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Article

Evaluating taxation's dual impact on business and social development: A case study of the Cape Coast metropolis in Ghana

Michael Provide Fumey[1], John Wiredu[2,*], Agnes Nyamenaose Essuman[3]

[1] School of Public Policy and Administration, Northwestern Polytechnical University, Xi'an 710072, China
[2] School of Management, Northwestern Polytechnical University, Xi'an 710072, China
[3] School of Economics and Management, Yanshan University, Qinhuangdao 066004, China
*** Corresponding author:** John Wiredu, johnwiredu50@gmail.com

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Abstract: Tax revenue is an important public asset that contributes significantly to a nation's economic development. The primary function of every government is to make provision in terms of infrastructure facilities, development, and better living conditions for its people. Due to the government's limited resources, it is necessary to impose taxes on all residents and businesses to strengthen its financial situation because it is impossible for it to carry out this large task in an effective manner. Governments have always passed numerous tax laws, and they have been amended to withstand the test of time. Therefore, this study's goal is to determine whether taxes have an impact on economic development in the Cape Coast Metropolis in Ghana. The study used the quantitative approach, survey technique, and questionnaire for the data collection process. A sample size of 115 respondents comprising the staff of the domestic tax revenue division's workforce and owners of registered SMEs were engaged in the study. The data was analyzed using SPSS version 26. The results indicated that the majority of the staff of the Ghana Revenue Authority (GRA) considered payment of tax as beneficial to the state, while few of the staff did not consider payment of tax as beneficial to the state. In addition, the study outcomes show that respondents are aware of the extent to which tax revenue can be used by the government for economic development. Furthermore, the researchers recommended that the head of GRA create a strong regulatory framework to monitor how tax money is used for economic growth. They should also make an effort to ensure that the tax revenue generated will be wisely used for the growth of the metropolis. This will make taxpayers appreciate the need to pay their taxes because they know they will benefit from it in the end in the form of social and economic developments.

Keywords: taxation; economic development; SMEs; Ghana revenue authority; SPSS analysis

1. Introduction

Tax revenue is an important public asset that can help the economy reach its full potential. Insufficient tax revenue, according to Danquah and Osei-Assibey [1], is responsible for many developing countries' declining access to public goods and services. The importance of domestic revenue mobilization is then emphasized in this declaration, resulting in the emphasis on Ghana's Beyond Aid goal. Ghana Beyond Aid is a new policy paradigm intended to increase the effectiveness and efficiency of income collection and utilization, particularly tax revenue, by focusing on the domestic sector [2]. This is due to Ghana's tax-to-GDP ratio being 15.6 percent, 11.9 percent, and 17.6 percent in 2018, 2017, and 2016, respectively [3]. These figures are lower than the ECOWAS Subregion's 19.1 percent. These low tax-to-GDP ratios in Ghana highlight the low domestic tax income collection despite the enormous

potential and significant inefficiency. Through these projects, Ghana Beyond Aid hopes to explore innovative strategies to widen our tax base and include the massive informal sector, which accounts for over 80% of employment and is the backbone of the Ghana Revenue Authority (GRA).

Accordingly, Act 2009 (Act 791) of the GRA posits that domestic taxes are mandatory levies levied on individuals and businesses inside Ghana's geographical boundaries. Property tax, corporation tax, personal tax, excise tax, value-added tax, capital gains tax, and other taxes are examples. The corporate income tax (CIT), personal income tax (PIT), and value-added tax (VAT), on the other hand, have substantial revenue elasticities, emphasizing the importance of these taxes [4,5]. CIT accounts for around 50.64 percent of Malaysians' total direct tax revenue, according to Ahmad et al. [6].

This emphasizes the importance of CIT in the economy once more. While these taxes bring in the necessary money for the country, inefficiencies in the tax system have made maximal collection impossible. Even though the country has reaped all of these earnings from the domestic economy throughout the years, data reveals that the government is always plagued by insufficient payments, which hurts the economy [7].

