Evaluation of the tactics for small- and medium-sized toy factories in China to deal with European and US toy safety requirements

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Abstract
China is the largest exporter of toys. Small- and medium-sized toy factories usually face various challenges when they deal with quality aspects and toy safety requirements. After a literature review and pilot study, a conceptual framework to improve factories' capabilities in dealing with European and US toy safety requirements through Toy safety assessment, Cost and resources optimization, Industry 4.0, ISO 19600:2014 (which has become ISO 37301:2021), and Web-based product compliance platforms, is proposed. In mid-2020, a questionnaire was designed, and an internet questionnaire survey empirical study was conducted. The statistical results from 107 responses suggested that Toy Safety Assessment, ISO 19600:2014 (ISO 37301), and Industry 4.0 have made positive and significant contributions to factories' capability to respond to European and US toy safety requirements. The study identifies and prioritizes the factors to improve toy factories' capabilities in dealing with European and US requirements.

Keywords
Toy safety assessment, industry 4.0, ISO 19600, ISO 37301, management system

Introduction
In 2016, there were 9,659 toy export enterprises in China and the average export value per enterprise was US$1.9 million.1 Of toy manufacturing enterprises in China, 80% were small- and medium-sized enterprises employing 20 to 1,000 employees.2,3 In the last decade, toy retailers have been increasingly dominating business negotiations, and given strict instructions to their suppliers regarding, e.g. price, safety, quality and reliability requirements, shipment terms, etc. This has already squeezed out from the market toy manufacturers running at a thin profit margin. For example, during the annual business review, toy buyers usually limit price increases by toy manufacturers, thereby lowering the profit margin of factories. Except for the pricing issue, toy factories in China have also faced challenges in addressing more and more safety and quality requirements set by foreign buyers.

There is a need among small- and medium-sized factories for an integrated framework that could be deployed at higher levels of efficacy to deal with European and US toy safety requirements. This research project aimed to establish a framework and investigate the effectiveness of it for small- and medium-sized toy factories in China in response to the European and US toy safety requirements. The framework was proposed from the perspective of quality management which mainly concerned technical/engineering practices.
The background of this study is that a conceptual framework for small- and medium-sized toy factories in China in response to the European and US toy safety requirements has been proposed after a literature review and pilot study. In the pilot study, a pilot internet questionnaire survey was performed in February and March 2020.4

This paper begins with a literature review. The background of the framework and its associated hypotheses are discussed in second section. Third section describes how a quantitative survey was conducted to assess the framework. In fourth and fifth sections, the data collected are analyzed and the results discussed. The final section concludes the contribution of this study, its limitations, and suggestion for future works.

**Literature review and the conceptual framework**

In the construction of the framework, “Toy Safety Assessment; Web-based product compliance platforms; Quality Management System ISO 9001:2015; Cost and resources optimization, Compliance Management Systems - Guidelines ISO 19600:2014 and Industry 4.0” were reviewed.4 In China, most toy factories implement quality management systems based on ISO 9001. The risk-based approach was introduced by ISO 9001:2015 into the quality management system so that factories can be proactive in taking continuous improvement and preventive actions.4,5 According to the China Trade Remedies Information website, in the first quarter of 2017, 70.54% of recalls in the European Union, the United States, and Canada were due to mechanical and physical safety, while 18.60% were related to chemical safety.4

Toy safety assessment consists of risk analysis of the physical and mechanical aspects, flammability, chemical, electrical, and biological nature, hygiene, and radioactivity of toys.4,6 Toy safety assessment is a regulatory requirement and the requirement of many customers. Both European and US toy safety requirements can be found on the websites of international testing laboratories such as BV, INTERTEK, SGS, etc. There are several methods to perform toy safety assessment, e.g. Failure Mode and Effects Analysis (FMEA), Fault Tree Analysis (FTA), Hazard and Operability Review (HAZOP), Hazard-Based Safety Engineering (HBSE), etc.6 In the toy industry, FMEA is commonly used in toy safety assessments. For chemical safety assessment, the review of Material Safety Data Sheets (MSDSs), Bill of Materials (BOM), Bill of Substances (BOS), test reports, etc. are essential.4 As toy safety assessment is an important process, H1 is postulated.

**H1**: Toy safety assessment has a positive impact on factories’ capability to respond to European and US toy safety requirements.

