AN EVALUATION OF ROBO-ADVISOR RISK ASSESSMENT QUESTIONNAIRES IN SELECTED ASIA PACIFIC ECONOMIES

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Abstract – *The study was conducted to evaluate the risk assessment questionnaires of a sample of 30 robo-advisors from seven selected Asia Pacific economies. Using a descriptive research approach, the study initially classified the questions gathered from the robo-advisor risk assessment questionnaires into risk capacity and risk tolerance, and further divided them into 26 subcategories. Then a comparison of the number of questions in each robo-advisor's questionnaire was performed, where risk tolerance was found to have a higher proportion of questions than risk capacity. Next, the study compared the questions per subcategory for each sample economy and reported that questions on investment amount dominated the risk capacity category, while risk versus return preference prevailed in the risk tolerance category. Lastly, the correlation between the answer value and percentage of equity in the recommended portfolios of robo-advisors in each sample economy was analyzed. The findings revealed that most of the robo-advisors formulated their portfolio recommendations without utilizing all the parameters or questions in the risk assessment questionnaires. The key influences of robo-advisors' portfolio recommendations were asset allocation choices of the investors, followed by the investors' attitude towards risk and risk versus return preference. This paper enriched the literature on robo-advisors by evaluating the risk assessment questionnaires adopted in the Asia Pacific region. In terms of practical implications, the results highlighted the deficiencies of the existing questionnaires and asserted that they should be reviewed and redesigned to more accurately capture investors' risk characteristics and reflect all information gathered in the portfolio recommendations.*

Keywords: Asia Pacific, financial technology, risk assessment questionnaire, robo-advisors.

I. INTRODUCTION

Financial technology (FinTech) has been a prominent technology disruption within the financial industry [1], in which it integrates innovation and technology into financial services [2, 3]. FinTech is considered an advanced application that broadens financial inclusion [4, 5] due to its highly adaptable nature as compared to incumbent financial institutions. The robo-advisor, one of the FinTech initiatives, can be seen as part of this promise [6]. It is a digital financial advisor that applies computer algorithms, mathematical logic, and machine intelligence to analyze inputs such as investment instruments' characteristics and investors' risk profiles. Robo-advisor also offers personalized financial and investment advice as well as monitors and rebalances investors' portfolios regularly [7, 8]. Unlike traditional financial advisory, all interactions are done online with minimal human interventions [7–9], where online-based questionnaires are used to assess investors' preferences and risks.

Varied questions are adopted by different robo-advisors in assessing investors' characteristics but to what extent robo-advisors are utilizing all the information collected and reflecting them in respective portfolio recommendations remains unknown. Moreover, many researchers and practitioners have raised doubts regarding the relevance of the questionnaires used by the robo-advisors

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in reflecting investors' actual risk characteristics and portfolio recommendations because they are too simplistic and general, whereby investors can purposely manipulate their answers [10, 11]. Different investors' risk characteristics can result in similar recommendations and this shows that robo-advisors lack personalization [3, 7]. In addition, some robo-advisors request investors to select portfolios with a stipulated level of risk and return and choose fixed asset allocations by themselves, implying that these robo-advisors are not providing asset allocation recommendations but only rebalancing services.

The main objective of this paper is to identify the essential risk factors which are then proposed to be applied to robo-advisors. Thus far, research on robo-advisors' questionnaires has primarily concentrated on developed countries, especially the United Kingdom (UK), the United States of America (USA), and Australia [7, 11, 12]. Nevertheless, very limited studies have been undertaken to analyze robo-advisors' questionnaires in the Asia Pacific. Robo-advisors can be regarded as a relatively new FinTech development in the Asia Pacific region since they were introduced less than a decade ago. As a result, very little is known about how these robo-advisors work in the Asia Pacific context, in particular concerning the asset allocation decisions generated by these digital platforms. Robo-advisors have been experiencing rapid growth since they were introduced in these Asia Pacific economies. Given the rising prominence of robo-advisors in this region, it is imperative to delve deeper into the risk assessment questionnaires of these robo-advisors to ensure that the portfolio recommendations provided are based on sound judgment and accurately reflect all the information collected. Hence, this study aims to address this research gap by evaluating the risk assessment questionnaires of robo-advisors in the Asia Pacific region. Particularly, the sample economies included are Malaysia, Singapore, Hong Kong Special Administrative Region (SAR), Taiwan (China), India, Japan, and South Korea.

This paper contributes to the literature by investigating how robo-advisors utilize information collected from the online questionnaires and reflect them in their portfolio recommendations. As robo-advisory is a new and fast-growing industry, research on this topic is still in its infancy. Thus, this research broadens the literature on robo-advisors by exploring the risk assessment questionnaires adopted. The remainder of the paper is organized as follows: Section 2 presents a background of the development of robo-advisors in the Asia Pacific region; Section 3 reviews the literature; Section 4 outlines the data and methodology; Section 5 discusses the results; and Section 6 provides the conclusion.

II. ROBO-ADVISOR DEVELOPMENT IN THE ASIA PACIFIC REGION

This study covers seven selected economies in the Asia Pacific region, namely Malaysia, Singapore, India, Hong Kong SAR, Taiwan, South Korea and Japan. These economies are chosen due to numerous factors. First, they are among the most important representative economies in this region. And second, the robo-advisory services in these economies are registering rapid growth since they were introduced.

The robo-advisor platform in Malaysia is called digital investment manager and it is one of the Securities Commission Malaysia's (SC) digital initiatives which was introduced in May 2017. Robo-advisors are at the early stage of development in Malaysia and have a high growth prospect. The robo-advisor platform providers have to adhere to the SC's Licensing Handbook and Guidelines on Compliance Function for Fund Management Companies. The first robo-advisor, StashAway Malaysia launched its platform in 2018. Seven other platforms were introduced in Malaysia as of 2021, namely Akru Now, Airo, Kenanga Digital Investing, MYTHEO, Raiz, UOBAM Invest and Wahed Invest. There were a total of 199,224 clients with RM466.2 million assets under management (AUM) as of 2020, which was a significant growth as compared to 23,803 clients and RM74.7 million AUM in 2019 [13].

As of July 2021, SC has reported a 90% rise in new account opening as compared to 2020 [14]. The increasing trend is aligned with the findings by Gan et al. [15] that Malaysians display a greater tendency towards the adoption of robo-advisors during the COVID-19 pandemic.

In 2017, the Monetary Authority of Singapore released the Industry Transformation Map (ITM) for financial services with the aim of transforming Singapore into a leading international financial center. Singapore has started embracing FinTech enthusiastically, which was broadly included as one of the agendas of the ITM- the use of technology to innovate and improve the delivery of financial services continuously. Among the FinTech products, robo-advisors are also known as digital advisory in Singapore which were introduced with the issuance of the Guidelines on Provision of Digital Advisory Services in October 2018. According to Balzer et al. [16], Singapore's digital wealth management industry has raised USD 207 million as of 2019.

