



Economic Development, Technological Change, and Growth

Are Robots Taking Over? Technological Advancements and Investor Risk Tolerance

Jaenre Pietersen¹, Sune Ferreira-Schenk², Zandri Dickason-Koekemoer³

Abstract: The banking industry is being overhauled by robots. Artificial intelligence (AI) is the most recent technological breakthrough made in the banking industry. There is a wide range of variables that influence investor risk tolerance which has previously been examined, however, the influence of technological advancements on investor risk tolerance in a South African context remains unsolved. This paper aims to investigate the influence of technological advancements on investor risk tolerance. The results of this study found technological factors contributed significantly towards explaining high risk tolerance behaviour to a rather moderate degree. Evidence suggests investors employing Robo-advisors for assistance when making investment decisions, tend to become more risk-tolerant. The results of this study procured that certain demographic variables included in this study have a significant influence on the individual investor risk tolerance levels of South African investors. It is recommended that the research study be utilised by individual investors, financial planners, investment companies and current or future researchers originating from both frontiers to be acquainted with how technological advancements influence investor risk tolerance. Therefore, ensuring technological advancements are used accordingly, to the benefit of the investor privately or in practice.

Keywords: Robo-advisors; risk tolerance; investors; technology

JEL Classification: G32

1. Introduction

Since the dawn of the 20th-century humanity has had the privilege to bear witness to some massive innovations in the banking industry (Clarke, 2019). These innovations serve to be the result of an ever increase of technological advancements,

¹ North West University, South Africa, Address: Private Bag X1290, Potchefstroom, 2520, South Africa, E-mail: jaenre.pietersen@gmail.com.

² North West University, South Africa, Address: Private Bag X1290, Potchefstroom, 2520, South Africa, E-mail: 23261048@nwu.ac.za.

³ North West University, South Africa, Address: Private Bag X1290, Potchefstroom, 2520, South Africa, Corresponding author: 20800274@nwu.ac.za.

regulatory changes, and the evolving preferences of the modern-day investor. From the 1970s onward, individuals have been seeing a considerable increase in the pace of change in the banking industry to accommodate bankers and investors with a more simplified method of banking, which gives rise to thousands of opportunities for investors and broaden their access to these opportunities (Clarke, 2019). When reflecting on the South African banking history, it was only in 1981 when the Standard Bank Group (Standard Bank Group, 2011) launched the first Automated Teller Machine (ATM). Fast forward to 2001 where mobile and digital banking revolutionized the banking sector, seen with First National Bank (FNB) launching the very first mobile banking application for smart cellular devices in South Africa (Shapshank, 2018). In 2016, the banking industry was talking robots, more specifically - Robo-advisors. Bizank was the first bank in South Africa to take advantage of launching a new piece of technology called the robot advisor to accommodate investors with a much more simplified and cost-effective method of investing (Armitage, 2016 & Sarpong, 2020). According to Statista (2020), it has been forecasted that \$81 million worth (United States) of asset funds are being managed by Robo-advisors in South Africa with around 106 000 users in 2020. The continuous development in technology creates the need for organisations to bring about changes to remain relevant in the financial sector. Therefore, Charles Darwin's survival of the fittest apophthegm is disproven since it is neither the strongest nor the most intelligent species that has survived but the one that is most adaptable to change (Wheeler, 2020).

In the 1980s and 1990s, investors were in their prime as they had the perfect market conditions to trade in. According to Taylor (2019), the ideal trading environment for an investor would be where inflation and interest rates decline, technological advancements increase, where the market becomes freer throughout the entire world and finally where capital is allowed to flow freely in the global economy. Although these perfect market conditions would tend to draw in many investors, the market still finds some investors who remain less risk-tolerant than others. Financial investment risk tolerance is defined as the amount of risk an investor is willing to take when making investment decisions (Sulaiman, 2012). The financial risk tolerance of each investor is influenced by a wide variety of recent occurrences that have taken place throughout their lifetime, also called demographic variables (MacCrimmon & Wehrung, 1986). According to Yao, Hanna and Lindamood (1983), a consequence of these recent occurrences could lead to investors having a higher or lower financial risk tolerance. There are internal factors that have a direct impact on how investors perceive risks such as age, time horizon, liquidity needs, portfolio size, income, investment knowledge and attitude toward price fluctuations (Sung & Hanna, 1996).

Wang and Hanna (1997) established the conclusion that there is a positive relationship between age and risk tolerance. In addition to Wang and Hanna's (1997)

paper, Grable and Lytton (1998) established that there is a positive relationship between age and gender on financial risk tolerance. Their research examines an array of demographic variables which incorporates marital status, occupation, self-employment, income, ethnicity and education. Grable and Joo (1999) detect that the demographic variables which include high levels of education, financial knowledge, internal locus of control, marital status, professional occupation, high income, solvency, and economic expectations are important variables that affect financial risk tolerance.

Grable and Joo (2002) deemed gender, age, and marital status not to be an influential variable that affects financial risk tolerance. In conclusion, many hours of research have gone into understanding the various demographic variables that have an effect on financial risk tolerance except for one variable, technological advancements (Dickason & Ferreira, 2018; Van den Bergh, 2020). Previous studies have failed to establish a link to investors since academics used ordinary individuals within their samples. There is currently limited research that attempts to investigate the influence technological advancements have on financial risk tolerance within a South African context. In the modern era, where technology has taken over the entire world, it is of great importance to understand whether technological advancements pose to be beneficial or disadvantageous to investors. Artificial intelligence (AI), applications are transforming how individuals are seeking advice since the launch of Robo-advisors. The utilisation of AI allows for a reduction in costs, therefore, attracting a large portion of individuals who believe financial services are otherwise cumbersome, time-consuming, and cost-prohibitive (Nelito, 2017). Furthermore, advantages contributing to the use of AI are that it increases personalised tax-optimised investment strategies and wealth management techniques for clients who do not have the traditional levels of asset classes to qualify for professional wealth management services (Wheeler, 2020). This paper will analyse, the demographic variables age, gender, ethnicity, education, financial knowledge and technological advancements and its effect on investor risk tolerance.