Toy manufacturers usually use traditional cost and resources optimization methods to improve their competitiveness.4 Cost and resources optimization, such as making high value-added toys by using “Content Creativity” and “Research & Development” could help a factory to differentiate itself among its rivalries. Also, “Brands” and “Intellectual Property (IP)” could help to increase the competitiveness of an enterprise.7 In general, the stronger the technical constitution and industrial supply chain control ability, the more value-added advantages that can be obtained.4,8 On the other hand, the profit of an enterprise could be affected by testing costs. In 2018, the laboratory STC published a valuable article that suggested practical recommendations for optimizing product testing without sacrificing product safety.4,9 Cost and resources optimization methods help share out additional resources in the factory so that these extra resources can be used to improve its operating and management mechanisms. Therefore, H2 is hypothesized.

**H2**: Cost and resources optimization has a positive impact on factories’ capability to respond to European and US toy safety requirements.

The concept of Industry 4.0 includes Cyber Physical System (CPS), Big Data, Artificial Intelligence, Internet of Things (IoT), three-dimensional (3D) printing, and the connections among equipment, machines, suppliers, people, materials, products, customers, etc.4,10 Data, predictive engineering, sustainability, resource sharing & network, manufacturing technology & processes, and materials are the six pillars of smart manufacturing.11 The advantages of using intelligent manufacturing are production cost reduction, shortening of production time, and decrease of defect rate. One of the successful cases in the toy industry was the toy factory of May Cheong Group in Dong Guan City of China. The person in charge of the factory mentioned that the introduction of Advanced Planning and Scheduling (APS) and Manufacturing Execution System (MES) projects in the factory realized the integration of planning and production, resulting in the improvement of production efficiency and quality, and reduction of costs.12 Among these new technologies, 3D printing, IoT, CPS, and Mixed Reality (MR) have been discussed as conducive to product safety.13–15 Therefore, H3 is proposed.

**H3**: Industry 4.0 has a positive impact on factories’ capability to respond to European and US toy safety requirements.

ISO 19600:2014 could be combined with ISO 9001:2015 to form an integrated management system that would help a factory maintain a culture of integrity and compliance.4,16 It would provide suggestions on how to improve product safety and quality. In 2019, ISO 19600 started to be revised into a requirements standard, and FDIS ISO 37301 was released in January 2021. ISO 37301:2021 was published as a requirements standard in April 2021 to replace ISO 19600:2014.17 Therefore, H4 is suggested.
ISO 19600 has a positive impact on factories’ capability to respond to European and US toy safety requirements.

Web-based product compliance platforms can help toy factories to deal with regulatory and customer requirements. Chemical safety is one of the important safety aspects for consumer products because chemicals used to produce consumer products could be harmful to humans or the environment. The purpose of chemical safety assessment is to assess the chemical hazard of products by reviewing the Bill of Materials (BOM), Bill of Substances (BOS), Safety Data Sheet (SDS) / Material Safety Data Sheet (MSDS), test reports, etc. Web-based product compliance platforms, e.g. Chemical Management Database (CMD), could help factories to perform chemical safety assessment by using updated standards and regulations. Therefore, hypothesis H5 is formulated.

Web-based product compliance platforms have a positive impact on factories’ capability to respond to European and US toy safety requirements.

To summarize, a conceptual framework to help toy factories increase their capabilities to respond to European and US toy safety requirements is proposed and shown in Figure 1. The proposed integrated framework is used to cover the product design and production stages and can deal with different kinds of toys. As mentioned in Section 1, apart from a literature review, a pilot internet questionnaire survey was used to preliminarily evaluate this framework in early 2020. The result supported the constructs in Figure 1.

Methodology

To further confirm the constructs in this framework, an internet questionnaire survey, as part of an empirical study, was performed to evaluate its robustness. The questionnaire consisted of 29 questions. Questions 1 to 10 collected the demographic information of the respondents. Questions 4 and 5 were screening questions to ensure that the respondents had jobs related to trading or manufacturing of toys and knowledge about Industry 4.0. For Questions 11 to 28, a “7-point Likert scale (1 = Strongly disagree, 2 = Disagree, 3 = Fairly disagree, 4 = Neutral, 5 = Fairly agree, 6 = Agree, 7 = Strongly agree) was used because methodologists recommend a 7-point scale for a bipolar scale.” To ensure the content validity of the questionnaire, the questionnaire was revised three times after receiving comments from industrial experts, practitioners, and academic scholars before actually using it.