In October 2016, the Securities and Exchange Board of India (SEBI) released a consultation paper to provide updated guidelines on the SEBI (Investment Advisers) Regulations 2013 with regards to the robo-advisor platforms and henceforth, the robo-advisory industry has come to a start in 2017. A Steering Committee is mandated under the Department of Economic Affairs of the Ministry of Finance to review the FinTech ecology in India. The committee has emphasized the prospects of continuously broadening the FinTech landscape and financial inclusion, as well as maintaining and expanding FinTech centers of excellence in the country. To improve the awareness of savings and investments among its citizens, the Ministry of Corporate Affairs of the Indian government has collaborated with the Investor Education and Protection Fund in organizing Investor Awareness Programs in rural, semi-rural and urban areas. As of 2019, the AUM of India's robo-advisors stood at USD 42 million and it is expected to grow at a compound annual growth rate of 36.2% to reach USD 145 million by 2023 [17].

Hong Kong SAR is a well-known international financial and FinTech hub in which China-based FinTech players utilize this market as a stepping stone to gain international exposure in investments. In July 2019, the Hong Kong Securities and Futures Commission issued the Guidelines on Online Distribution and Advisory Platforms to regulate the robo-advisor industry. As of 2021, the digital wealth management industry has captured 19% of Hong Kong's FinTech ecosystem [18]. The Financial Supervisory Commission (FSC) of Taiwan published the Financial Technology Development Policy White Paper to promote innovative financial services and the development of the FinTech industry in June 2016. In January 2018, the Taiwanese government enacted the FinTech Development and Innovation and Experiment Act to regulate the FinTech industry. The FSC has indicated its intention to lessen the regulations governing securities investment consulting services using robo-advisors in order to improve financial inclusion of retail investors of the country. Therefore, a new regulatory sandbox experiment is authorized by the FSC in March 2021. In November 2021, the FSC issued an order to further relax regulatory provisions regarding automated rebalancing transactions in robo-advisors [19].

The South Korean government has introduced a FinTech policy roadmap in January 2015 to foster growth in the FinTech industry in the country. In light of the increasing demand for comprehensive and customized financial advisory services, the Financial Services Commission of South Korea has outlined the requirements to launch robo-advisor platforms, but all robo-advisor platforms must pass the Koscom's Robo Advisor Test-Bed (RATB) before they are authorized to provide fully automated financial advisory services. Subsequently, the first robo-advisor was launched in July 2016. There are 14 fully automated robo-advisors that fall under electronic investment advice device and do not need to be reviewed by RATB as they have passed the test. As of the end of March 2022, the number of robo-

advisor subscribers stood at 426,539 while the amount of managed assets was KRW1.8 trillion [20].

In its effort to encourage FinTech innovation in Japan, the Japan Financial Services Agency (JFSA) has established the FinTech Innovation Hub to oversee and guide Japan's FinTech activities and development in July 2018. Since 2016, JFSA has been regularly organizing global symposiums on FinTech called FIN/SUM. Meanwhile, robo-advisors were first mentioned in the Guidance to the Asset Management Industry in Japan in 2017, where this technology is a new attempt by internet brokers or technology start-ups to offer automated asset allocation and investment advice. The guidelines and regulatory requirements of this industry were further explained in the 2021 revised guidebook. According to the Organization of Global Financial City Tokyo [21], the market size of robo-advisors is forecasted to reach 2.6 million accounts in 2023.

III.   LITERATURE REVIEW

Markowitz [22] introduced the modern portfolio theory (MPT) in selecting portfolios that maximize returns with anticipated levels of risk based on the assumption that investors are risk averse. Based on the MPT, the efficient frontier is formed by a set of efficient portfolios that gives the highest expected return for each level of risk or standard deviation using the mean-variance analysis. Investors can select an optimal portfolio from the efficient frontier according to their respective risk characteristics. In formulating these efficient portfolios, diversification is the core strategy of the MPT where different assets and investment instruments that are not perfectly positively correlated should be held to achieve the ideal trade-off between risk and return. Therefore, asset allocation decision-making plays a critical role in formulating the optimal portfolio because a balanced portfolio can provide investors with protection and opportunities for different contingencies. The MPT is largely adopted by robo-advisors to formulate portfolio recommendations according to certain expected return and risk characteristics.

Robo-advisor platforms typically use passive management that mainly invests in exchange-traded funds (ETFs) and other financial products such as insurance, cash, commodities, and unit trust funds [23]. An ETF can be defined as a basket of stocks that trades on an exchange with the same simplicity and liquidity as an individual stock, where investors are freely transacting in the collective performance of an entire stock, bond, or commodity [12]. According to Balchunas [24], an ETF is a combination of passively managed, low cost and diversified index funds with the trading features and pricing transparency of stocks. As compared to other investment instruments, the ETF is relatively cheap, liquid, tax efficient, transparent, diversified, standardized, and simple.

Extant literature on robo-advisors has documented the opportunities and perils of robo-advisors. For instance, the rise of robo-advisors not only radically restructured the wealth management ecology, it also encompasses a series of chain reactions vertically from fund providers, trading centers, information technology (IT) related suppliers, and human capital. Nwankpa et al. [25] demonstrate that digitalization in investment mediates the relationship between IT competence and IT innovation among investment or IT organizations. Meanwhile, Britton et al. [26] have empirically identified that the existing entry-level employees with systematic, routine, and repetitive tasks are replaced by automation. Moreover, employees in the new environment are to be furnished with analytical skills to interpret and apply algorithm-generated data to remain competitive. To date, there is a paucity of literature that has explored and evaluated the robo-advisors' questionnaires. For instance, Tertilt et al. [11] empirically analyzed the process of investors' have individual risk preferences assessment, including the questionnaires used and portfolio recommendations, of robo-advisors, based in the UK, the USA, and Germany. The authors find that robo-advisors are prone to employ fewer questions than human advisors and include neutral questions in their risk assessments. Moreover,

they assert that there is no significant difference between the portfolio recommendations of robo-advisors and human advisors, which indicates that big-data analytics have not been very beneficial. To collect and process the data, the authors apply a self-developed automated form tester and categorize all the questions into three groups, which are general information, risk tolerance, and risk capacity. They find that robo-advisors that consist of at least five parameters under risk capacity and risk tolerance respectively can generate the most optimal portfolio recommendations. The authors conclude that the robo-advisors apply an average of ten questions and only approximately 60% of them are reflected in the risk assessments and portfolio recommendations. They also discover a deficiency whereby the robo-advisors' portfolio recommendations are rather conservative and therefore, robo-advisors are deemed to play a limited role in assisting investors with goal-specific risk appetite.