The tax gap is the difference between what a taxpayer owes in taxes and what they pay. Toder [8] claims that the three elements of the tax gap are underpayment, underreporting of tax owed, and failure to file tax returns. The three elements are inextricably intertwined. When a taxpayer who is expected to file a return refuses to do so or does so late, this is known as the non-filing gap. The under-reporting tax gap refers to the tax owed by a taxpayer who, whether or not they filed returns on time, did not report the full amount of the tax base they should have reported. The uncollected tax revenue from taxpayers who file tax returns but do not pay the amount they report, whether on purpose or accidentally, is also related to the underreporting tax gap.

Furthermore, tax evasion is also a big issue for Ghana's tax system [9]. Tax evasion is when a person, entity, or company knowingly fails to pay a tax liability that is owed to them. In other words, an illegal attempt to reduce the tax burden by using deceptive strategies to avoid or defy tax regulations. In Ghana, it is well known that the informal sector employs a large number of people. There is no doubt that the bulk of workers in the informal sector are self-employed and work from home; however, some work from any available public space. Thus, with a table and a chair, one might simply establish a business with the help of family. The question of how to tax the unorganized sector is still a hot topic. Given that the informal sector makes up a sizable and appreciable portion of the economies of developing nations while contributing very little to tax revenues, it is only natural that it gets attention [10]. In 2016, Ghana's Minister of Finance and Economic Planning voiced worry that broadening the tax net remains one of the country's primary issues. The sheer reality that a larger number of Ghanaians work in the informal private sector makes revenue-generating a difficult endeavor [11].

The willingness of a society to be taxed is largely determined by its perception of how the tax proceeds will be used. If government spending patterns do not significantly boost national revenue and if tax expenditures and developmental benefits are not distributed equitably across the population, it may be challenging to

increase tax efforts. As a result, tax efficacy and efficiency are matters of administration. According to Oliver [12], tax compliance can be adversely impacted when administrative flaws make evasion and avoidance easy to do. This is especially true in the Cape Coast Metropolitan Area, where evasion is rampant. The integrity of the tax-collection system and the tax functions have control over a similar issue that affects people's desire to pay taxes.

Moreso, consumer satisfaction is defined as what the customer claims it to be. A sequence of transitory emotional reactions affected by practically everything imaginable makes up satisfaction [13]. Taxpayer satisfaction is critical to successful tax mobilization and effective use of the taxpayer's money in the tax division, among other things. It is the difference between what you expect and what you get [14]. It refers to the ease with which a service can be acquired. It also refers to how the taxes are regarded as being used effectively. The economic and developmental characteristics of a location also influence citizen contentment with taxation. Because taxes are one of the most crucial components of managing national income and maintaining national development and economic freedom, the country cannot afford to lose a significant portion of its national income [15].

Motivation and contribution of the study

Studying taxation's dual impact on business and social development in Ghana and Africa is motivated by several factors. Firstly, taxation is a crucial component of managing nationwide income and promoting economic growth and development [15]. Secondly, there is a growing interest in including informal sector workers in tax nets, as taxing the informal economy can lead to greater revenue mobilization and improve government accountability and civic engagement [16]. Additionally, tax revenue is considered an alternative form of sustainable financing to promote growth and enable governments to finance social and infrastructure needs. Furthermore, taxation plays an important role in the development and growth of small and medium enterprises (SMEs), which are critical for socio-economic development in countries like Ghana [17–19]. The present investigation focuses on Ghana because the effective and efficient collection of tax money is critical to the nation's prosperity. Tax money, on the other hand, is insufficient to adequately fund government activities. The degree of economic activity in a given location determines the amount of possible tax income [20]. The Ghana Revenue Authority sets targets for its many divisions across the country each year to guarantee that they maximize revenue for the government through tax collection. The division, on the other hand, is frequently unable to reach the goals set. According to the GRA end-of-year report, the Cape Coast Metropolis had 329 companies and 639 small and medium enterprises at the end of 2015, which accounts for the most recent database about SMEs in the area. According to the research, less than 60% of those who prospered paid their taxes (GRA, end-of-year report 2016). This means that over 40% of anticipated revenue was lost. The percentage loss, however, was not given a specific cause in the study. The metropolis and the country lose revenue that would have been earned if the tax was not evaded. This unprecedented rate of loss of tax revenue because of evasion has motivated the authors of this study to assess tax as an aid to economic development in the Cape Coast metropolis, Ghana. Therefore, the essential objective of this study is to determine how