The internet questionnaire survey was performed by using the platform of wjx.cn. It is a professional online platform which helps perform questionnaire surveys more easily and effectively, e.g. by providing different templates during the questionnaire design stage. It also provides data collection, data storage, and analysis services, etc. From the information on its official website, www.wjx.cn, from 2006 to May 2021, more than 119 million questionnaires have been released.
Data collection was started on 28th July 2020 for 3 weeks. The internet questionnaire in Chinese was distributed by using a purposive sampling approach to 382 recipients in Hong Kong and China by e-mail and instant messaging apps of WhatsApp, WeChat, and QQ. By using the platform, wjx.cn, duplicated submission by the same person was avoided by setting limits of one computer, one mobile phone, or one IP address answering only once. Purposive sampling was used because the respondents should have jobs related to the trading or manufacturing of toys and know about Industry 4.0. After sending out the questionnaire by e-mail, a reminder e-mail was sent to the recipients after 1 week. For questionnaires sent out by instant messaging apps, reminder messages were sent to the recipients after 3 days. For the questionnaire sent out by WeChat, one more reminder message was sent to recipients on 7th August 2020. The message reminded and suggested they relay the questionnaires to their friends by using the friends’ circle function in WeChat. The purpose of this referral sampling method was to further increase the response rate. The survey was closed by 17th August 2020. Altogether, 121 completed questionnaires were returned. The response rate was 32%. After screening, 107 questionnaires were usable. The response rate after the screening was 28%. In the questionnaire, questions 11 to 28 were used to find out how toy factories use toy safety assessment (Questions 11, 12, 13), cost and resource optimization (Questions 14, 15, 16), Industry 4.0 (Questions 17, 18, 19), ISO 19600 (Questions 20, 21, 22), and web-based product compliance platforms (Questions 23, 24, 25) to improve factories’ capability to respond to European and US toy safety requirements (Questions 26, 27, 28). Figure 1 is the hypothesis diagram.

**Result and data analysis**

From the 107 usable questionnaires, the demographic data show that 56.1% of the respondents had bachelor’s degrees, 31.8% were post-secondary, and 9.3% of the respondents had master’s degrees or above. Regarding job type, 35.5% of the respondents worked in sales and merchandizing, 29.9% in quality management, testing, inspection, and certification, 24.3% in management, 4.7% in engineering, research, and development, and 4.7% in manufacturing and production. Regarding the age of the respondents, all of them were 22 or above, 29.9% of the respondents were between the age of 35 and 39, 29.0% of the respondents were 40 or above, 22.4% were between the age of 30 and 34, 11.2% were between the age of 26 and 29. Regarding factory size, 34.6% of the respondents replied that their factories had 100–299 people, 30.8% said that they had 300–600 people, 19.6% of the respondents said that they had 601–1000 people, and 14.0% of the respondents replied that they had 20–99 people. This suggested that 99% of the usable questionnaires were related to small- and medium-sized toy factories. Regarding the location of the factories, 61.7% were in Guang Dong Province and 29.0% were in Zhe Jiang Province. This matches the fact that these two provinces are the largest toy-exporting provinces in China. Regarding the business nature of the factories, 57.0% of the respondents replied that their factories were Original Equipment Manufacturers (OEM), 30.8% replied that their factories were Original Design and Manufacturers (ODM) and 12.2% replied that their factories were Original Brand Manufacturers (OBM), showing that most factories were pure-play sub-contracting factories with little negotiation power. Table 1 is a summary of the respondents’ profiles from the 107 usable questionnaires.

