 13. Figure 14 indicates that the most influential positive keywords were 'good', 'comprehensive', 'safe', and 'support', while the most influential negative keywords were 'epidemic', 'good', and 'relevant' (Figure 15). After comparing the epidemic mentioned

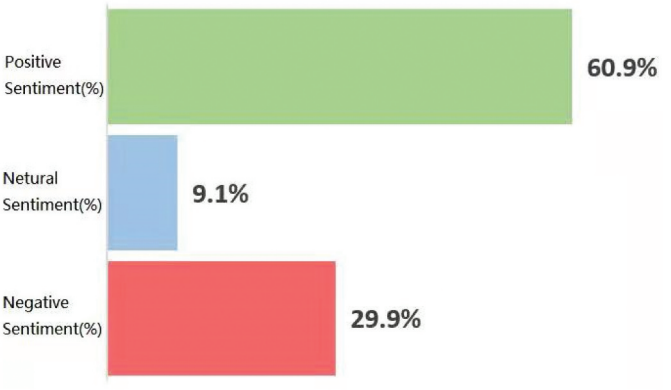

Figure 12. Net sentiment.

Figure 13. Tag clouds- all sentiment.

Figure 14. Positive sentiment.

Figure 15. Negative sentiment.

Table 3. Summary of sentiments and number of words in microblog posts.

	Positive	Negative	Neutral	no sentiment	no data	Overall	Net Sentiment =	31.0%
Total Items Processed	1179	579	177	246	0		% Positive	60.9%
Total Items Processed	54%	27%	8%	11%	0%	100%	% Neutral	9.1%
							% Negative	29.9%
Average Number of Words per Item	566	308	287	61		418	Total #	1935
No. Containing a URL or Email Addr	12	2	1	0		15		
Percentage	1%	0%	1%	0%		1%		

Table 4. Top six contents with the most forward number.

Main Contents	Forward number
Donglai Police Station Organised Summer Fire Safety Publicity for Construction Sites. To improve the safety awareness of fire and electricity use in summer at construction sites in the jurisdiction and enhance the ability to self-prevent and rescue. Recently, the police and fire assistant of Donglai Police Station walked into the Jiangfan Garden Phase II construction site to share knowledge of fire safety with the construction workers. They urged the person in charge of the construction site to implement the summer wrong-time work system, do an excellent job in heatstroke prevention and cooling, and pay attention to the safety of high-temperature construction.	856
Recently, the police officers and fire coordinators of Donglai Police Station walked to the Jiangfan Garden Phase II construction site to promote fire safety knowledge to construction workers. They do an excellent job of preventing heatstroke and cooling and pay attention to the safety of high-temperature construction. They urged the person in charge of the construction site to implement the staggered working system in the summer.	856
To further promote the "visit and send" activities, Houcheng Police Station police to go deep into the construction site of Xincheng Community to carry out safety prevention publicity. They distributed safety prevention publicity materials to construction site workers and explained safety prevention knowledge and common sense of heatstroke prevention and cooling. They also worked with construction site management personnel to find potential safety hazards and put forward rectification measures to effectively maintain the safety of construction sites in the summer.	430
In Jiangxia, Wuhan, Hubei, Maintenance Company of State Grid of grass-roots units to enter Jiangxia Metro Construction Project Department of China Construction Third Bureau to carry out safety awareness education and publicity of power safety knowledge under the theme of "fully implementing the theme responsibility of enterprise safety production" in the safety production month. Through onsite safety lectures, signing ceremonies, power safety books, and building an interactive communication platform, a harmonious environment for cooperation and joint maintenance of power line safety has been created, a win-win situation for enterprise safety production has been achieved, and safety production has been dramatically improved.	326
Employees of Wuchang Power Distribution and Transportation Inspection Office of Wuhan Power Supply Company of the State Grid issued a safety production notice to the construction units with hidden dangers in the area under their jurisdiction. It aimed to share public knowledge of electricity protection, strengthen the inspection during National Day, and strive to ensure the safety and reliability of "double section" electricity use by residents in the area.	304
Recently, Jinfeng Police Station go deep into the construction site of Shagang Group to carry out a "legal aid by your side" publicity campaign for more than 200 construction workers. During the period, the police explained relevant policies and regulations and safety prevention knowledge to the workers using exhibition board publicity, distributing publicity materials, and providing consulting services and effectively improved their legal awareness and safety prevention ability.	297

earlier (COVID-19), propaganda, problem, quality, health, (environment) protection, etc., were most mentioned in microblog posts.

Table 4 lists Top six contents with the most forward number. Three were about the police visiting the construction site and promoting fire safety information there. Table 5 illustrates that the posts that attracted the most comments were mainly related to

Table 5. Top five contents with the most comment number.