2. Literature Review

In this study, the literature review lends its focus to the most important factors affecting investor risk tolerance in the banking sector but also addresses the factors which tend to make an investor more risk-tolerant. By looking at previous research papers Grable & Lytton, (1998), Coet & McDermott, (1979) and Yao, Gutter & Hanna, (2005), it indicates a clear need in the market for a paper that addresses the technological factor since there were second to none academic papers addressing the topic in a South African context. When researching the effect that technology has on investor risk tolerance, the researcher finds that there is only a single paper written which was based on China. The academic papers that were indeed found to test

investor risk tolerance based their research on a different view and indicators such as age, gender, ethnicity (Botwinick, 1966; Vroom & Pahl, 1971; Baker & Haslem, 1974; Okun & DiVesta, 1976; Van de Venter, Michayluk, & Davey 2012; Yao & Hanna, 2005 and Dickason & Ferreira, 2018).

Under the classic paradigm of financial theory, it remains believed that investors act in a rationally way when making investment decisions (Elton, Gruber & Busse, 2011). However, there are various factors which influence an investor's risk tolerance when making investment decisions. Investors are generally classified to have a relatively low, medium, or extremely high investor risk tolerance, which serves as a determinant for returns on investment (Yao & Hanna, 2005). According to Grable and Lytton (2001), investors who are perceived to have a low investor risk tolerance are investors that have a less aggressive stand towards trading financial instruments. Also, low-risk tolerance consists of investors who do not take excessive risks while remaining satisfied with low returns. Investors who have a medium investor risk tolerance take on small amounts of risk but do not trade aggressively. Finally, investors who have exceedingly high investor risk tolerance take on large amounts of risk while making investment decisions to ensure an immense return (Riley, Brown, & Leeds, 2018).

Table 1. Factors Associated with Financial Risk Tolerance

Individual Characteristics	Assumed to be more tolerant
Age	Younger people
Education	Bachelor's degree or higher
Employment status	Employed full time
Ethnicity	Non-Hispanic white
Financial knowledge	High
Financial satisfaction	High
Gender	Male
Home ownership	Owner
Household size	Large
Income	High
Income source	Business owner
Income variability	Stable and predictable
Locus of control	Internal
Marital status	Single
Marital/gender interaction	Single male
Mood	Happy
Net worth	High
Occupation	Professional

Personality	Type A
Religiosity	Less religiosity
Self-esteem	High
Sensation seeking	High
Technological capability	High

Source: Adapted from Irwin (as cited in Bell & Bell, 1993).

Table 1 indicates the various demographic variables that were found by (Irwin, 1973) that influence individual risk tolerance. In addition to the different factors that influence individual risk tolerance, it is found that the table gives an indication of the individual characteristics that are assumed more risk-tolerant. According to Bell and Bell (1993), Irwin Jr. first created the model in 1993 to identify the various factors that have an influence on investment decision making and in 2020 the research article aims to build on Irwin's model by adding technological capability as an essential individual characteristic which influences investor risk tolerance.

In the 21st century, there is an array of different investor personalities, each of whom wants to make considerable returns on investments without having to take on a large amount of risk. Technological developments have increased at such a rapid pace from the 1970s onward, that it finds itself having massive influences on the way countless people bank (Anyasi & Otubu, 2009). The objective of this paper is to conduct in-depth research into the various factors that influence an investor's risk tolerance with the focus remaining on how technological advancements influence investor risk tolerance. Numerous factors are conducive to the way investors make investment decisions but for this paper, the researcher will look at the demographic variables that seem to have the largest impact on an investors risk tolerance.

These factors include age, gender, ethnicity, education, financial knowledge, and technology. Some variables that are being used in the paper have already been thoroughly examined by previous researchers but it remains a critical necessity to include these factors to get the most relevant outcome (Grable & Lytton, 1998; Coet & McDermott, 1979 and Yao, Gutter & Hanna, 2005). Researchers find that each factor relies on the capability or condition of the next. However, based on previous studies that solely focused on technology, the assumption established indicates technology to be a variable that has a massive influence on the way investors make investment decisions (King, 2010).

In-depth research is still required since there are only a limited number of researchers who have investigated the topic, none of which are based in the same context or within a South African context. According to Batiz-Lazo and Wood (2002), the technological advancement process never seems to stop, which is why it continues to revolutionise the banking sector repeatedly. Academics, investors and ordinary individuals need to get an in-depth understanding of how technological advancements can be used to their advantage when making investment decisions.

Therefore, the contributions made by the paper will enable investors to have an alternative approach to investing. It will provide new, as well as established investors, with the relevant information and knowledge on the latest technological advancements (Robo-advisors) within the banking sector to accommodate their investment needs. Finally, it will fulfil the trust factor gap between man and machine when analysing real data to assess whether the use of Robo-advisors has a positive or negative contribution to investor risk tolerance.

The age factor plays a pivotal role in assessing an investor's risk tolerance. Age is one of the demographical factors that have been most widely assessed throughout the years. According to Grable and Lytton (1998), older investors tend to be less risk-tolerant than other investors due to the small amount of recovery time they have if financial losses were to be incurred. The work of Irwin (1993) as indicated in Table 1 (as cited in Bell & Bell, 1993), also advise that younger people are assumed to be more risk-tolerant. Wallach and Kogan (1961) were the first researchers to investigate the relationship found between age and investor risk tolerance. Their conclusion from the investigation revealed that older investors were conservative with their funds and cautious in enormous risk financial decision making. The concluding statement made public by these researchers remains to this day as the majority of researchers find that there is a positive relationship between age and investor risk tolerance (Botwinick, 1966; Vroom & Pahl, 1971; Baker & Haslem, 1974; Okun & DiVesta, 1976; Van de Venter, Michayluk, & Davey, 2012; Yao & Hanna, 2005; and Dickason & Ferreira, 2018). In addition to these researchers, many researchers concluded that no positive relationship was established between age and risk tolerance (Grable & Joo, 1999; Anbar & Eker, 2010).