Data collected were analyzed by using the software IBM SPSS Statistics version 26. Reliability analysis (Cronbach’s Alpha), Construct validity analysis (Factor analysis), Correlation analysis (Pearson correlation coefficient), and Regression analysis (Coefficient of determination $R^2$, significance value, and unstandardized coefficient B) were used. The 107 usable questionnaires comprised an acceptable sample size because there were five independent variables in this model. Also, most statisticians agree that a minimum sample size of 100 is able to generate a meaningful result based on the theory of margin of error. When using multiple regression analysis, the dependent variable (factory’s capability to respond to European and US toy safety requirements) should approximately follow a normal distribution. In normality testing, the parameters of skewness and kurtosis are applied. If a dataset exactly follows normal distribution, the values of both skewness and kurtosis will be zero. If skewness is between −0.5 and 0.5, the distribution will be approximately symmetrical. Meanwhile, kurtosis is related to the sharpness of the central peak. The individual value of the dependent variable was calculated by using the sum of the marks from Questions 26, 27, and 28 in each valid questionnaire, then dividing by 3. The calculated skewness was −0.42, and the calculated kurtosis was −0.19. Therefore, the dependent variable approximately followed a normal distribution.

Table 2 shows the descriptive statistics of the constructs. All the mean values of the five independent variables were greater than 5, suggesting that the respondents generally had a positive attitude toward toy safety assessment, cost and resource optimization, Industry 4.0, ISO 19600, and web-based product compliance platforms. Table 3 shows the results of Reliability analysis and Construct validity analysis of the questionnaire items. Cronbach’s Alpha is also called the reliability coefficient or internal consistency coefficient. Generally, a Cronbach’s alpha of 0.70 and above is satisfactory. Construct validity analysis evaluates whether the construct of the items in the questionnaire can effectively measure the variables of interest. The Cronbach’s alpha values in this table have values between 0.890 and 0.958. Therefore, the Reliability analysis result was satisfactory. In the construct validity analysis, the Kaiser-Meyer-Olkin (KMO) value was 0.844 (i.e., > 0.6), and Bartlett’s test of sphericity significance value
was 0.000 (i.e., < 0.05), so the data were suitable for factor analysis.\textsuperscript{21} Six factors were identified by factor analysis (highlighted in gray in Table 3). Their factor loading coefficients were between 0.717 and 0.869, which were higher than 0.5. Therefore, the construct of the items in the questionnaire could effectively measure the research variables.

Table 4 shows the results of the Correlation analysis. The Pearson correlation coefficient ranges from \(-1\) to 1. A value of 0 means that there is no linear correlation between two variables. A Pearson correlation coefficient of 0.4 to 0.6 means moderate positive correlation.\textsuperscript{25} If a Pearson correlation coefficient is greater than 0.6, it means a strong positive correlation. From the table, Toy safety assessment and ISO 19600 (Pearson correlation coefficient = 0.664 and 0.678, respectively) had a strong positive correlation with factories’ capability to respond to European and US toy safety requirements. For the other three independent variables, Cost and resource optimization, Industry 4.0, and Web-based product compliance platforms (Pearson correlation coefficient = 0.560, 0.586, and 0.532, respectively), they had moderate positive correlations with factories’ capability to respond to European and US toy safety requirements.

Table 5 shows the results of regression analysis. The coefficient of determination, \(R^2\) represents the explaining power of the independent variables in relation to the dependent variable.\textsuperscript{21} Adjusted \(R^2\) represents the adjusted explaining power of the independent variables with the consideration of not significant independent variable(s). The value of \(R^2\) was 0.587. The result suggested that independent variables in the model could explain 59% of the changes of the dependent variable. The value of Durbin-Watson is a measure of autocorrelation, i.e. the correlation

\begin{table}[h]
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\begin{tabular}{llr}
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Item & Categories & Frequency & Percentage \\
\hline
Education & Bachelor’s degree & 60 & 56.1 \\
& Post-secondary & 34 & 31.8 \\
& Master’s degree or above & 10 & 9.3 \\
& Senior high school & 3 & 2.8 \\
Job type & Sales and merchandising & 38 & 35.5 \\
& Quality management, testing, inspection, and certification & 32 & 29.9 \\
& Management & 26 & 24.3 \\
& Engineering, research, and development & 5 & 4.7 \\
& Manufacturing and production & 5 & 4.7 \\
& Purchasing and material control & 1 & 0.9 \\
Age & 35–39 & 32 & 29.9 \\
& 40 or above & 31 & 29.0 \\
& 30–34 & 24 & 22.4 \\
& 26–29 & 12 & 11.2 \\
& 22–25 & 8 & 7.5 \\
Factory size & 100–299 people & 37 & 34.6 \\
& 300–600 people & 33 & 30.8 \\
& 601–1000 people & 21 & 19.6 \\
& 20–99 people & 15 & 14.0 \\
& others & 1 & 0.9 \\
Factory location & Guang Dong Province & 66 & 61.7 \\
& Zhe Jiang Province & 31 & 29.0 \\
& Fu Jian Province & 6 & 5.6 \\
& others & 4 & 3.7 \\
Business nature of factory & Original Equipment Manufacturers (OEM) & 61 & 57.0 \\
& Original Design and Manufacturers (ODM) & 33 & 30.8 \\
& Original Brand Manufacturers (OBM) & 13 & 12.2 \\
\hline
\end{tabular}
\caption{Respondents’ profile from the 107 usable questionnaires.}
\end{table}