Content	
[Quanyechang Street Binxi Community Launches Safety Production Inspection Work]# Beautiful Community# To further strengthen the safety production work, Binxi Community conducts safety production inspections on modern city construction sites within its jurisdiction. It distributes more than 60 copies of publicity knowledge materials. Through publicity, site workers understand the matters needing attention in daily work, eliminate hidden dangers, and ensure construction safety.	215
# Zhejiang Electric Power News# [Spend Summer with Parents] A few days ago, Haiyan County Power Supply Company of the State Grid held a "Spend Summer with Parents-" Walk with Bright "Summer Warm Practice for Small Reporters". The event invited the employees' children in the company's system to visit the construction site and learn about the emergency repair process. While enriching students' summer life and popular science knowledge of safe electricity use, they also let them understand their parents' work and experience their parents' hard work.	202
In Jiangxia, Wuhan, Hubei Maintenance Company of State Grid of grass-roots units to enter Jiangxia Metro Construction Project Department of China Construction Third Bureau to carry out safety awareness education and publicity of power safety knowledge in combination with the theme of "fully implementing the theme responsibility of enterprise safety production" in the safety production month. Through onsite safety lectures, signing ceremonies, giving away power safety books, and building an interactive communication platform, a harmonious environment for sincere cooperation and joint maintenance of power line safety has been created, and a win-win situation for enterprise safety production has been achieved, and safety production has been greatly improved.	326
The Tongliao Electric Power Section of Shenyang Railway Bureau held a construction safety management course. They summed up construction management experience, learned equipment quality standards, carried out safety knowledge training for electrified sections, and invited the chief of the Signal Section of the Electric Power Department. It explained the knowledge of electrified railways and lay a solid foundation for the electrification construction of nearly 1,000 kilometres this year. The picture shows the chief of the Signal Section of the Electricity Department of Shenyang Railway Bureau explaining the critical links of electrification construction monitoring.	286
# Fire Fighting Knowledge# 【Emergency passage! Green Passage of Life] In almost all public buildings, we will see the green sign of "emergency exit. Nevertheless, do we know the emergency channel? Forward for safety!	137
The Party member service team of Zhangjiagang Power Supply Company of the State Grid went to Xiangshan scenic area and Zhangjiagang Bay in Jingang town to carry out power knowledge publicity activities, distribute publicity materials, and public power knowledge such as safe use of electricity, saving electricity and intelligent electricity to scenic spot staff, construction personnel and tourists, laying a solid foundation for safe use of electricity during the double festival.	151

electricity usage on site or maintenance (note that small-scale repair and maintenance are also a kind of construction activity). Table 6 evidenced that posts with the most likes were related to site electricity usage and maintenance.

Regarding microblog comments, there were 8200 in total. Six thousand eight hundred and twenty comments were purely emoji; only 1380 comments contained words. Among comments with words, 74.5% were positive, and 20.7% were negative. It indicates that the impact of microblogs on safety knowledge sharing is more optimistic among the public. Thus, they support microblogs written by governments. Figure 16 shows the highest frequency of mentioned words. Figure 17 records that the most mentioned positive word is 'good', and the negative sentiment words include damage and tragedy (Figure 18), indicating that many mentioned the consequence of construction accidents.

Table 7 records the regional economic performance across various provinces and municipalities in China in 2021 which encompasses Regional Gross Domestic Product (GDP) and Real GDP per Capita, shedding light on the economic development and its distribution among residents in each location. The results highlight significant disparities in economic development in these regions. Provinces such as Guangdong, Jiangsu, and Shandong have outstanding economic performance. Meanwhile, Yunnan, Gansu and Heilongjiang exhibit lower GDP and slower economic growth. Furthermore, the 'Location Counts' column indicates the number of construction safety microblogs sharing

Table 6. Top five contents with the most like number.