much revenue collected from taxes has been used for economic growth by the government and to examine the impact of tax rates on the rate of investment in the Cape Coast metropolis. Lastly, to evaluate the general willingness of businesses to invest as a result of a tax incentive program. Accordingly, to attain the objectives of the paper, the following research interrogations were designed: (Q1) To what extent has the government used tax money to promote economic development? (Q2) What effect does taxation have on the rate of investment in the Cape Coast metropolis? (Q3) What is the general willingness of businesses to invest as a result of tax incentives?

The contributions of this current paper are as follows: first, theoretically, the present paper enriches the classical theories on taxation (CTT) by evaluating taxation's dual impact on business and social development in the Cape Coast Metropolis. Secondly, the study advances the frontiers of knowledge by providing important data to other scholars interested in issues of the compliance burden and tax gap. The study will therefore aid academics and scholars, particularly when it comes to conceptualizing challenges, exposing gaps for future research because other aspects of the subject matter are beyond our grasp. Lastly, this research will help various members of Ghanaian society as well as the global community, such as industries, government, investors, and society. It will also give important stakeholders, particularly the GRA, useful information on the severity of tax policy. The tax gap estimates will also aid in the GRA's performance evaluation, benchmarking against other revenue streams, compliance risk management, and quantifying, comparing, and prioritizing responses to risk in the tax system.

The rest of the study is organized as follows: Section 2 of the study entails the theory that underpins the study and review of related literature. Section 3 provides a thorough explanation of the research methodology, research design, demographics, sample size, and data collection procedure. Section 4 presents the study results and discussions. Section 5 provides the conclusion, limitations, and recommendations for future studies.

2. Theoretical underpinning and literature review

2.1. Classical theories on taxation (CTT)

Since the taxpayers only pay VAT. when they have the money to buy anything, it is regarded as a convent tax. Taxpayer obligations should be guaranteed by the quantity of anticipated revenue. This is crucial for both planning and budgeting purposes for both government and private businesses. The production theory of Adam Smith is based on the idea of 'Laissez-Faire,' which states that the state should not put any restrictions on an individual's freedom. The pillars of saving, division of labour, and a broad market are the foundations of economic development theory [21]. Producers can produce as much as they want, earn as much as they can, and save as much as they want under the laissez-faire principle.

The creation of machines and equipment, a decrease in the time needed to produce goods, and increased worker dexterity are all benefits of the division of labour. The exchange of goods results from the division of labour, which promotes trade and broadens the market. A large market is an essential prerequisite for economic growth [22]. If total earnings rise above the subsistence level at any point in time, the

labour force expands, job rivalry intensifies, and wages fall below the subsistence level. According to Gashenko et al. [23], wage rates fall to subsistence levels under stationary conditions, but they rise above this level during periods of fast capital creation. Population increase determines how far they rise. As a result, raising the rate of investment could enhance the wage fund. Growth-promoting agents Farmers, producers, and business people, according to Gashenko et al. [23], are significant economic growth agents. It was free commerce, enterprise, and innovation that made this possible, and farmers, producers, and businesspeople competed to grow the market, which caused economic development to become intertwined. Construction and commerce both increased because of agricultural development. Demand for commercial services and manufactured commodities rises when there is an agricultural surplus because of economic growth [21]. This results in commercial progress and the development of industrial industries. When farmers utilize modern technology, however, their progress leads to a rise in agricultural productivity. Capital accumulation and economic development happen because of the emergence of the farmer, producer, and executive.