Along the same lines, So [7] evaluates risk assessment questionnaires of the financial institutions in Hong Kong SAR, Australia, Canada, the UK, and the USA by applying inductive content analysis. The purpose of this evaluation is to gain an in-depth understanding of investors' risk profiles and identify the relevant risk factors to be incorporated into robo-advising in Hong Kong. The author compares 180 questions collected from 20 questionnaires and identifies the five most important risk factors, namely investment objectives, risk appetite, investment knowledge and experience, investment behavior, and ability to take risks. Apart from risk factors, the author also focuses on the essential characteristics of the robo-advisor questionnaires, which are the number of questions that should economize user time, and that the questions asked should be succinct. Moreover, the author recommends that investors' risk profiles should be updated regularly instead of upon the request of the investors to maintain the consistency of risk scoring.

Consistent with this notion, Tillmans [12] investigates the robo-advisors' risk assessment process in the EU, the USA, and Australia and compares them with traditional advisors. To gain access to the robo-advisors' questionnaires and portfolio recommendations, the author constructs a fictitious investor profile and registers with the robo-advisors to gather information for data analysis. The findings reveal that robo-advising comprises three stages in general, which are general information collection, actual risk profiling, and presentation of risk scores with portfolio suggestions. Furthermore, the questions collected are categorized into four groups, namely subjective measures (expected utility framework, general financial risk attitude, and emotional association), objective measures, risk capacity (portfolio goals or constraints, income amount, income stability, expenses, balance sheet, and financial obligations) and financial knowledge or experience. The author claims that both human and robo-advisors include biased instruments in their risk assessment questionnaires. Despite this, robo-advisors tend to adopt more varied risk capacity measures. The author further asserts that robo-advisors are capable of collecting and processing a larger volume of data and have the potential to incorporate mental accounting by developing new asset allocation methodology through machine learning. The author also suggests that robo-advisors should provide services other than investing, such as personal financial planning and investor education.

Taken together, extant studies on robo-advisor questionnaires are predominantly conducted in Western developed countries, in particular the UK and the USA. Nonetheless, studies on robo-advisor questionnaires in the context of the Asia Pacific are conspicuously absent. Hence, this paper aims to fill this research void by evaluating the questionnaires of robo-advisors in selected economies in the Asia Pacific region.

IV.   RESEARCH METHODS

This is a descriptive study performed in 2022 based on seven selected economies in the Asia Pacific region, namely Malaysia, Singapore, Hong Kong SAR, Taiwan, India, Japan, and South Korea. A sample of 30 robo-advisors

is constructed, where one is from India, two are from Hong Kong SAR and South Korea respectively, six are from Malaysia, Singapore, and Taiwan respectively, and seven are from Japan, and data from each robo-advisor's risk assessment questionnaires and portfolio recommendations are gathered and analyzed. To obtain access to the questionnaires and portfolio recommendations, the study has constructed a general investor risk profile to fill up the online questionnaires. The official statistics provided by the government of each country were utilized to calculate the average or median values of each risk profile characteristic, in particular the investor's age, educational level, occupation, and monthly income. Following Boreiko et al. [27], this study does not distinguish between male and female investors for the sake of generalization. According to Belanche et al. [28], gender exerts no impact on the intention to adopt robo-advisors, as both males and females tend to make identical adoption decisions. Consistent with Stanley et al. [29], the investor's net worth is measured as follows:

$$Networth = Age \times \frac{(Annual\,income)}{10}$$

Therefore, the profile constructed is of a 40-year-old male who possesses an upper secondary school qualification. Besides, the investor is a sales-and-service personnel who earns a monthly income of approximately USD 2,300 and has an individual net worth of approximately USD 110,000.

Subsequently, the profile is further segregated into three different risk attitudes, namely conservative, moderate, and aggressive risk profiles. Prior studies have shown that investment behavior can be influenced by the marital status of the investors, where unmarried or single individuals generally possess more freedom in investment decision-making, while the investment behavior of married individuals is affected by their marital status [30, 31]. At the same time, previous research has demonstrated that married individuals have greater wealth and can afford to invest more [32, 33]. Furthermore, investment behavior is

also influenced by whether the individual has any dependents or not, where dependents may reduce the amount of resources available for investments [30]. Hence, in this paper, the conservative investor is set as married with dependents, while the moderate investor is single without dependents and the aggressive investor is married without dependents.

In terms of investment philosophy, Damodaran [34] has shown the connection between investment philosophy and risk tolerance, where lower risk-tolerance investors tend to prefer lower risk and steady returns relative to higher risk-tolerance investors. Accordingly, this paper defines a conservative investor as one who has lower risk tolerance and focuses on stable returns and minimum loss on investments, a moderate investor as one who requires higher returns with acceptable losses, and an aggressive investor as one who has higher risk tolerance and seeks maximum returns.

Financial planners have recommended that individuals should set aside about 10% of their income for investment [35, 36]. Therefore, this paper has allocated a monthly investment amount of approximately 10% of monthly income, or USD 230 for all three risk profiles. Lastly, to ensure generalization and consistency, this paper selects 'general investment to increase personal wealth' as the investment goal for a period of five to ten years.

V.   RESULTS AND DISCUSSION

A. Analysis of questionnaires

For comparison, the questions are categorized into two main categories, namely risk capacity and risk tolerance, as shown in Table 1, since each robo-advisor has different questions to determine the investors' risk characteristics. The two categories are further divided into 26 subcategories. It is worth noting that the categorization adopted in this study is different from Tertilt et al. [11] but follows Tillmans [12] who suggests that investors' general characteristics, such as age and income, will affect their risk profiles.

Table 1: Questionnaires' categories
and subcategories

Risk capacity	Risk tolerance
Assets	Age
Employment status	Asset allocation choices
Expenses	Attitude towards risk
Income level	Dealing with financial decisions
Income prediction	Family and household status
Investment amount	Gender
Investment horizon	Investment choices
Liabilities	Investment experience
Net worth	Investment goal
Savings	Investment knowledge
Source of income	Investor type/self-assessment risk tolerance
Total investment capital	Marital status
	Portfolio management and rebalancing
	Risk versus return preference