Previous studies conducted on the effect of gender on investor risk tolerance also established the importance of gender on investor risk tolerance (Coet & McDermott, 1979; Rubin & Paul, 1979; Yao & Hanna, 2005; Dickason & Ferreira, 2018). Moreover, it is concluded that women who invest tend to invest in securities that are more risk-free making them less risk-tolerant as men (Sung & Hanna, 1996; Yao & Hanna, 2005). According to Irwin (as cited in Bell & Bell, 1993, 7-28), concerning Table 1, male investors are assumed to be more risk-tolerant. Although most studies appear to agree that gender does play a significant role on risk tolerance, a minority of researchers Embrey and Fox (1997) and Sundén and Surette (1998) believe gender is not a significant determinant of financial risk tolerance.

In addition to the research conducted on age and gender, ethnicity remained a significant factor to investigate. According to Dickason and Ferreira (2018), a positive relationship was found between different ethnic groups and investor risk tolerance. Their conclusion indicated that African investors are more risk-tolerant than White, Coloured and Asian investors. Evidence suggests that white men are the investors who tend to take on above-average investment opportunities while white

women investors are perceived to take on the average risk or no risk at all. Although many studies that have researched the effect that ethnicity has on investor risk tolerance, all indicate a positive relationship but vary in terms of which ethnic group is considered more risk-tolerant (Yao, Gutter & Hanna, 2005).

“Education is the most powerful weapon which you can use to change the world” (Mandela, 2014). Although many people in South Africa are not as privileged to receive proper schooling, it remains a vital factor to investigate its influence on financial risk tolerance. In a study conducted by Grable (1997), it was found that increased levels of education had a positive relationship with risk tolerance. Moreover, it was considered the variable that had the most significant optimizing factor. According to MacCrimmon and Wehrung (as cited by Grable, 1997), having access to higher education encourages investors to be more risk-taking as such it concluded that increased levels of education lead to higher risk tolerance. Table 1, extracted from Irwin (1993), indicates that individuals with a relevant Bachelor’s degree or higher, are assumed to be more risk-tolerant.

Financial knowledge may heavily affect decision-making ability when it comes to making investment decisions. According to Alba and Hutchinson (1987), financial knowledge can be defined as information that is learned over time and stored in memory. The information obtained from past experiences is used to assist us in present investment decision making. Therefore, it is assumed that an increase in financial knowledge would steer investors into making riskier investments. Extracted from Table 1, it is believed that individuals with high financial knowledge tend to be assumed as more risk-tolerant Irwin (as cited in Bell & Bell, 1993). Financial knowledge has a positive relationship with investor risk tolerance (Lyons, Palmer, Jayaratne, & Scherpf, 2006). According to Friestad and Wright (as cited by Wang, 2009), financial knowledge is considered to have two components, namely objective knowledge and subjective knowledge, where objective knowledge is considered as accurately stored information while subjective knowledge relates to a state of belief about knowledge (Bettman & Park, 1980). According to Irwin (1993), adolescence that has high financial knowledge is assumed to be more risk-tolerant.

Technological advancements have experienced a rapid uptick in recent years and might serve as one of the most influential factors to affect investors risk tolerance (Clarke, 2019). Due to the pace at which technology has developed, a growing gap in knowledge has occurred among investors as only a handful of academic articles have been published around the world in the attempt to explain the effects of technological advancements on investor risk tolerance. With the launch of the new Robo-advisors (RA’s) in 2016, the investment industry has been turned on its head. Previous studies conducted by Deloitte (2016) and Business Insider Intelligence (2016) concluded that technological advancements had a massive influence on the banking industry. The success of technological advancements in the banking and

investment sector comes from their ability to draw in a new generation of investors and bankers. Additionally, the new generation is more open to making use of technological advancements to benefit themselves rather than using traditional methods of banking. Since Robo-advisors are more appealing to the millennial consumer, these will continue to emerge as significant role players in traditionally underserved markets that consist of smaller investors not deemed profitable up to larger organisations and established advisors (Wheelan, 2020). Finally, it can be assumed that there is a positive relationship regarding technological advancements and investor risk tolerance since the millennial are more willing to invest their money. Technological advancements do not only benefit the younger generation as the older generation is finally learning how to adapt and adjust (Beketov, Lehmann & Wittke, 2018).

2. Methodology

The sections to follow represent the research approach and instrument used, sample size and statistical analysis. This study makes use of secondary data previously collected by Van den Bergh (2020). The questionnaire was electronically distributed to individual investors in the database of the designated South African investment company.

2.1. Research Instrument

In addition to the use of theory, the Grable and Lytton scale (1999) was used as a development feature of the new risk tolerance scale by Van den Bergh (2020). Regarding the inclusion of the Grable and Lytton scale (1999), it is a risk tolerance scale that was developed in 1999 which were used by consumers, financial advisors and researchers to determine an individual's ability to take on risk (Kuzniak, Rabbani, Heo, Ruiz-Menjivar & Grable, 2015) The Survey of Consumer Finance scale (SCF scale) is also used for the better development the newly developed investor risk tolerance scale (20-items). Section A of the questionnaire consisted of demographical and socio-cultural questions to obtain general background information of the participants and more importantly, to identify and analyse the effect of demographical and socio-cultural factors, as endogenous factors, on individual investor risk tolerance behaviour. The last section included questions regarding technological advancements and the effect on investors financial and investment decisions. The questions were aimed at determining whether investors will be open to using Robo-advisors or still rely on personal financial advisors. These were close-ended questions using a six-point Likert-scale (ranging from likely to unlikely):

- Advances in technology affect how I invest.
- I rely on and make use of technological tools which provide me with more knowledge to make investment decisions.
- Technological advances provide me with more control over my investment decisions.
- With the development of Robo-advisers (automated online advisers) that focus on low cost and some offering free services, I am more likely to make use of Robo-advisers to assist in doing my own investment planning.
- Despite technological advances, I will still be very reliant on my financial adviser, that I trust and have a well-established relationship with, for financial and investment advice.