Due to the increased national income and output brought about by the division of labor made possible by capital accumulation and market expansion, saving and new investment are encouraged, and economic development keeps advancing. Natural resource scarcity halts the growing process. A stagnant economy lacks net investment, removes profit beyond the risky minimum, and has a fixed population, constant total revenue, and subsistence pay [21].

2.2. Nature of taxation

Because the government has particular tasks to undertake for the benefit of the people it rules, taxation is considered a burden that every citizen must incur to sustain his or her government. Farayola [24] and Shome [22] define taxation as "one of the sources of revenue for the government, such revenue being used to finance or operate public utilities and perform other social responsibilities." Also, Ochowgu [25] and Gashenko et al. [23] define tax as a levy levied by the government on individuals' or corporation's income, profit, or wealth. Taxation, according to Adams [26], the most significant source of revenue for contemporary governments, accounts for 90% or more of their income. According to Aguolu [27], taxation is the government's obligatory levy on the income and consumption of its subjects and capital through its agencies.

Moreover, personal income is taxed, including salary, company earnings, interest, dividends, discounts, and royalties. Additionally, it applies to capital gains, capital transfers, and a company's income from petroleum. Contrarily, Ojo [28] and Huang et al. [29] argue that taxes are both a notion and a science. Tax, he claims, is in and of itself a mandatory levy that must be paid by every citizen. It is often regarded as a civic obligation. The imposition of taxes is supposed to generate revenue that may be used to provide social and security benefits, as well as establish circumstances for society's economic well-being, which is in line with the CTT viewpoint. Huang et al. [29] assert that income tax is a tool of fiscal policy used by governments all over the world to influence favorably or unfavorably particular forms of economic activity to achieve desired goals. The fundamental economic objectives of emerging countries

are to boost economic growth and thus per capita income, resulting in a greater standard of living. To ensure equal resource allocation, a progressive tax rate can be used. To stimulate or discourage various industries (e.g., agriculture, manufacturing, or construction), the government can raise or lower tax rates, increase or reduce the rate of capital allowances (granted in place of depreciation), or give tax breaks to pioneer enterprises. Based on the CTT, when exploited as a creative force in economic planning and development, income tax can thus be used as a driver for social change [30].

2.3. Income tax and economic performance

Several tests were performed on the model to determine its accuracy and dependability. The researcher conducted a regression with the rate of population growth, income tax, international trade, and government consumption as the independent factors and economic performance as the dependent variable. Economic performance was measured as a ratio of gross domestic product (GDP), whereas income tax, consumption tax, foreign trade, and government consumption were all calculated as a percentage of GDP [31]. Economic performance has been found to suffer from income taxes, but this effect is only marginal. It was discovered that government consumption had a considerable positive link with economic performance. Population expansion was discovered to be beneficial [32].

Although the effect was not significant, it affected economic performance. VECM was also used to fit the regression. The Johnsen cointegration test demonstrated that the variables have a long-term association. Although there is no substantial correlation between income and GDP per capita growth rate, the variables used in the vector error correction model (VECM) seem to have a long-term relationship [33]. Although there is a negative correlation between income taxes and economic success, it is flimsy and statistically negligible. Comparable negative relationships were produced by the VECM and ordinary least squares (OLS), although they were not statistically significant. This suggests that in Cape Coast, there is no link between income tax and economic performance. Gachanja [34] examined Ghana's economic growth and taxation using time-series data from 1971 to 2010.

The study shows a positive correlation between taxation and economic growth. GDP is positively correlated with income tax, import duty, excise duty, sales tax, and VAT, with income tax having the largest effect. Economic growth and excise tax have a reverse causal link, according to Orji (2023), who also discovered a one-way relationship between income taxes and economic growth as well as a unidirectional association between economic growth and VAT. According to Orji [35], different uses of tax money have varying effects on growth. The model does not capture other factors that influence GDP, such as government expenditure and investment. Achkasov [36] examined the impact of income taxes on growth using a simple endogenous model; his study found that a 10% increase in income tax results in a 2% decrease in economic growth. Income tax has been found to have a significant impact on economic performance. In Malaysia, there is bidirectional causality between economic performance and tax revenue, indicating that both variables influence each other in achieving long-run sustainability [36]. These findings highlight the importance of tax policy in promoting sustainable economic growth and suggest that policymakers

should focus on improving the performance of the tax sector to enhance economic performance, which is supported by the CTT standpoint. Therefore, we hypothesize that income tax contributes to social and economic performance.