\begin{table}[h]
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\begin{tabular}{lcccc}
\hline
 & Mean & Standard deviation & Skewness & Kurtosis \\
\hline
Toy safety assessment (Q11 & 12 & 13) & 5.93 & 0.77 & -0.39 & -0.37 \\
Cost and resources optimization (Q14 & 15 & 16) & 5.90 & 0.87 & -0.41 & -0.38 \\
Industry 4.0 (Q17 & 18 & 19) & 5.19 & 0.80 & 0.07 & -0.17 \\
ISO 19600 (Q20 & 21 & 22) & 5.56 & 0.77 & -0.28 & 0.01 \\
Web-based product compliance platforms (Q23 & 24 & 25) & 5.29 & 0.82 & -0.62 & 1.59 \\
Factory’s capability to respond to European and US toy safety requirements & 5.63 & 0.83 & -0.42 & -0.19 \\
(Q26 & 27 & 28) & \\
\hline
\end{tabular}
\caption{Descriptive statistics of the constructs.}
\end{table}
Table 3. Reliability analysis and construct validity analysis.

| Questions                                                                 | Factor loading coefficient | Cronbach’s Alpha |
|---------------------------------------------------------------------------|-----------------------------|------------------|
| Q11. Is toy safety assessment a daily job in your factory?                | 0.158 0.816 0.323 0.265 0.135 0.198 | 0.950 |
| Q12. Does your factory perform toy safety assessments for all toy products? | 0.144 0.865 0.282 0.219 0.184 0.158 |          |
| Q13. Do the staff concerned have sufficient toy safety assessment knowledge? | 0.172 0.794 0.285 0.277 0.153 0.106 |          |
| Q14. Is your factory optimizing its costs and resources by developing high-value-added products? | 0.088 0.291 0.252 0.279 0.205 0.793 | 0.890 |
| Q15. Is your factory optimizing its cost and resources through research & development in design and content creation (for example, animation, games, and videos)? | 0.178 0.041 0.105 0.145 0.328 0.813 |          |
| Q16. Is your factory improving its competitiveness through cost control management? | 0.445 0.212 0.257 0.100 0.229 0.717 |          |
| Q17. Regarding Industry 4.0, does your factory use real-time monitoring in the production process? | 0.305 0.115 0.161 0.196 0.792 0.280 | 0.931 |
| Q18. Regarding Industry 4.0, does your factory use digitalization and data connectivity to manage its equipment and machinery? | 0.234 0.240 0.170 0.292 0.800 0.234 |          |
| Q19. Regarding Industry 4.0, does your factory use 3D printing technology to make samples or in production? | 0.301 0.146 0.107 0.129 0.820 0.233 |          |
| Q20. Do you agree with your factory’s product compliance culture?         | 0.268 0.301 0.794 0.253 0.074 0.255 | 0.958 |
| Q21. Do you think that your factory’s employees are conscientious in regard to product compliance? | 0.134 0.353 0.778 0.250 0.282 0.172 |          |
| Q22. Has the factory’s product compliance policy and related procedures been fully implemented? | 0.103 0.381 0.821 0.295 0.134 0.181 |          |
| Q23. Is it your factory’s daily work to use a web-based product compliance platform to evaluate the chemical safety of purchased materials and accessories? | 0.865 0.220 0.219 0.167 0.233 0.165 | 0.948 |
| Q24. Is it your factory’s daily work to use a web-based product compliance platform to evaluate the chemical safety of finished products? | 0.869 0.230 0.220 0.171 0.257 0.136 |          |
| Q25. Does your factory use a web-based product compliance platform to gain knowledge of chemical safety assessment? | 0.846 0.017 0.001 0.191 0.263 0.200 |          |
| Q26. Is the rework rate caused by product safety issues lower than that of the industry? | 0.189 0.241 0.281 0.827 0.232 0.231 | 0.947 |
| Q27. Is the internal product safety testing failure rate lower than that of the industry? | 0.159 0.276 0.275 0.828 0.213 0.222 |          |
| Q28. Is the factory’s product safety testing failure rate in third-party laboratories lower than that of the industry? | 0.288 0.328 0.211 0.731 0.194 0.094 |          |