2.2. Research Sample Selection

Within this study, the sample frame used consists of a purposive sampling method of individual investors within a South African context. Purposive sample methods are considered to be a type of sampling technique which is non-probability and most effective when used to study a certain cultural domain with experts (Tongco, 2007). The purposive sampling method can also be used with either quantitative or qualitative research techniques. With the use of the purposive sampling method, the researcher can eliminate individuals that have other products but no investments. The inclusion criteria for the investor were as follow:

- Older than 18 years;
- A current investor (a screening question was asked); and
- Resides within Gauteng, South Africa.

According to Babbie and Quinlan (2010), as cited by Van den Bergh (2020), it is of utmost importance that each individual who is selected as a participant in a study should make a valuable contribution. The secondary data sample which is used in this study consisted out of a sample of 463 South African investors who have completed questionnaires.

2.3. Statistical Analysis

This research study made specific use of descriptive statistics and correlations to establish if and how demographic variables, financial knowledge and technological advancement influence investor risk tolerance levels.

3. Analysis and Interpretation of Empirical Findings

3.1. Demographic Information

For this study, data from a secondary database was made use of to determine the relationship between age, gender, ethnicity (race), education, financial knowledge and technological advancements on investor risk tolerance. The secondary data sample that was used in this study consisted out of 463 South African investors who have completed questionnaires. The demographical information for this study consists of frequencies and percentages for the following factors relating to age, gender, ethnicity, education, financial knowledge and technological advancements.

Table 2. Demographical Information of the Sample

Construct	Category	Frequency (<i>f</i>)	Percentage (%)
Age	18–24 years	4	0.9
	25–34 years	83	17.9
	35–49 years	176	38.0
	50+ years	200	43.2
Gender	Male	205	44.3
	Female	258	55.7
Ethnicity	African	88	19.0
	Asian	38	8.2
	Coloured	27	5.8
	White	306	66.1
	Other	4	0.9
Education	No matric	12	2.6
	Matric	87	18.8
	Further training	57	12.3
	3-year diploma	60	13.0
	3+year diploma	58	12.5
	Bachelor's degree	87	18.8
	Honours degree	53	11.4
	Master's degree	30	6.5
Financial and investment knowledge	Doctoral degree	10	2.2
	Other	9	1.9
	Little	93	20.1
	Average	233	50.3
	Above-average	124	26.8
	Superior	13	2.8

Table 2 provides the age distribution information enabling the reader to effortlessly identify the age distribution for each of the four age groups. Reference to the table indicates the 50 years or older age category to have the majority of participants classified under its category of 43.2 per cent of the sample. Furthermore, the 35-49

year's age category had the second-largest participants classified under its category of 38.0 per cent. The age categories that had the lowest participants partaking in the sample was the 25-34 year's age category, resembling 17.9 per cent of the sample whilst the 18-24-year age category had the lowest amount of participants classified under its category with a mere 0.9 per cent participants within the sample. Reference to Table 2 indicates that 55.7 per cent of participants classified as female, whilst 44.3 per cent of participants classified as males. The sample consisted of the majority of White participants (66.1%) followed by African participants (19.0%). Furthermore, the sample is completed by the minor segment of the sample consisting of Asian/Indian (8.2%) and Coloured (5.8%).

Reference to Table 2 indicates that the sample consists of participants that have no matric (2.6%), matric (18.8%), and further training (12.3%). Referring to higher levels of education which requires acceptance to a college or university, participants consisted over a less than three-year diploma (13.0%), longer than three-year diploma (12.5%) and a bachelor's degree (18.8%). Numerous participants within the sample completed a higher form of education beyond the average bachelor's degree. Participants within the sample that in possession of an honours degree (6.5%), and a doctoral (2.2%). The sample also included participants that had an "other" form of education and amounted to 1.9 per cent of the portfolio. Participants with an average amount of financial knowledge consisted of 50.3 per cent of the sample. Furthermore, participants who had an above-average amount of financial knowledge consisted of 26.8 per cent whilst participants who had superior financial knowledge pertained to a mere 2.8 per cent. Finally, participants who had under the average amount of financial knowledge consisted of 20.1 per cent of the sample.

Table 3. Descriptive Statistics for Risk Tolerance and Subsections

Descriptive Statistics									
	N	Minimum	Maximum	Mean	Standard Deviation	Skewness	Kurtosis		
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. error	Statistic	Std. error
Age	463	2	5	4.24	0.769	-0.545	0.113	-0.751	0.226
Gender	463	1	2	1.56	0.497	0.231	0.113	1.955	0.226
Ethnicity	463	1	4	3.20	1.216	1.032	0.114	-0.728	0.227
Education	463	1	10	4.75	2.176	0.230	0.113	-0.780	0.226
Financial investment knowledge	463	1	4	2.12	0.753	0.190	0.113	-0.410	0.226
Technological advancements	463	1.00	6.00	3.8472	0.99838	0.302	0.113	0.391	0.226
High risk tolerant	463	1.00	6.00	3.0968	1.06269	0.081	0.113	-0.493	0.226
Average risk tolerant	463	1.00	6.00	3.5754	1.01588	0.408	0.113	-0.181	0.226
Low risk tolerant	463	1.00	6.00	3.3857	0.89919	0.156	0.113	0.171	0.226
Risk tolerance	463	3.00	17.26	10.0579	1.88627	0.615	0.113	2.533	0.226