Table 2: Number of questions in questionnaires

Name		Number of questions per category		
		Risk capacity	Risk tolerance	Total
Hong Kong SAR	Robo-advisor 1	1	5	6
	Robo-advisor 2	0	1	1
India	Robo-advisor 3	0	1	1
Japan	Robo-advisor 4	2	1	3
	Robo-advisor 5	1	11	12
	Robo-advisor 6	3	4	7
	Robo-advisor 7	4	7	11
	Robo-advisor 8	1	15	16
	Robo-advisor 9	3	1	4
	Robo-advisor 10	3	3	6
Malaysia	Robo-advisor 11	5	7	12
	Robo-advisor 12	0	4	4
	Robo-advisor 13	3	3	6
	Robo-advisor 14	5	1	6
	Robo-advisor 15	1	5	6
	Robo-advisor 16	3	5	8
Singapore	Robo-advisor 17	4	5	9
	Robo-advisor 18	3	3	6
	Robo-advisor 19	7	4	11
	Robo-advisor 20	0	3	3
	Robo-advisor 21	1	5	6
	Robo-advisor 22	0	1	1
South Korea	Robo-advisor 23	0	12	12
	Robo-advisor 24	1	3	4
Taiwan	Robo-advisor 25	3	9	12
	Robo-advisor 26	2	4	6
	Robo-advisor 27	3	5	8
	Robo-advisor 28	5	7	12
	Robo-advisor 29	2	3	5
	Robo-advisor 30	0	4	4
Total		66	142	208

B. Comparison of questions per category

Table 2 tabulates the number of questions in each robo-advisor's risk assessment questionnaire. It can be observed that on average, the risk assessment questionnaires from Hong Kong SAR and India have the least number of questions relative to other economies. By contrast, the risk assessment questionnaires from Japan have the highest number of questions, ranging between 3 and 16. Additionally, most robo-advisors have more questions on risk tolerance than on risk capacity, with a total of 142 questions on risk tolerance and 66 questions on risk capacity. This observation is similar to So [7].

These findings are consistent with Tertilt et al. [11] who assert that questionnaires need to economize user time, as lengthy risk assessments may make investors feel tired and reluctant to complete the questionnaires [7]. In addition, Revilla et al. [37] propose that the average ideal time to fill up a survey questionnaire is 10 minutes, with a maximum of 20 minutes. Furthermore, Sharma [38] elucidates that a well-designed questionnaire can have 25 to 30 questions that can be administered within 30 minutes to maintain participants' interest and attention. Therefore, there is no standardized rule for an optimal questionnaire and it ultimately depends on the discretion of the researcher.

C. Comparison of questions per subcategory for each economy

Table 3 presents the distribution of questions per subcategory for each economy. Overall, the risk tolerance category contains twice as many questions as the risk capacity category, with 142 and 66 questions, respectively. Within the risk capacity category, the majority of robo-advisors have included the question about the investment amount, where there is a total of 17 questions, with 57% of robo-advisors from Japan, 50% from Singapore, 50% from South Korea and 67% from Taiwan including this question. Regarding the risk tolerance category, the subcategory of risk versus return preference is the most frequently asked, with a total of 24 questions, with 43% of

robo-advisors from Japan, 50% from Malaysia, 50% from Singapore, 50% from South Korea and 50% from Taiwan incorporating this question.

In Hong Kong SAR, 50% of the robo-advisors asked questions about income level, age, asset allocation choices, family and household status, gender, investment goal, and marital status. In India, all the robo-advisors enquired about the investors' asset allocation choices. Among the robo-advisors in Japan, 86% of them asked for the investors' age, 57% enquired about the investors' income level, investment amount, and attitude towards risk while 43% wanted to know about the investment goal and risk versus return preference. Approximately 67% of robo-advisors in Malaysia asked investors regarding their income level and investment goal, while 50% enquired about the investment horizon, age, investment knowledge, and risk versus return preference.

In Singapore, 67% of robo-advisors asked about the income level while 50% wanted to know about the investment amount, age, attitude towards risk, investment goal, and risk versus return preference. In South Korea, 50% of the robo-advisors have included questions about investment amount, asset allocation choices, attitude towards risk, dealing with financial decisions, portfolio management and rebalancing, and risk versus return preference. Lastly, 83% of Taiwan's robo-advisors asked about investors' age and investment choices, 67% enquired regarding the investment amount and attitude towards risk while 50% incorporated questions about investment goal and risk versus return preference.

D. Analysis of correlation by question subcategory for each economy

Table 4 reports the correlation between the answer value and percentage of equity in the recommended portfolios of robo-advisors for each economy for all risk profiles, while Tables 5 through 7 tabulate the findings based on the respective conservative, moderate, and aggressive risk profiles. This paper finds that the majority of robo-advisors formulate their portfolio recom-

mendations without utilizing all the parameters, which is in line with Tertilt et al. [11] who report that the sample robo-advisors in their study only consider 60% of the questions asked. In the case of India, the results show that the correlation between asset allocation choices and the percentage of equity in the recommended portfolio for all risk profiles is positive and statistically significant. This indicates that robo-advisors in India are 100% dependent on the investors' asset allocation choices without further analyzing other risk characteristics of the investors. However, none of the correlations are statistically significant for each risk profile.

For Japan, the findings demonstrate that both the attitude towards risk and risk versus return preference have a significant positive correlation with the percentage of equity in the recommended portfolio for all risk profiles. This indicates that robo-advisors in Japan depend on investors' attitudes towards risk and risk versus return preference when providing their portfolio recommendations. Regarding individual risk profiles, income level has a significant positive correlation with the percentage of equity in the recommended portfolio for the moderate risk profile, while attitude towards risk has a significant positive correlation for the aggressive risk profile. The findings indicate that the level of income is the primary factor to be considered by robo-advisors in Japan when formulating their portfolio recommendations for moderate-risk investors, while attitude towards risk is the main determinant in the case of aggressive risk investors.

In the context of Malaysia, both the savings and investment knowledge of the investors have a significant positive correlation with the percentage of equity in the recommended portfolio for all risk profiles. The results indicate that portfolios with a higher weightage of equity are recommended for investors who possess greater savings and investment knowledge. By contrast, the correlation between age and percentage of equity in the recommended portfolio is negative

Table 3: Distribution of questions per robo-advisor by economy

Question category	Robo-advisors by economy							
	HK	IND	JAP	MAL	SING	KOR	TWN	Total
Risk capacity								*66*
Assets	0%	0%	29%	17%	17%	0%	17%	5
Employment status	0%	0%	0%	33%	0%	0%	0%	2
Expenses	0%	0%	0%	0%	0%	0%	17%	1
Income level	50%	0%	57%	67%	67%	0%	17%	14
Income prediction	0%	0%	14%	0%	0%	0%	0%	1
Investment amount	0%	0%	57%	0%	50%	50%	67%	17
Investment horizon	0%	0%	29%	50%	17%	0%	33%	8
Liabilities	0%	0%	0%	17%	17%	0%	17%	4
Net worth	0%	0%	0%	17%	17%	0%	0%	2
Savings	0%	0%	29%	33%	17%	0%	17%	7
Source of income	0%	0%	14%	33%	17%	0%	0%	4
Total investment capital	0%	0%	0%	0%	17%	0%	0%	1
Risk tolerance								*142*
Age	50%	0%	86%	50%	50%	0%	83%	18
Asset allocation choices	50%	100%	0%	0%	17%	50%	0%	4
Attitude towards risk	0%	0%	57%	33%	50%	50%	67%	18
Dealing with financial decisions	0%	0%	29%	0%	0%	50%	17%	21
Family and household status	50%	0%	0%	33%	17%	0%	0%	4
Gender	50%	0%	14%	17%	17%	0%	0%	4
Investment choices	0%	0%	29%	17%	33%	0%	83%	13
Investment experience	0%	0%	29%	0%	0%	0%	17%	3
Investment goal	50%	0%	43%	67%	50%	0%	50%	16
Investment knowledge	0%	0%	29%	50%	0%	0%	33%	8
Investor type/self-assessment risk tolerance	0%	0%	0%	17%	0%	0%	0%	1
Marital status	50%	0%	0%	17%	17%	0%	17%	4
Portfolio management and rebalancing	0%	0%	14%	0%	0%	50%	17%	4
Risk versus return preference	0%	0%	43%	50%	50%	50%	50%	24
Total								208