Kaiser-Meyer-Olkin (KMO) value = 0.844 and Bartlett’s test of sphericity significance value = 0.000.
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization. Rotation converged in seven iterations.
degree between the values of the same variable across different respondents. If the value of Durbin-Watson is close to 2, there is no autocorrelation. B (Unstandardized Coefficient) represents the relationship between the changes of the predictors with the dependent variable. A positive number of B means a positive correlation. Regarding the Significance (Sig.) value, less than 0.05 means a confidence level of 95%. The value of the Variance Inflation Factor (VIF) is used to judge the existence of multicollinearity. If the value is less than 5, it means that there is no multicollinearity. From Table 5, the VIF values of the five independent variables were less than 5, and so there was no multicollinearity. All the independent variables had no mutual interference.

As concluded from Table 5, Toy safety assessment (Sig. = 0.006, B = 0.296), Industry 4.0 (Sig. = 0.04993, B = 0.196) and ISO 19600 (Sig. = 0.005, B = 0.313) were significantly and positively related to factories’ capability to respond to European and US toy safety requirements. Therefore, the hypothesis testing results of H1, H3, and H4 were supported as summarized in Table 6.

Regarding the factors of Cost and resources optimization (Sig. = 0.473, B = 0.064) and Web-based product compliance platforms (Sig. = 0.188, B = 0.116), they were positively related to factories’ capability to respond to European and US toy safety requirements, but they were not significant because their Significance (Sig.) values were larger than 0.05. Therefore, the hypothesis testing results of H2 and H5 were rejected as summarized in Table 6.

Discussion

The statistical results show that the independent variables of the model explained 59% of the changes of the dependent variables. In general, if the value of R² was between 0.5 and 0.7, the result was considered to have a moderate effect size.

Among the five constructs proposed, the most significant contributor was ISO 19600 (Beta = 0.290, sig = 0.005). ISO 19600 (ISO 37301) which emphasizes the importance of culture, especially the culture of integrity and compliance, and communicates this importance throughout the standard. The involvement of all staff in the compliance management system is an important factor to ensure the effectiveness of product safety as well as quality management system implementation. ISO 37301 helps all employees to understand their responsibilities and look at toy safety matters more proactively.

Toy safety assessment (Beta = 0.273, sig = 0.006) was found to have similar positive effects as that of ISO 19600. This result is in line with expectations. Toy safety assessment is a regulatory requirement and the requirement of many toy retailers and importers.

Industry 4.0 (Beta = 0.189, sig = 0.04993) was found to significantly contribute to the improvement of a factory’s capability, though its effect is weaker than that of the previous two constructs. One of the possible reasons is that
Industry 4.0 is still new to most China factories. With the increasing popularity of Industry 4.0 worldwide, it is expected that its influence on quality improvement will become more visible soon. Industry 4.0 can help to optimize a factory so that more resources can be allocated to product safety and quality. Also, Industry 4.0 can help reduce product safety and quality issues due to human error. Recently, the use of collaborative robots has been a flexible and cost-effective way to implement industry 4.0 because the workers next to a production line or an assembly line can be replaced by collaborative robots.

Though cost and resource optimization and web-based product compliance platforms have positive correlations with a factory’s capability to respond to European and US toy safety requirements, they were not found to be significant in the regression analysis. From the demographic data in the questionnaire survey, most of the respondents reported OEM-based factories. Therefore, there is little chance for China factories to propose new products or use alternative materials. It was expected that when factories transformed into ODM or even followed the OBM business model, these two factors would play more important roles in the future.

The result provides useful guidelines for the toy industry to decide which tactics and what priorities to employ when responding to European and US toy safety requirements. Also, this research has contributed to the knowledge about the application of ISO 19600 (ISO 37301) and industry 4.0 in toy factories.