Alluding to the subsections of risk tolerance, average risk tolerance recorded the highest mean (3.5754) compared to low-risk tolerance (3.3857) and high-risk tolerance (3.0968). However, the highest standard deviation was recorded on the high-risk tolerance section (1.06269). This was followed by the average risk tolerance with a standard deviation of 1.01588 and low-risk tolerance 0.89919. Results indicate that the average risk category reported the highest mean (3.5754), implying that the majority of individual investors have the propensity to take average risks when making investment decisions. Furthermore, the low-risk category reported the second-highest mean (3.3857), which serves as an indicator of the propensities of individual investors to take on low-risk investments when making investment decisions. Finally, the high-risk category recorded the lowest mean (3.0968) which implies that the minority of individual investors partaking within the study have the propensity to take on high-risk investments when making investment decisions.

Table 4. Independent-Samples T-Test for Gender and Risk Tolerance

Risk tolerance	Gender	N	Mean	SD	t	df	Sig.	Mean difference
High risk	Male	205	3.37	1.03	5.14	440.064	0.000*	0.50
	Female	258	2.88	1.04				
Average risk	Male	205	3.94	0.95	7.30	443.301	0.000*	0.66
	Female	258	3.29	0.98				
Low risk	Male	205	3.24	0.97	-	401.074	0.002*	-0.26
	Female	258	3.50	0.82				

*Statistically significant at the 0.05 level (2-tailed)

Table 4 shows statistically significant differences between gender and the high risk tolerance, average risk tolerance as well as the low risk tolerance category ($p = 0.000 < 0.05$). This indicates that the effect of gender on individual investor risk tolerance behaviour is statistically significant. These findings are in line with those of previous studies (Coet & McDermott, 1979; Rubin & Paul, 1979; Yao & Hanna, 2005; Dickason & Ferreira, 2018).

Table 5. Ethnicity and Risk Tolerance

	Sum of squares	Df	Mean square	F-ratio	Sig.
High risk tolerance	78.742	3	26.25	27.019	0.000*
Average risk tolerance	5.909	3	1.97	1.922	0.125
Low risk tolerance	4.113	3	1.37	1.703	0.166

*Statistically significant at the 0.05 level

A statistically significant difference between ethnicity and high risk tolerance was found in Table 5, conversely, no statistically significant difference was found between ethnicity and average risk tolerance as well as low risk tolerance. These results confirm those of Dickason and Ferreira (2018).

Table 6. Relationship between independent variables and investor risk tolerance

Risk tolerance	Spearman's correlation	Technological advancements	Financial and investment knowledge	Age	Education
High risk	Correlation coefficient	0.358**	0.235**	-	0.082
	Sig. (2-tailed)	0,000	0,000	0.002	0.078
	N	463	463	463	463
Average risk	Correlation coefficient	0.118*	0.431**	0.151**	0.297**
	Sig. (2-tailed)	0,011	0,000	0.001	0.000
	N	463	463	463	463
Low risk	Correlation coefficient	0,054	-0.200**	-0,063	-0.136**
	Sig. (2-tailed)	0,243	0,000	0.173	0.003
	N	463	463	463	463

***Statistically significant at the 0.05 level*

Concerning Table 6 a medium, positive statistically significant relationship between technological factors and high risk tolerance was found ($p = 0.000 < 0.05$). This indicates that individual investors whose investment decisions are influenced by technological factors have a propensity to take high risks. Likewise, a small, positive statistically significant relationship was established between technological factors and average risk tolerance behaviour ($p = 0.011 < 0.05$). This indicates that individual investors whose investment decisions are influenced by technological factors have a propensity to take average risks. Contrariwise, no statistically significant relationship was established between technological factors and low risk tolerance.

A small, positive statistically significant relationship was found between financial and investment knowledge and high risk tolerance and average risk tolerance behaviour ($p = 0.000 < 0.05$). This denotes that the propensities of individual investors to take high risks increase as financial and investment knowledge increases. Accordingly, individual investors with more financial and investment knowledge have greater propensities to take high risks than individual investors with less financial and investment knowledge.

Relating to the relationship between age and individual investor risk tolerance behaviour a small, negative statistically significant relationship between age and the high risk tolerance was found. This indicates that individual investors propensity to take risky financial decisions decrease with age. Thus, younger individual investors

have greater propensities to take high risks than older individual investors. Furthermore, a small, positive statistically significant relationship was established between age and average risk tolerance behaviour indicating that individual investors propensity to take average financial risk decisions to increase with age. Therefore, the findings of this article are in line with that of previous studies (Botwinick, 1966; Vroom & Pahl, 1971; Baker & Haslem, 1974; Okun & DiVesta, 1976; Van de Venter, Michayluk, & Davey, 2012; Yao & Hanna, 2005; and Dickason & Ferreira, 2018).

It was found in Table 6 that there is no statistically significant relationship between education and high risk tolerance behaviour. Conversely, a medium positive statistically significant relationship was indeed found between education and average risk tolerance. For that reason, an individual with a higher educational level will be more inclined to take average financial risks. A small, negative statistically significant relationship in Table 6, indicates that the propensities of an individual to take low risk will decline when that individual has a higher level of education (Irwin, 1993; Ferreira & Dickason-Koekemoer, 2019).

4. Conclusion

The primary objective of this paper was to determine the influence of technological advancements on investor risk tolerance. To achieve the primary objective formulated for this paper, the relationship between age, gender, ethnicity, education, financial knowledge and technological advancements had to be determined. Technological factors contributed significantly to explaining high risk tolerance behaviour to a rather moderate degree.