Content	Number of likes
[Longtan Street Held Grid Staff Safety Training]# Chenghua News# Recently, Longtan Street held grid staff safety training. The training focused on electrical line construction, gas pipeline construction, gas storage and other safety knowledge. Participants said they would apply their knowledge to actual management, implement the safety production responsibility system, and strive to improve safety assurance.	486
# Zhejiang Electric Power News# [Spend Summer with Parents] A few days ago, Haiyan County Power Supply Company of the State Grid held a "Spend Summer with Parents-" Walk with Bright "Summer Warm Practice for Small Reporters". The event invited the employees' children in the company's system to visit the construction site and learn about the emergency repair process. While enriching students' summer life and widespread science knowledge of safe electricity use, they also let them understand their parents' work and experience their parents' hard work.	240
In Jiangxia, Wuhan, Hubei Maintenance Company of State Grid of grass-roots units to enter Jiangxia Metro Construction Project Department of China Construction Third Bureau to carry out safety awareness education and publicity of power safety knowledge in combination with the theme of "fully implementing the theme responsibility of enterprise safety production" in the safety production month. Through onsite safety lectures, signing ceremonies, giving away power safety books, and building an interactive communication platform, a harmonious environment for sincere cooperation and joint maintenance of power line safety has been created, and a win-win situation for enterprise safety production has been achieved, and safety production has been greatly improved.	218
# Fire Fighting Knowledge# 【Emergency passage! Green Passage of Life] In almost all public buildings, we will see the green sign of "emergency exit. Nevertheless, do we know about the emergency channel? Forward for safety!	178
On 28th September, the Party member service team of Zhangjiagang Power Supply Company of the State Grid went to Xiangshan Scenic Area and Zhangjiagang Bay in Jingang Town to carry out power knowledge publicity activities, distribute publicity materials, and power knowledge such as safe use of electricity, saving electricity and intelligent electricity to scenic spot staff, construction personnel and tourists, laying a solid foundation for safe use of electricity during the double festival. stow d	109
On 8th June, Tianjin Electric Power Maintenance Company employees introduced the safety distance of construction and the protection knowledge of power facilities to the construction personnel under Tower 143 of 500 kV Beiwu Line.	107

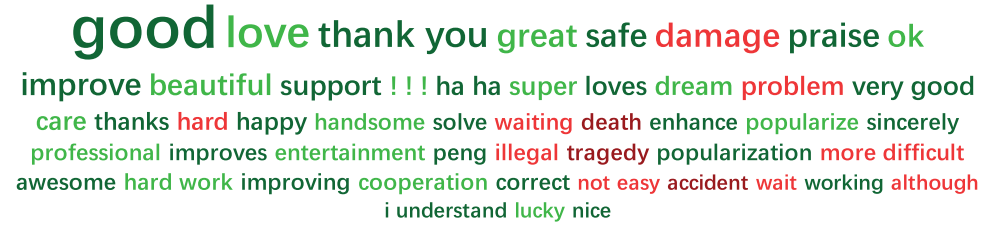

Figure 16. Total clouds- all sentiment.

Figure 17. Positive sentiment.

Figure 18. Negative sentiment.

Table 7. Regional economic indicators in China and microblog engagement.

Location Name	Regional GDP in 2021/one billion (RMB) yuan	Real GDP per capita in 2021/ten thousand (RMB) yuan	Location Counts
Yunnan	27146.8	5.769	70
Sichuan	53850.8	6.433	61
Hubei	50012.9	8.642	53
Shandong	83095.9	8.173	39
Guangdong	124369.7	9.829	37
Jiangsu	116364.2	13.704	25
Shaanxi	29801.0	7.536	25
Hunan	46063.1	6.944	24
Beijing	40269.6	18.398	23
Gansu	10243.3	4.105	22
Xinjiang	15983.7	6.173	19
Inner Mongolia	20514.2	8.542	18
Fujian	48810.4	10.272	16
Henan	58887.4	5.941	16
Tianjin	15695.1	11.373	16
Heilongjiang	14879.2	4.727	14
Zhejiang	73516.0	11.303	12

activities within each location, offering context for the geographical scope of the data. The Workers in less developed economic regions (Yunnan, Sichuan and Hubei) are the most active microblog-sharing for construction safety knowledge. This finding differs from our survey findings that workers in wealthier regions positively affect workers' willingness to share construction safety knowledge via IoT, Web 2.0 and mobile apps. This is possibly because Yunnan, Sichuan and Hubei regions experienced more serious natural disasters, active earthquakes and COVID-19. However, workers in wealthier regions like Guangdong and Jiangsu actively share construction safety knowledge, supporting our survey findings. This textual mining of microblog findings underscores the complex interplay of economic factors influencing construction safety knowledge-sharing.

6. Discussion

This study investigated construction practitioners' motivations to share safety knowledge, utilising quantitative auto-machine learning and qualitative text analysis of Weibo. The results revealed that perceived organisational support (POS) and leader-member

exchange (LMX) most affected workers' willingness to share safety information, especially in wealthier regions. The Weibo results underscored government key opinion leaders (KOL) in safety knowledge sharing, unlike overseas contexts where most of the KOL are individuals or private firms. The results highlight the vital role of cultural and institutional factors in shaping knowledge-sharing activities.

Regarding academic contributions, this study extends the existing knowledge-sharing literature by integrating micro-psychological and macroeconomics. The findings highlight the importance of a supportive organisational culture to enhance knowledge sharing and subsequently a safer workplace. Companies may invest in training and team-building activities that promote POS and enhance LMX; digital platform developers should include features that improve online user engagement and community-building functions. Also, managers should enhance the psychosocial safety climate in the workplace (Dong and Li 2024), allowing staff to make a voice on social media for sharing knowledge. Policymakers should provide grants that encourage collaboration between governmental departments and construction firms, leveraging government KOL to disseminate safety knowledge. Furthermore, understanding the role of regional economics on knowledge sharing helps managers orient their related strategies.