**Conclusion**

From the literature review and pilot investigations, the research gap has been identified and a conceptual framework has been proposed. A quantitative study based on 107 responses showed that the relationships among the capabilities of factories with Toy safety assessment, Industry 4.0, ISO19600, Web-based product compliance platforms were positively marked. The result provides valuable references to toy manufacturers in their selection and implementation of product safety tactics in their response to European and US toy safety requirements. The framework provides guidelines to the toy manufacturers.

### Table 5. Regression analysis.

| R | R square | Adjusted R square | Std. error of the estimate | Durbin-Watson |
|---|---------|------------------|---------------------------|---------------|
| 0.766<sup>a</sup> | 0.587 | 0.567 | 0.54656 | 1.733 |

**Coefficients<sup>b</sup>**

| Model | Unstandardized Coefficients | Standardized Coefficients | Collinearity Statistics |
|-------|-----------------------------|---------------------------|-------------------------|
|       | B | Std. Error | Beta | t | Sig. | Tolerance | VIF |
| (Constant) | 0.118 | 0.469 | 0.252 | 0.801 |
| Toy safety assessment | 0.296 | 0.105 | 0.273 | 2.831 | 0.006 | 0.439 | 2.279 |
| Cost and resource optimization | 0.064 | 0.089 | 0.067 | 0.720 | 0.473 | 0.473 | 2.116 |
| Industry 4.0 | 0.196 | 0.099 | 0.189 | 1.984 | 0.04993 | 0.453 | 2.209 |
| ISO 19600 | 0.313 | 0.109 | 0.290 | 2.871 | 0.005 | 0.402 | 2.487 |
| Web-based product compliance platforms | 0.116 | 0.087 | 0.115 | 1.326 | 0.188 | 0.548 | 1.825 |

<sup>a</sup>Predictors: (Constant), Toy safety assessment, Cost and resource optimization, Industry 4.0, ISO19600, Web-based product compliance platforms

<sup>b</sup>Dependent Variable: Factories’ capability to respond to European and US toy safety requirements

| Table 6. Results of hypothesis testing. |
|----------------------------------------|
| **Hypothesis** | **Results** |
| Toy safety assessment has a positive impact on factories’ capability to respond to European and US toy safety requirements. | Supported |
| Cost and resource optimization has a positive impact on factories’ capability to respond to European and US toy safety requirements. | Not Supported |
| Industry 4.0 has a positive impact on factories’ capability to respond to European and US toy safety requirements. | Supported |
| ISO 19600 has a positive impact on factories’ capability to respond to European and US toy safety requirements. | Supported |
| Web-based product compliance platforms have a positive impact on factories’ capability to respond to European and US toy safety requirements. | Not Supported |
industry on how to improve their capabilities to respond to European and US toy safety requirements.

The study provides a useful reference for suppliers deciding how to run their factories in a more effective light of European and US requirements. The framework provides useful guidelines for the toy manufacturers when deciding which tactics and what priorities they should deploy to respond to European and US toy safety requirements. Also, the work is beneficial to not only toy product safety, but also valuable to the management of the entire company in order to polish its operating practices.

One of the limitations of this research project is that the survey was conducted in China. Because of the increase in the cost of production in China, some factories have already been moved to Vietnam or other Southeast Asian countries recently. These countries have different cultures and management styles, compared with China. It would be valuable to study the factories in these countries to ascertain whether the same set of constructs have similar impacts on the capabilities of factories to deal with overseas toy safety requirements. Another limitation of this study is that it is cross-sectional research. Although the coefficient of determination provides some useful insights regarding the regression model, it does not disclose information about the causation relationship between the independent and dependent variables. A longitudinal study would be needed to monitor the improvements over time.

A longitudinal study has been performed in four selected small- and medium-sized toy factories in China. These four factories are in Guang Dong Province and Zhe Jiang Province. After 1 year of implementation in 2020, the results were like this internet questionnaire survey empirical study, i.e. Toy safety assessment, Industry 4.0 & ISO 19600 (ISO 37301) were found to have positive effects on factories’ capability to respond to European and US toy safety requirements. The details will be discussed in a paper which is expected to be published at the end of 2021.

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