The results pertaining to this study procured that certain demographic variables included in this study have a significant influence on the individual investor risk tolerance levels of South African investors. The first demographic variable, age, which commonly plays a pivotal role in assessing investor risk tolerance reported a negative relationship prevailing between age and investor risk tolerance, indicating that investors take less risk the older they get. The second demographic variable, gender, which conspicuously contribute its importance toward investor risk tolerance reported a statistically significant difference between male and female investors where these findings were in line with those of previous studies. This study, therefore, opposes the views established by Embrey and Fox (1997) and Sundén and Surette (1998) who believe gender is not a significant determinant of financial risk tolerance. The third demographic variable, ethnicity, signifies a predominant contribution toward investor risk tolerance profiling. Alluding to the influence of ethnicity on investor risk tolerance results denote a, a statistically significant difference in the high risk tolerant category and ethnicity. Therefore, the study

concur with previous studies that suggest the ethnicity demographic variable to be statistically significant, however, disputes regarding which ethnic group is considered more risk-tolerant becomes relevant. The fourth demographic variable, education, confound the expectations regarding its relationship towards investor risk tolerance. Results report a non-statistical significance between high risk tolerance and education. Conversely, a medium positive statistically significant relationship was indeed found between education and average risk tolerance. For that reason, an individual with a higher educational level will be more inclined to take average financial risks.

The fifth and second to last demographic variable, financial knowledge, which heavily affects decision-making ability of investors when it comes to making investment decisions reported a positive relationship between investor risk tolerance and financial knowledge, whereby, a statistically significant relationship exists within the context of this study. Investors can deduce information obtained from past experiences to assist in present investment decision making. Therefore, it is assumed that an increase in financial knowledge would steer investors into making riskier investments.

The sixth and final variable, technological advancements, which have experienced a rapid uptick in recent years and is as one of the most influential factors to affect investors risk tolerance. The relationship between technological advancements and investor risk tolerance denotes a positive relationship, whereby, a statistical-significant relationship exists between investor risk tolerance and technological advancements exist within the context of this study. Therefore, evidence suggests investors employing Robo-advisors for assistance when making investment decisions, tend to become more risk-tolerant. Additionally, when analysing the levels of investor risk tolerance of investors in South Africa, results suggest that the majority of individual investors partaking within the study have the propensity to take average risks when making investment decisions. Furthermore, it is followed by individual investors have the propensities to take in low-risk investments when conducting investment decisions and finally, the minority of individual investors partaking within the study have the propensity to take on high-risk investments when making investment decisions.

With the compilation of any research study, there are bound to be certain limitations, which provide future opportunities for researchers to investigate. The first limitation pertaining to the research study confers to the primary quantitative data set that was obtained from a South African investment company with a sample size of 463 individual investors in Gauteng. Correspondingly, a recommendation with regards to the first limitation perceived within the study would be to engage and encourage several investment companies to partake within the research study to analyse the influence of technological advancements on investor risk tolerance from a more

extensive database set, which includes the perspectives of not only a singular but several investment companies. Also, to proliferate the participation of several investment companies within the research study, the sample size would tend to expand. The sample size of 463 individual investors which was incorporated within the research study, sufficiently met all the requirements necessary to perform the statistical analysis employed. However, given the recommendation pertaining to an enlarged data set developed and validated scales can be reviewed and utilised for intended future research studies in which the robustness of scale can be reviewed accordingly with regards to investor risk tolerance for a more accurate result. The second limitation pertaining to the research study was the regulation to which the data set was filtered to include some specific demographic individual investors. Therefore, the data set was filtered to include individual investors who meet the criteria of being 18 years and older, a current investor with an investment company and who resides in the Gauteng province. Correspondingly, a recommendation with regards to the second limitation perceived within the study would be to use adjusted or extended criteria of the research study as preferred by the researcher in order to draw a representative sample from the population. Finally, it is recommended that the research study be utilised by individual investors, financial planners, investment companies and current or future researchers originating from both frontiers to be acquainted with how technological advancements influence investor risk tolerance. Therefore, ensuring technological advancements are used accordingly, to the benefit of the investor privately or in practice.

Reference

- Alba, J. W. & Hutchinson, J. W. (1987). Dimensions of consumer expertise. *Journal of Consumer Research*, 13(4), pp. 411-454.
- Amaratunga, D.; Baldry, D.; Sarshar, M. & Newton, R. (2002). Quantitative and qualitative research in the built environment: application of "mixed" research approach. *Work study*, 51(1), pp. 17-31.
- Anyasi, F. I. & Otubu, P. A. (2009). Mobile phone technology in banking system: It's economic effect. *Research Journal of Information Technology*, 1(1), pp. 1-5.
- Armitage, P. (2016). *Bizank – SA's first robo-advisor*. <http://www.peterarmitage.co.za/bizank-sas-first-robo-advisor/>.
- Arora, R. (2017). Banks That Don't Invest in Technology Risk Falling Behind Permanently. *Forbes*. <https://www.forbes.com/sites/rohitarora/2017/07/20/banks-that-dont-invest-in-technology-risk-falling-behind-permanently/?sh=39706ccf2bc>.
- Baker, H. K. & Haslem, J. A. (1974). The impact of investor socioeconomic characteristics on risk and return preferences. *Journal of Business Research*, 2(4), pp. 469-476.
- Bátiz-Lazo, B. & Wood, D. (2002). An historical appraisal of information technology in commercial banking. *Electronic Markets*, 12(3), pp. 192-205.
- Bazeley, P. (2013). *Qualitative data analysis: Practical strategies*. Sage.