H1: Income tax improves economic performance.

2.4. Excise duty and economic performance

Wachuka [37] employed an empirical cause-and-effect study design to examine how excise taxes affected the revenues and alcohol and/or cigarette consumption of the Cape Coast Metropolitans as well as their consumption patterns. There was no correlation between changes in excise taxes and alcohol or cigarette use, but there was one between excise taxes and government revenue contribution. The study revealed that increasing excise taxes on cigarettes and alcohol has no effect on consumption and that other measures to reduce consumption should be sought. The demand inelasticity of cigarettes and alcohol to price changes is one of the contributing factors to no changes in consumption [37]. The study is empirical and tailored to the goals, and it aids in determining how the study will be conducted and the expected outcomes. Wiredu et al. [38] examined Ghana's excise taxing system to see how well it achieves its stated goals of discouraging and thereby reducing consumption of certain products, such as alcohol, promoting equity, and increasing government revenue. It was established that excise duties may be used to increase government revenue using a variety of empirical equations and data. The study also found that Ghana's current excise tax system (at the time) was effective in terms of producing revenue; excise taxes on cigarettes in the Cape Coast Metropolis. Results in significant additional revenues for the government, and its income elasticity is close to 1 (one); excise tax in general contributes to 4.5% of Ghana's GDP (Ghana National Commission, 2020). The study's comprehensive research design, equations, analytical techniques, and conclusions give background information on the effects of excise taxes on alcohol and cigarettes in Ghana before the imposition of those taxes in 2010.

Additionally, excise taxes on cigarettes, according to a study by Mwiti [39], are highly regressive because low-income individuals typically endure the most of the burden. As more people quit smoking, increased cigarette prices place a greater financial strain on them. Poor people pay a higher percentage of their income in taxes than affluent people do because excise taxes are typically passed on to the consumer. If they continue to smoke at the same rate while cigarette prices rise owing to excise taxes, the poor will pay larger taxes because they smoke far more than the wealthy [40]. In addition to price elasticity of demand, people respond differently to tax increases and, consequently, price increases for cigarettes; some people cut back on their use, others do not alter their behavior, and still others may completely stop smoking because of price increases for cigarettes, which is grounded on the CTT theory. The choice of excise duty on mineral oils can affect transport performance in road freight transport, and the analysis of these relationships can inform decisions on setting excise duty amounts [41]. Therefore, we hypothesize that excise duties contribute to social and economic performance.

H2: Excise duty improves economic performance.

2.5. Value-added tax (VAT) and economic performance

Wasylenko [42] asserts that the policy can affect how quickly the economy performs by affecting economic choices through taxation. Tax hikes decrease the returns on investment for R&D, physical capital, and human capital. Lower returns imply less accumulation and innovation, resulting in a slower rate of growth. This is one of the disadvantages of taxation. Taxation, on the other hand, has a positive side in that some public expenditures, such as infrastructure, public education, and health care, can boost productivity. Taxation provides the means to fund these expenditures, and it can indirectly contribute to a rise in the pace of growth. A taxable person in the Cape Coast Metropolis (VAT Act, Sec. 2) levies value-added tax on the importation of goods and services into Ghana as well as the provision of taxable products or services. Wawame [43] and Wiredu et al. [38] looked into the factors that influence VAT income and discovered that growth elasticities for VAT are substantial. The outcomes of the study revealed that VAT revenues respond to changes in their determinants with considerable lags and that VAT revenues are sensitive to unexpected conditions. This study found that the VAT revenue of Cape Coast's Revenue Authority is quite responsive to changes in its determinants, particularly international ones.