Note: HK = Hong Kong SAR; IND = India; JAP = Japan; MAL = Malaysia; SING = Singapore;
KOR = South Korea; TWN = Taiwan

and statistically significant. The finding implies that the percentage of equity recommended for the investors' portfolio decreases for older investors. In terms of individual risk profile, the investment horizon exhibits a significant negative correlation with the percentage of equity in the recommended portfolio for the moderate risk profile. It suggests that the percentage of equity recommended for the moderate risk investors' portfolio decreases as the investment horizon becomes longer.

Turning to Singapore, the results reveal that the correlation between risk versus return preference and the percentage of equity in the recommended portfolio is positive and statistically significant for all risk profiles. Similar to the case of robo-advisors in Japan, the findings reflect the tendency of robo-advisors in Singapore to rely on the investors' preferences for risk and return to ascertain their risk profiles and to recommend suitable portfolios. As for the individual risk profiles, the source of income has a significant negative correlation with the percentage of equity in the recommended portfolio for the conservative risk profile, while the attitude towards risk has a significant positive correlation for the moderate risk profile.

The results suggest that the source of income is the most important factor to be considered by robo-advisors in Singapore when developing

Table 4: Correlation by questions subcategory for robo-advisors by economy (all risk profiles)

Question category	Robo-advisors by economy							
	HK	IND	JAP	MAL	SING	KOR	TWN	Total
Risk capacity								
Assets	n/a	n/a	0.48	n/a	n/a	n/a	n/a	-0.04
Employment status	n/a	n/a	n/a	0.44	n/a	n/a	n/a	0.44
Expenses	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Income level	n/a	n/a	-0.26	-0.15	-0.31	n/a	0.40	-0.12
Income prediction	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Investment amount	n/a	n/a	0.30	n/a	n/a	n/a	0.02	0.10
Investment horizon	n/a	n/a	-0.13	0.16	n/a	n/a	0.62	0.38
Liabilities	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Net worth	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.32
Savings	n/a	n/a	n/a	0.95*	n/a	n/a	n/a	0.05
Source of income	n/a	n/a	n/a	0.80	n/a	n/a	n/a	0.47
Total investment capital	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Risk tolerance								
Age	n/a	n/a	n/a	-0.79*	n/a	n/a	n/a	-0.20
Asset allocation choices	0.99	1.00*	n/a	n/a	0.99	0.98	n/a	0.95*
Attitude towards risk	n/a	n/a	0.81*	0.46	0.49	1.00*	0.56	0.56*
Dealing with financial decisions	n/a	n/a	-0.16	n/a	n/a	0.85	n/a	-0.02
Family and household status	-0.10	n/a	n/a	0.28	-0.91	n/a	n/a	0.15
Gender	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Investment choices	n/a	n/a	n/a	n/a	0.27	n/a	0.46	0.34
Investment experience	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Investment goal	n/a	n/a	-0.30	-0.02	0.48	n/a	0.25	0.24
Investment knowledge	n/a	n/a	0.14	0.71*	n/a	n/a	n/a	0.18
Investor type/self-assessment risk tolerance	n/a	n/a	n/a	0.98	n/a	n/a	n/a	0.98
Marital status	-0.10	n/a	n/a	0.10	-0.10	n/a	0.00	0.03
Portfolio management and rebalancing	n/a	n/a	n/a	n/a	n/a	n/a	-0.76	0.23
Risk versus return preference	n/a	n/a	0.79*	0.29	0.74*	-0.15	0.64	0.45*

Note: HK = Hong Kong SAR; IND = India; JAP = Japan; MAL = Malaysia; SING = Singapore; KOR = South Korea; TWN = Taiwan.
* Statistical significance at the 5% level or less

their portfolio recommendations for conservative risk investors, while attitude towards risk is the primary determinant in the case of moderate risk investors.

As regards to South Korea, attitude towards risk is the only question that has a significant positive correlation with the percentage of equity in the recommended portfolio for all risk profiles. Put differently, robo-advisors in South Korea are 100% reliant on the investors' attitude towards risk to generate their portfolio recommendations without further incorporating other risk characteristics of the investors. Moving on to individual risk profiles, attitude towards risk,

dealing with financial decisions and preference regarding risk versus return have significant positive correlations with the percentage of equity in the recommended portfolio for each type of risk profile. On the flip side, investment amount, asset allocation choices, and portfolio management and rebalancing have significant negative correlations for all individual risk profiles.

Interestingly, the correlation analysis also reveals that robo-advisors in Hong Kong SAR, and Taiwan did not consider any of the questions in their portfolio recommendations for all risk profiles. Turning to individual risk profiles for Hong Kong, asset allocation choices have a sig-

Table 5: Correlation by questions subcategory for robo-advisors by economy
(conservative risk profile)