- Beketov, M.; Lehmann, K. & Wittke, M. (2018). Robo advisors: Quantitative methods inside the robots. *Journal of Asset Management*, 19(6), pp. 363-370.
- Bettman, J. R. & Park, C.W. (1980). Effects of prior knowledge and experience and phase of the choice process on consumer decision processes: A protocol analysis. *Journal of Consumer Research*, 7(3), pp. 234-248.
- BI Intelligence (2017). *The robo-advising report: Market forecasts, key growth drivers, and how automated asset management will change the advisory industry*. <https://www.businessinsider.com.au/the-robo-advising-report-market-forecasts-key-growth-drivers-and-how-automated-asset-management-will-change-the-advisory-industry-2016-6>.
- Bickel, P. J. & Lehmann, E. L. (2012). Descriptive statistics for nonparametric models I. Introduction. *Selected Works of EL Lehmann*, pp. 465-471. Springer, Boston, MA.
- Botwinick, J. (1966). Cautiousness in advanced age. *Journal of Gerontology*, 21(3), pp.347-353.
- Chatterjee, S. & Hadi, A. S. (2015). *Regression analysis by example*. John Wiley & Sons.
- Chen, J. (2019). *Skewness*. <https://www.investopedia.com/terms/s/skewness.asp>.
- Clark, K. (2019). *The changing face of investing: a brief history*. <https://www.equitiesforum.com/blog/2019/06/14/the-changing-face-of-investing-a-brief-history>.
- Coet, L. J. & McDermott, P. J. (1979). Sex, instructional set, and group make-up: Organismic and situational factors influencing risk-taking. *Psychological Reports*, 44 (3_suppl), 1283-1294.
- Creswell, J. W. & Clark, V.L.P. (2017). *Designing and conducting mixed methods research*. Sage publications.
- De Iorio, M.; Müller, P.; Rosner, G. L. & MacEachern, S. N. (2004). An ANOVA model for dependent random measures. *Journal of the American Statistical Association*, 99(465), pp. 205-215.
- Deloitte (2016). Robo Advisory in wealth management. *White Paper*.
- Diggory, K. (2018). Technology in the 21st Century, Blessing or curse? <https://www.explore-life.com/en/articles/technology-in-the-21st-century>.
- Draper, N. R. & Smith, H. (1998). *Applied regression analysis* (Vol. 326). John Wiley & Sons.
- Elton, E. J.; Gruber, M. J. & Busse, J. A. (2011). Are investors rational? Choices among index funds. *Investments and Portfolio Performance*, pp. 145-172.
- Embrey, L. L. & Fox, J. J. (1997). Gender differences in the investment decision-making process. *Financial Counselling and Planning*, 8(2), pp. 33-40.
- Ferreira, S. J. & Dickason-Koekemoer, Z. 2019. The relationship between depositor behaviour and risk tolerance in a South African context. *Advances in Decision Sciences*, 23(3), pp. 1-19.
- Franzese, M. & Iuliano, A. (2019). *Correlation analysis*.
- Friestad, M. & Wright, P. (1994). The persuasion knowledge model: How people cope with persuasion attempts. *Journal of Consumer Research*, 21(1), pp. 1-31.
- Frost, J. (2017). How to interpret R-squared in regression analysis. *Statistics By Jim*.
- Grable, J. E. (2000). Financial risk tolerance and additional factors that affect risk taking in everyday money matters. *Journal of Business and Psychology*, 14(2), pp. 625-630.

Grable, J. E. & Joo, S. (1999). Factors related to risk tolerance: a further examination. *Consumer Interests Annual*, 45(1), pp. 53-58.

Grable, J. E. & Lytton, R. H. 1998. Investor risk tolerance: testing the efficacy of demographics as differentiating and classifying factors. *Financial Counselling and Planning*, 9(1), pp. 61-73.

Grable, J. E. & Lytton, R.H. 2001. Assessing the concurrent validity of the SCF risk tolerance question. *Journal of Financial Counselling and Planning*, 12(2), p. 43.

Grable, J. E. (1997). *Investor risk tolerance: Testing the efficacy of demographics as differentiating and classifying factors*. Doctoral dissertation, Virginia Tech.

Hargrave, M. (2020). *Standard Deviation Definition*. <https://www.investopedia.com/terms/s/standarddeviation.asp>.

Irwin, C. E. (1993). Adolescence and risk taking: How are they related? In N. J. Bell & R. W. Bell (Eds.). *Adolescent risk taking*, pp. 7-28. Newbury Park, CA: SAGE.

Kenton, W. (2019). *Descriptive Statistics*. https://www.investopedia.com/terms/d/descriptive_statistics.asp.

Kuzniak, S.; Rabbani, A.; Heo, W.; Ruiz-Menjivar, J. & Grable, J. E. (2015). The Grable and Lytton risk-tolerance scale: A 15-year retrospective. *Financial Services Review*, 24(2), pp. 177-192.

Lyons, A. C.; Palmer, L.; Jayaratne, K. S. & Scherpf, E. (2006). Are we making the grade? A national overview of financial education and program evaluation. *Journal of Consumer Affairs*, 40(2), pp. 208-235.

MacCrimmon, K. R. & Wehrung, D. A. (1986). *Risk management*. New York: The Free Press.

Mandela, N. (2014). Education is the most powerful weapon which you can use to change the world. *Computer*, 8, p. 45.

McLeod, S. (2019). *What is Kurtosis?* <https://www.simplypsychology.org/kurtosis.html>.

Nelito (2017). *AI and its impact on the finance industry*. <https://www.nelito.com/blog/ai-and-its-impact-on-the-finance-industry.html>.

Okun, M. A. & DiVesta, F. J. (1976). Cautiousness in adulthood as a function of age and instructions. *Journal of Gerontology*, 31(1), pp. 571-576.

Pallant, J. (2016). *SPSS survival manual: a step by step guide to data analysis using SPSS*. 6th ed. England: McGraw Hill.