Researchers used average GDP to account for the fact that taxes are collected over a fiscal year (July to June) rather than a calendar year, as is the case with GDP data. Mbiti [44] investigated the factors influencing VAT productivity on Cape Coast. The parameters affecting VAT productivity were acquired through surveys of both taxpayers and the tax administration. Productivity was evaluated using an autoregressive model. VAT was found to be responsive to changes in GDP, which contradicts earlier Cape Coast studies. Up until the financial year 2022/2023, the research revealed that VAT was resistant to fluctuations in GDP. The last seven years, from 2016/06 to 2023/012, were the ones that saw a shift in responsiveness. The survey also discovered that taxpayers faced high compliance expenses and that, due to computational challenges and a lack of audits, the medium and small taxpayers were overlooked [33]. In light of the foregoing, GRA Cape Coast should adjust its attention away from revenue collection and toward developing systems that are more taxpayer-friendly to improve compliance with VAT legislation.

H3: VAT improves economic performance.

2.6. Custom duty and economic performance in Ghana

Egbunike et al. [16] researched to examine the impact of customs duties on Ghana's economic performance. Correlation research was used in this study. His research was limited to the performance of SMEs in Cape Coast; hence, a sample size of over 40 registered SMEs was chosen. Primary data were gathered through questionnaires. The registered businesses provided secondary information on ROA, employment quantity and value, and firm length of stay. For data analysis, the study used both descriptive and inferential statistics. At a 5% level of significance, the study discovered a significant correlation between custom duty incentives and SME company performance as measured by Return on Assets (ROA).

In addition, Opoku's [45] study revealed that custom duty incentives have a significant link with the performance of SME enterprises measured using the total

number of workers in Cape Coast at a 5% significance level. The findings also demonstrated that, at a 5% level of significance, custom duty incentives had a positive and significant association with SME business performance as evaluated by the number of years in operation. The study's findings suggest that the government should increase excise duty incentives to decrease imports and, as a result, encourage an increase in domestic product demand. The government to prevent smuggling and encourage the expansion of the tourism sector may use this strategy. The research also recommends that decision-makers create strategic incentive programs, such as targeted incentive programs that focus on particular industries or strategic tax incentives that advance economic growth and are in line with the nation's 2030 goal [46].

According to Owino [47], the economic crisis brought on by the global oil shock in the early 1970s prompted the Ghanaian government to change its tax strategy to rely more on indirect taxes. As a result, customs and excise tax collection grew progressively between 1973 and 2010. However, this was accompanied by a consistent decline in economic growth. This scale of increases in customs and excise tax revenue raises crucial questions about how they may affect economic expansion. As a result, Owino [47] investigated how customs fees affected economic growth on the Cape Coast between 1973 and 2010.

H4: Custom duty improves economic performance.

Figure 1 below represents the conceptual framework for the study.

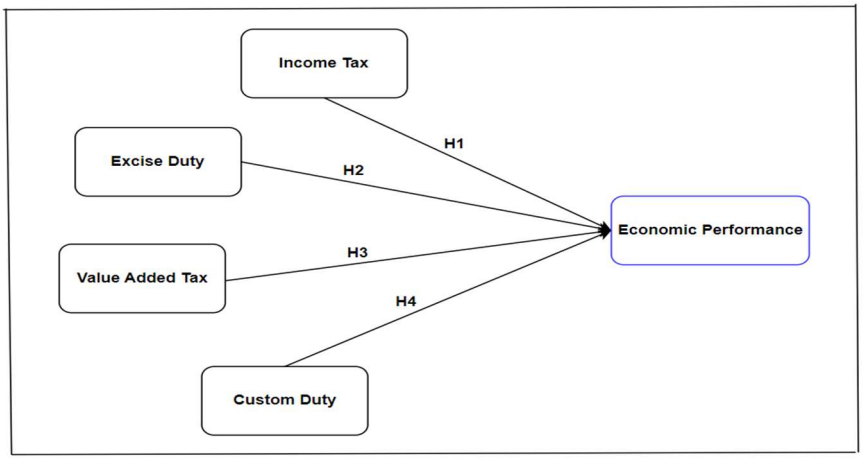

Figure 1. Conceptual framework.