Question category	Robo-advisors by economy							
	HK	IND	JAP	MAL	SING	KOR	TWN	Total
Risk capacity								
Assets	n/a	n/a	0.22	-0.28	0.32	n/a	0.11	0.14
Employment status	n/a	n/a	n/a	-0.21	n/a	n/a	n/a	-0.13
Expenses	n/a	n/a	n/a	n/a	n/a	n/a	0.11	0.17
Income level	-1.00**	n/a	0.71	0.33	-0.45	n/a	0.11	0.07
Income prediction	n/a	n/a	-0.36	n/a	n/a	n/a	n/a	-0.02
Investment amount	n/a	n/a	0.04	n/a	-0.14	-1.00**	-0.19	0.13
Investment horizon	n/a	n/a	-0.49	-0.65	0.32	n/a	0.56	0.03
Liabilities	n/a	n/a	n/a	-0.18	0.32	n/a	-0.47	-0.16
Net worth	n/a	n/a	n/a	-0.29	0.32	n/a	n/a	-0.15
Savings	n/a	n/a	0.49	0.62	0.32	n/a	-0.47	0.16
Source of income	n/a	n/a	-0.15	0.77	-0.83*	n/a	n/a	0.03
Total investment capital	n/a	n/a	n/a	n/a	0.32	n/a	n/a	-0.04
Risk tolerance								
Age	-1.00**	n/a	0.48	0.23	-0.66	n/a	0.37	0.32
Asset allocation choices	1.00**	n/a	n/a	n/a	0.26	-1.00**	n/a	-0.27
Attitude towards risk	n/a	n/a	-0.19	0.15	0.07	1.00**	0.73	0.31
Dealing with financial decisions	n/a	n/a	-0.38	n/a	n/a	1.00**	-0.18	0.04
Family and household status	-1.00**	n/a	n/a	-0.15	-0.38	n/a	n/a	-0.28
Gender	-1.00**	n/a	-0.36	-0.38	-0.38	n/a	n/a	-0.30
Investment choices	n/a	n/a	-0.20	-0.28	0.49	n/a	-0.19	0.13
Investment experience	n/a	n/a	-0.35	n/a	n/a	n/a	0.11	0.14
Investment goal	-1.00**	n/a	0.06	0.13	-0.66	n/a	0.47	0.10
Investment knowledge	n/a	n/a	-0.18	0.48	n/a	n/a	-0.03	0.20
Investor type/self-assessment risk tolerance	n/a	n/a	n/a	-0.28	n/a	n/a	n/a	-0.15
Marital status	-1.00**	n/a	n/a	-0.38	-0.38	n/a	-0.18	-0.28
Portfolio management and rebalancing	n/a	n/a	-0.15	n/a	n/a	-1.00**	0.89*	0.05
Risk versus return preference	n/a	n/a	-0.55	-0.25	0.65	1.00**	0.33	0.23

Note: HK = Hong Kong SAR; IND = India; JAP = Japan; MAL = Malaysia; SING = Singapore;
KOR = South Korea; TWN = Taiwan.
* Statistical significance at the 5% level or less

nificant positive correlation with the percentage of equity in the recommended portfolio for all three risk profiles. Conversely, income level, age, family and household status, gender, investment goal, and marital status record significant negative correlations for each type of risk profile. As for the case of Taiwan, the investment horizon has a significant positive correlation with the percentage of equity in the recommended portfolio for the moderate risk profile, while portfolio management and rebalancing have a significant positive correlation for both the conservative and moderate risk profiles.

As a whole for all risk profiles, the question on asset allocation choices has the highest positive and statistically significant correlation with the percentage of equity in the robo-advisors' recommended portfolios, followed by questions regarding attitude towards risk and risk versus return preference, respectively. Notwithstanding the preceding observations, it is worth noting that the correlation between most of the risk assessment answer values and the percentage of equity in the recommended portfolios is not statistically significant. The findings suggest that the robo-advisor risk assessment questionnaires consist of many questions that are not relevant to the portfolio recommendations.

Table 6: Correlation by questions subcategory for robo-advisors by economy (moderate risk profile)

Question category	Robo-advisors by economy							
	HK	IND	JAP	MAL	SING	KOR	TWN	Total
Risk capacity								
Assets	n/a	n/a	0.23	-0.02	0.61	n/a	-0.46	0.09
Employment status	n/a	n/a	n/a	-0.56	n/a	n/a	n/a	-0.49**
Expenses	n/a	n/a	n/a	n/a	n/a	n/a	-0.46	-0.13
Income level	-1.00**	n/a	0.80*	-0.23	0.39	n/a	-0.46	-0.03
Income prediction	n/a	n/a	-0.55	n/a	n/a	n/a	n/a	-0.07
Investment amount	n/a	n/a	0.14	n/a	0.78	-1.00**	0.31	0.28
Investment horizon	n/a	n/a	-0.45	-0.82*	0.61	n/a	0.87*	-0.17
Liabilities	n/a	n/a	n/a	-0.31	0.61	n/a	-0.25	-0.19
Net worth	n/a	n/a	n/a	-0.55	0.61	n/a	n/a	-0.26
Savings	n/a	n/a	0.18	0.33	0.61	n/a	-0.25	0.21
Source of income	n/a	n/a	-0.46	0.03	-0.18	n/a	n/a	-0.16
Total investment capital	n/a	n/a	n/a	n/a	0.61	n/a	n/a	0.23
Risk tolerance								
Age	-1.00**	n/a	0.12	0.52	-0.09	n/a	0.17	0.23
Asset allocation choices	1.00**	n/a	n/a	n/a	-0.29	-1.00**	n/a	-0.15
Attitude towards risk	n/a	n/a	0.22	-0.07	0.83*	1.00**	0.75	0.31
Dealing with financial decisions	n/a	n/a	-0.60	n/a	n/a	1.00**	0.20	0.09
Family and household status	-1.00**	n/a	n/a	0.31	-0.55	n/a	n/a	-0.14
Gender	-1.00**	n/a	-0.55	-0.01	-0.55	n/a	n/a	-0.26
Investment choices	n/a	n/a	-0.06	-0.02	0.32	n/a	-0.29	0.09
Investment experience	n/a	n/a	-0.33	n/a	n/a	n/a	-0.46	-0.06
Investment goal	-1.00**	n/a	0.27	-0.32	-0.09	n/a	0.20	-0.13
Investment knowledge	n/a	n/a	-0.26	0.54	n/a	n/a	0.19	0.11
Investor type/self-assessment risk tolerance	n/a	n/a	n/a	-0.02	n/a	n/a	n/a	-0.15
Marital status	-1.00**	n/a	n/a	-0.01	-0.55	n/a	0.20	-0.17
Portfolio management and rebalancing	n/a	n/a	-0.46	n/a	n/a	-1.00**	0.90*	-0.05
Risk versus return preference	n/a	n/a	-0.17	0.52	0.59	1.00**	0.32	0.04*

Note: HK = Hong Kong SAR; IND = India; JAP = Japan; MAL = Malaysia; SING = Singapore; KOR = South Korea; TWN = Taiwan.
* Statistical significance at the 5% level or less

VI. CONCLUSION

Using a descriptive research approach, this paper evaluates the risk assessment questionnaires of 30 robo-advisors from seven selected Asia Pacific economies. First, this study classifies the questions obtained from the robo-advisor risk assessment questionnaires into two major categories, namely risk capacity and risk tolerance. Then, these categories are segregated into 26 subcategories. Second, the study compares the number of questions in each robo-advisor's risk assessment questionnaire. There is a higher proportion of questions related to risk tolerance than risk capacity. Third, this

research performs a comparison of questions per subcategory for each sample economy and reports that within the risk capacity category, the majority of robo-advisors have incorporated the question about the investment amount. Meanwhile, risk versus return preference is the most frequently asked question in the risk tolerance category.