Finally, this study is limited by textual data obtained from Chinese Weibo. Some people rarely share anything on social media. Construction staff may worry about the adverse consequences if they share negative information, such as construction accidents. Future research may include data from other social media platforms such as YouTube international users for cross-country comparisons. Additionally, including Weibo with other grey literature, such as national construction safety reports and news on construction accidents could contribute to construction literature. Similarly, the survey should include construction participants worldwide.

7. Conclusion

This research investigated knowledge sharing via digital tools in civil engineering and building sectors. This research is vital after COVID-19, which barred us from face-to-face communications and knowledge-sharing. Many onsite knowledge-sharing activities have been changed to online. Focusing on technology-enabled safety knowledge sharing, this study uncovers critical factors that motivate engineering workers to share technology-enabled safety knowledge. This study has three-folded contributions to addressing the intelligent city essential stakeholders in enterprise information management: people, organisation and government. Theoretically, it extends the knowledge-sharing literature by adding technology-enabled safety knowledge-sharing willingness in China. This study extends Javernick-Will's (2012) findings regarding social motivations in motivating knowledge sharing in engineering and construction companies. It indicated that willingness to share construction safety knowledge needs to be activated and supported by the micro-macro-level of perceived organisatonal support, rewards, and leader-membership exchange under different economic development levels.

Second, this paper contributes to the methodological foci by employing a new quantitative H2O Driverless AI modelling approach. This is the first study to use that

for building model knowledge sharing in construction to the best of our knowledge. Our analytical approach contributes to academia. Third, while China is the leading country with the most mobile phone usage for payments and banking, our study offers practical implications for China's building sectors regarding its use for knowledge sharing. Workers with long years of service in a company were more willing to share knowledge and retaining them to coach and support Green Leaf for knowledge sharing becomes essential.

Furthermore, considering the regional economic impact on technology-enabled safety knowledge sharing, this research found that perceived organisation support under better economic development and longer years of service for the companies were the top influential factors that affect willingness to share construction safety information via IoT. The importance of perceived organisation support (POS) is echoed in Web 2.0. This reflects the importance of retaining company employees to enhance a knowledge-sharing culture. The results may also be generalised to other sectors or knowledge in the construction industry.

The microblogs showed that government departments were key opinion leaders in knowledge sharing. While microblog posts forwarded were most concerned about police visiting the construction site to promote fire safety, posts related to electrical safety attracted the most comments and likes. Thus, government officials should initiate public campaigns encouraging local engineering citizens to share knowledge.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

Data will be made available on the reasonable request. This research obtained ethics approval from Hong Kong Shue Yan University.

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Appendix

Data collection protocol

1) Are you willing to share construction safety knowledge via Web 2.0 (allows you to read and write on the internet such as Facebook, LinkedIn)? Yes = 1, No = 0
2) Are you willing to share construction safety knowledge via mobile apps? Yes = 1, No = 0
3) Are you willing to share construction safety knowledge via Internet of Things? Yes = 1, No = 0

Perceived organisation support (total scores of 4 and 5)

4) Does your organisation concern about employees' wellbeing? Yes = 1, No = 0
5) Does your organisation value employees' contributions? Yes = 1, No = 0

Leader membership exchange (total scores of 6a to 6 l, per Liden and Maslyn (1998)

6a) I like my supervisor as a person. Yes = 1, No = 0
6b) Everybody tends to like my supervisor as a friend. Yes = 1, No = 0
6c) I feel pleasure when working with my superior. Yes = 1, No = 0
6d) My boss supports me as a superior even if he doesn't have enough information about my activities. Yes = 1, No = 0
6e) When I was attacked by others, my boss defended me. Yes = 1, No = 0
6f) If I make a mistake, my boss protects me against others. Yes = 1, No = 0
6g) I do more than my regular work just to please my superior. Yes = 1, No = 0
6h) I put in more effort than the job requires to fulfil my manager's objectives. Yes = 1, No = 0
6i) I am ready to work my hardest for my boss. Yes = 1, No = 0
6j) I admire my boss's professional knowledge. Yes = 1, No = 0
6k) I respect my supervisor's knowledge and competency on the job. Yes = 1, No = 0
6l) I admire my supervisor's professionalism and competency on the job. Yes = 1, No = 0

Reward

7)Would you be more willing to share construction safety knowledge if there was a valuable reward? Yes = 1, No = 0

Respondents' background

Age, Work Experience, sex, migrant, Ethnic Minority, company size, years of work for the company, building (= 1, civil engineering works = 0)