Riley, F. K.; Brown, K. C. & Leeds, S. J. (2018). *Investment analysis & portfolio management*. 11th ed. MA: Cengage.

Riley, J. (2019). *Technological Impact on the Future of Investing*. <https://www.itbriefcase.net/technological-impact-on-the-future-of-investing>.

Rogers, E. M. (2010). *Diffusion of Innovations*. 4th ed. Simon and Schuster.

Rouse, M. (2019). *Statistical mean, median, mode and range*. <https://searchdatacenter.techtarget.com/definition/statistical-mean-median-mode-and-range>.

Rubin, P. H. & II, C. W. P. (1979). An evolutionary model of taste for risk. *Economic Inquiry*, 17(4), pp. 585-596.

Sarpong, P. (2020). Robo-Advisors: Exploring and Leveraging the Competition. *Centre for Financial Planning Studies*.

- Shapshak, T. (2018). South Africa's Newest Bank, App-Driven Bank Zero, Begins Trials. <https://www.forbes.com/sites/tobyshapshak/2018/11/09/south-africas-newest-bank-app-driven-bank-zero-begins-trials/#17ee39b36f6c>.
- Standard Bank Group (2011). *It's been 30 years of ATMs in South Africa*. <https://community.standardbank.co.za/t5/Community-blog/It-s-been-30-years-of-ATMs-in-South-Africa/ba-p/1801>.
- Statista (2020). *Robo-Advisors*. <https://www.statista.com/outlook/337/112/robo-advisors/south-africa>.
- Statistic Solutions (2020). *Conduct and Interpret a Multinomial Logistic Regression*. <https://www.statisticssolutions.com/mlr>.
- Sulaiman, E. K. (2012). An empirical analysis of financial risk tolerance and demographic features of individual investors. *Procedia Economics and Finance*, 2, pp. 109-115.
- Sunden, A. E. & Surette, B. J. (1998). Gender differences in the allocation of assets in retirement savings plans. *The American Economic Review*, 88(2), pp. 207-211.
- Sung, J. & Hanna, S. D. (1996). Factors Related to Risk Tolerance. *Financial Counseling and Planning*, 7, pp. 11-19.
- Taylor, B. (2019). *Ten Lessons for the Twenty-first Century Investor*. <http://globalfinancialdata.com/ten-lessons-for-the-twenty-first-century-investor/>.
- Taylor, C. (2018). *What Are the Maximum and Minimum?* <https://www.thoughtco.com/what-are-the-maximum-and-minimum-3126236#:~:text=We%20start%20by%20looking%20more,in%20our%20set%20of%20data.&text=T here%20cannot%20be%20two%20minima,be%20less%20than%20the%20other>.
- Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research and applications*, 5, pp. 147-158.
- Van de Venter, G.; Michayluk, D. & Davey, G. (2012). A longitudinal study of financial risk tolerance. *Journal of Economic Psychology*, 33(4), pp. 794-800.
- Van den Bergh, A. (2020). The influence of endogenous and exogenous factors on investor risk-tolerance behaviour. *Thesis-Phd*. NWU: Vanderbijlpark.
- Vroom, V. H. & Pahl, B. (1971). Relationship between age and risk taking among managers. *Journal of Applied Psychology*, 55(5), pp. 399-405.
- Wang, A. (2009). Interplay of investors' financial knowledge and risk taking. *The Journal of Behavioral Finance*, 10(4), pp. 204-213.
- Wheeler, D. W. (2020). Co-opting Artificial Intelligence as an Opportunity for Financial Service Professionals. *Journal of Financial Service Professionals*, 74(1), pp. 66-72.
- Yao, R. & Hanna, S. D. (2005). The effect of gender and marital status on financial risk tolerance. *Gender and Behaviour*, 16(1), pp. 10851 – 10862.
- Yao, R.; Gutter, M. S. & Hanna, S. D. (2005). The financial risk tolerance of Blacks, Hispanics and Whites. *Journal of Financial Counselling and Planning*, 16(1), pp. 51-62.
- Yao, R.; Hanna, S. D. & Lindamood, S. (2004). *Changes in Financial Risk Tolerance*, 2001, pp. 249-266.
- Young, D. (2015). Why technology is important for banking. *Global Finance and Banking*, 10 Jan. <https://www.globalbankingandfinance.com/why-technology-is-important-for-banking/>.

Wang, H. & Hanna, S. 1997. Does risk tolerance decrease with age? *Financial Counselling and Planning*, 8(2), pp. 27-32.

Anbar, A. & Melek, E. 2010. An empirical investigation for determining of the relation between personal financial risk tolerance and demographic characteristic. *Ege Akademik Bakış Dergisi*, 10(2), pp. 503-522.

Andrew, G., Arora, R., Bilmes, J. and Livescu, K., 2013, May. Deep canonical correlation analysis. In *International conference on machine learning, PMLR*. pp. 1247-1255.

Aliyu, A. A.; Bello, M. U.; Kasim, R. & Martin, D. 2014. Positivist and non-positivist paradigm in social science research: Conflicting paradigms or perfect partners. *J. Mgmt. & Sustainability*, 4(3), pp. 79-95.

Dickason, Z. & Ferreira, S.J. 2018. The effect of age and gender on financial risk tolerance of South African investors. *Invest. Manage. Financ. Innov*, 15(2), pp. 96-103.

Dickason, Z. & Ferreira, S.J. 2018. The effect of gender and ethnicity on financial risk tolerance in South African. *Gender and Behaviour*, 16(1), pp. 10851-10862.

Lane, D. (2013). *Sample Size*. <http://davidmlane.com/hyperstat/A104571.html>.

King, B. (2010). *Bank 2.0: How customer behaviour and technology will change the future of financial services*. Marshall Cavendish International Asia Pte Ltd.