Lastly, this paper analyzes the correlation between the answer value and the percentage of equity in the recommended portfolios of robo-advisors for each sample economy. The findings reveal that most of the robo-advisors develop their portfolio recommendations without utilizing all the parameters or questions in the risk assess-

Table 7: Correlation by questions subcategory for robo-advisors by economy (aggressive risk profile)

Question category	Robo-advisors by economy							
	HK	IND	JAP	MAL	SING	KOR	TWN	Total
Risk capacity								
Assets	n/a	n/a	0.39	-0.31	-0.27	n/a	0.37	0.03
Employment status	n/a	n/a	n/a	0.07	n/a	n/a	n/a	-0.08
Expenses	n/a	n/a	n/a	n/a	n/a	n/a	0.37	0.15
Income level	-1.00**	n/a	-0.13	-0.13	0.14	n/a	0.37	-0.08
Income prediction	n/a	n/a	-0.50	n/a	n/a	n/a	n/a	-0.15
Investment amount	n/a	n/a	0.68	n/a	0.60	-1.00**	0.35	0.30
Investment horizon	n/a	n/a	0.52	-0.67	-0.27	n/a	0.44	-0.14
Liabilities	n/a	n/a	n/a	-0.74	-0.27	n/a	0.20	-0.41
Net worth	n/a	n/a	n/a	0.16	0.27	n/a	n/a	0.05
Savings	n/a	n/a	-0.53	-0.28	-0.27	n/a	0.20	-0.21
Source of income	n/a	n/a	0.03	0.61	0.80	n/a	n/a	0.34
Total investment capital	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.14
Risk tolerance								
Age	-1.00**	n/a	-0.65	-0.09	0.33	n/a	0.24	-0.05
Asset allocation choices	1.00**	n/a	n/a	n/a	-0.01	-1.00**	n/a	-0.02
Attitude towards risk	n/a	n/a	0.84*	-0.62	0.27	1.00**	0.56	0.05
Dealing with financial decisions	n/a	n/a	-0.50	n/a	n/a	1.00**	0.20	0.03
Family and household status	-1.00**	n/a	n/a	0.47	-0.63	n/a	n/a	-0.12
Gender	-1.00**	n/a	-0.50	-0.20	-0.63	n/a	n/a	-0.39*
Investment choices	n/a	n/a	-0.14	-0.31	0.09	n/a	0.00	-0.02
Investment experience	n/a	n/a	-0.37	n/a	n/a	n/a	0.37	0.02
Investment goal	-1.00**	n/a	0.27	-0.49	0.33	n/a	0.36	-0.90
Investment knowledge	n/a	n/a	0.04	0.08	n/a	n/a	0.37	0.07
Investor type/self-assessment risk tolerance	n/a	n/a	n/a	-0.31	n/a	n/a	n/a	-0.26
Marital status	-1.00**	n/a	n/a	-0.20	-0.63	n/a	0.20	-0.26
Portfolio management and rebalancing	n/a	n/a	0.03	n/a	n/a	-1.00**	0.35	-0.10
Risk versus return preference	n/a	n/a	0.63	0.29	-0.24	1.00**	-0.25	0.26

Note: HK = Hong Kong SAR; IND = India; JAP = Japan; MAL = Malaysia; SING = Singapore; KOR = South Korea; TWN = Taiwan.
* Statistical significance at the 5% level or less

ment questionnaires. Out of all the questions, the results illustrate that the most important question that influences the robo-advisors' portfolio recommendations is the asset allocation choices of the investors, followed by the investors' attitude towards risk and risk versus return preference, respectively.

This study contributes to the existing literature on robo-advisors by focusing on the risk assessment questionnaires adopted by these automated advisory services. While robo-advisors offer a user-friendly and innovative approach to expanding financial inclusion, their ability to replace traditional human advisory services is still uncertain. Although robo-advisor risk assessment questionnaires cover basic risk parameters that are suitable for the average investor, they may not be equipped to handle complex investment requirements. Therefore, the question remains whether robo-advisors can effectively address the diverse needs of all investors. So far, there is a paucity of research being conducted to analyze the robo-advisors' questionnaires, especially in the context of the Asia Pacific region. Hence, this paper enriches the literature on robo-advisors by evaluating the risk assessment questionnaires adopted in selected Asia Pacific economies.

Besides, the findings of this research have practical implications for the system developers of robo-advisor platforms. This paper contends

that these system developers should re-examine the risk assessment questions employed as well as the utilization of answers by the algorithm system. Moreover, the results of this study have shed light on the limitations of the existing questionnaires employed and underscore the continued importance of human interventions in providing comprehensive and tailored investment guidance. Hence, system developers should review and re-design a better questionnaire to capture investors' risk characteristics accurately and reflect all information gathered in the robo-advisors' portfolio recommendations. Additionally, it is necessary to create more complex risk assessment algorithms that consider a wider variety of variables in addition to the current risk assessment questions. Investors should be able to better configure the system to fit their unique financial tastes, such as socially conscious investing, thematic investing, and other customizable techniques. FinTech firms can improve the effectiveness and efficiency of their robo-advisory platforms and better meet the various needs of investors by deploying these solutions.

REFERENCES

[1]   Wexler MN, Oberlander J. Robo-advisors (RAs): The programmed self-service market for professional advice. *Journal of Service Theory and Practice*. 2021;31(3): 351–365. https://doi.org/10.1108/JSTP-07-2020-0153.

[2]   Chuyen DLK. Fintech and alternative investment. *The Journal of Alternative Investments*. 2018;20(3): 6–15. https://doi.org/10.3905/jai.2018.20.3.006.

[3]   Phoon K, Koh F. Robo-advisor and wealth management. *The Journal of Alternative Investment*. 2018;21(3): 79–94. https://doi.org/10.3905/jai.2018.20.3.079.

[4]   Loo KLM. Enhancing financial inclusion in ASEAN: identifying the best growth markets for FinTech. *Journal of Risk and Management*. 2019;12(181): 1–21. https://doi.org/10.3390/jrfm12040181.

[5]   Wojcik D. Financial geography II: the impacts of FinTech – financial sector and centres, regulation and stability, inclusion and governance. *Progress in Human Geography*. 2021;45(4): 878–889. https://doi.org/10.1177/0309132520959825.

[6]   Bianchi M, Brière M. *Robo-advising: Less AI and more XAI? Augmenting algorithms with humans-in-the-loop*. France: Amundi Institute. Working Paper No.: 109, 2021. https://researchcenter.amundi.com/article/robo-advising-less-ai-andmore-xai [Accessed 13th March 2023].

[7]   So MKP. Robo-advising risk profiling through content analysis for sustainable development in the Hong Kong financial market. *Sustainability*. 2021;13(3): 1–15. https://doi.org/10.3390/su13031306.

[8]   Tan KSG. Robo-advisors and the financialization of lay investors. *Geoforum*. 2020;117: 46–60. https://doi.org/10.1016/j.geoforum.2020.09.004.

[9]   Faloon M, Scherer B. Individualization of robo-advice. *The Journal of Wealth Management*. 2017;20(1): 30–36. https://doi.org/10.3905/jwm.2017.20.1.030.

[10] Abraham F, Schmukler SL, Tessada J. *Robo-advisors: investing through machines*. Washington: World Bank Group. Report No.: 134881, 2019. https://documents1.worldbank.org/curated/en/27504 1551196836758/pdf/Robo-Advisors-Investing-through-Machines.pdf [Accessed 12th March 2023].

[11] Tertilt M, Scholz P. To advise, or not to advise – how robo-advisors evaluate the risk preferences of private investors. *The Journal of Wealth Management*. 2018;21(2): 70–84. https://doi.org/10.3905/jwm.2018.21.2.070.

[12] Tillmans SPA. *Robo-advisors: how can automated investment advice change risk profiling practices?*. Master thesis. Radboud University; 2017. https://theses.ubn.ru.nl/handle/123456789/5205 [Accessed 17 March 2023].

[13] Capital Markets Malaysia. *Digital investment managers*. 2022. https://www.capitalmarketsmalaysia.com/digital-investment-managers/ [Accessed 10th April 2022].

[14] Securities Commission Malaysia. *Fintech to help Malaysia build back better*. https://www.sc.com.my/resources/media/media-release/fintech-to-help-malaysia-build-back-better [Accessed 10th April 2022].

[15] Gan LY, Khan MTI, Liew TW. Understanding consumer's adoption of financial robo-advisors at the outbreak of the COVID-19 crisis in Malaysia. *Financial Planning Review*. 2021;4(3): e1127. https://doi.org/10.1002/cfp2.1127.

[16] Balzer B, Lavery B, Lee SH, Ong J. *Singapore FinTech landscape 2020 and beyond*. Singapore: Oliver Wyman; 2020.

[17] KPMG. *Digital wealth management in Asia Pacific*. China: KPMG; 2021. https://assets.kpmg.com/content/dam/kpmg/cn/pdf/en/2021/03/digital-wealth-management-in-asia-pacific.pdf [Accessed 15th March 2023].

[18] GovHK. *Hong Kong – the facts*. 2022. https://www.gov.hk/en/about/abouthk/facts.htm [Accessed 10th April 2022].

[19] Financial Supervisory Commission of Taiwan. *FSC authorizes new regulatory sandbox experiment-robo-advisor service for implementing financial inclusion*. 2021. https://www.fsc.gov.tw/en/home.jsp?id=54&parentpath=0,2&mcustomize=multimessage_view.jsp&dataserno=202103120001&dtable=News [Accessed 14th April 2022].

[20] Robo-Advisor Testbed Secretariat of South Korea. *RA market size trend data* (as of the end of March 22nd). 2022. https://www.ratestbed.kr:7443/portal/bbs/B0000006/view.do?nttId=8486&searchCnd=&searchWrd=&menuNo=200241&algrthSn=&odrSn=&option1=&delCode=0&sdate=&edate=&viewType=&pageIndex=1 [Accessed 14th April 2022].

[21] Organization of Global Financial City Tokyo. *Monthly Market Report*. Tokyo: Organization of Global Financial City Tokyo; 2021. https://fincity.tokyo/en/ [Accessed 16th March 2023].

[22] Markowitz H. Portfolio selection. *The Journal of Finance*. 1952;7(1): 77–91. https://doi.org/10.1111/j.1540-6261.1952.tb01525.x.

[23] Wagner D, Farley A. *Trading ETFs: gaining an edge with technical analysis*. New Jersey: John Wiley & Sons; 2012.

[24] Balchunas E. *The institutional ETF toolbox: how institutions can understand and utilize the fast-growing world of ETFs*. New Jersey: John Wiley & Sons; 2016.

[25] Nwankpa JK, Merhout JW. Exploring the effect of digital investment on IT innovation. *Sustainability*. 2020;12(18): 7374. https://doi.org/10.3390/su12187374.

[26] Britton BL, Atkinson DG. An investigation into the significant impacts of automation in asset management. In: *Proceedings of the 17th International Scientific Conference on Economic and Social Development*. Warsaw, Poland: Varazdin Development and Entrepreneurship Agency; 2016. p.393–404.

[27] Boreiko D, Massarotti F. How risk profiles of investors affect robo-advised portfolios. *Frontiers in Artificial Intelligence*. 2020;3(60): 1–9. https://doi.org/10.3389/frai.2020.00060

[28] Belanche D, Casaló LV, Flavin C. Artificial intelligence in FinTech: understanding robo-advisors adoption among customers. *Industrial Management & Data Systems*. 2019;119(7): 1411–1430. https://doi.org/10.1108/IMDS-08-2018-0368.

[29] Stanley TJ, Danko WD. *The millionaire next door: the surprising secrets of America's wealthy*. Georgia: Longstreet Press; 1996.

[30] Baker HK, Ricciardi V. *Investor behavior: the psychology of financial planning and investing*. New Jersey: John Wiley & Sons; 2014.

[31] Thanki H, Baser N. Interactive impact of demographic variables and personality type on risk tolerance. *Emerging Economy Studies*. 2019;5(1): 42–54. https://doi.org/10.1177/2394901519825924.

[32] Christiansen C, Joensen JS, Rangvid J. Understanding the effects of marriage and divorce on financial investments: the role of background risk sharing. *Economic Inquiry*. 2015;53(1): 431–447. https://doi.org/10.1111/ecin.12113.

[33] Gakhar DV, Prakash D. Investment behaviour: A study of relationship between investor biases and Myers Briggs type indicator personality. *Opus: HR Journal*. 2017;8(1): 32–60.

[34] Damodaran A. *Investment philosophies: successful strategies and the investors who made them work*. New Jersey: John Wiley & Sons; 2012.

[35] Greninger SA, Hampton VL, Kitt KA, Achacoso JA. Ratios and benchmarks for measuring the financial well-being of families and individuals. *Financial Services Review*. 1996;5(1): 57–70. https://doi.org/10.1016/S1057-0810(96)90027-X.

[36] Warren E, Tyagi AW. *All your worth: The ultimate lifetime money plan*. New York: Free Press; 2006.

[37] Revilla M, Ochoa C. Ideal and maximum length for a web survey. *International Journal of Market Research*. 2017;59(5): 557–565. https://doi.org/10.2501/IJMR-2017-039.

[38] Sharma H. How short or long should be a questionnaire for any research? Researchers dilemma in deciding the appropriate questionnaire length. *Saudi Journal of Anaesthesia*. 2022;16(1): 65–68. https://doi.org/10.4103/sja.sja_163_21.