3. Research methodology

3.1. Research approach

The study employs a quantitative research methodology. One of the numerous benefits of a quantitative research approach is its capacity to increase research pace. Furthermore, by combining statistics from a larger sample, it provides a wider coverage of a sequence of events [48,49]. Additionally, a quantitative approach improves the application of statistical data analysis techniques, which facilitates the generalization of the study's conclusions. Quantitative methods also bring the conjecture to a clearer conclusion [50]. This is so that the results can be applied in the

future and compared to other efforts since they are frequently based on quantitative measurements rather than merely interpretation. The ability to perform research more quickly is a key benefit of quantitative research. According to this perspective, a quantitative method "demands that you explain how variables numerically affect one another and to compare different results," according to Creswell and Poth [51]. In a quantitative approach, numbers represent data that has been gathered for research or investigation.

Additionally, the quantitative approach offers the chance to apply statistical analytic techniques to aid in generalizing the study's conclusions. Researchers can conclude with a degree of confidence when making specific remarks, which is another benefit. The quantitative approach is based on numerical values and uses questionnaires and checklists as data collection tools.

3.2. Population and study area

The population can be seen as the whole accumulation of cases that meet an outlined arrangement of criteria. It must be noticed that whatever the fundamental unit, the populace dependably involves the whole accumulation of components in which the study is keen on picking up data and reaching inferences. It can likewise be seen as the objective gathering about which the study will be occupied with picking up data and making determinations [52,53].

The populace of the study was all staff of the Domestic Tax Revenue Division (DTRD) of the Ghana Revenue Authority and owners of registered SMEs. The employees of the DTRD were thought to be one of the significant groups that can add to the accomplishment of the Ghana Revenue Authority's assessment of taxation.

Cape Coast Metropolis is the area being researched. Specifically, the Cape Coast North Sub-Metropolitan Assembly and the Cape Coast South Sub-Metropolitan Assembly are the two (2) sub-metros that make up the Metropolis, which was divided into them in 2012. The study location was picked because of its convenience.

3.3. Sample and sampling procedure

Not all of the respondents can be included in the survey because it covers such a wide area. Therefore, selecting a sample from the population is important. The sample size for the study was 115. These sample sizes were determined based on the recommendation of Krejcie and Morgan [54] to choose the sample for the study; both probability and non-probability methods were used. The Domestic Tax Revenue Division's workforce was chosen using the purposive sampling approach, which is a non-probability method. Because it is thought to be the best method for obtaining respondents who are knowledgeable and up-to-date on the subject matter of interest, the purposive sampling method is employed [50,55]. The probability method was used to select respondents from the owners of SMEs for the studies.

3.4. Instrument for data collection

Questionnaires are to be answered by the staff of the Domestic Tax Revenue Division of the Ghana Revenue Authority and owners of the small-scale enterprise. The questionnaire or poll was regarded as proper for the study since it gives a much

speedier method for gathering data from a genuinely extensive populace. Again, it is efficient and simple to build, and inquiries are predictable and uniform. Poll likewise permits the secrecy of the respondents, making it simpler for the respondents to volunteer data without trepidation of exploitation [56]. However, according to White [57], the survey is limited to a skilled population and does not provide an opportunity to obtain further data. Fortunately for this project, every respondent was capable of reading, writing, and understanding the materials used in creating the instrument.

Accordingly, five sections made up the survey (from A-E). Data on the respondents' background characteristics were gathered using Section A. Age, gender, and the highest degree of education are all factors that were considered. Sections B, C, D, and E elicited data on staff and owners' views on the extent to which the government has been using revenue generated from tax for economic development and assessed how tax rates affect the rate of investment within the Cape Coast metropolis, assessed the general desirability of firms to invest as a result of tax incentive measures, and found out the factors that militate against the effective mobilization of tax revenue for economic development in the Cape Coast metropolis. The researchers used six weeks to gather the data from respondents from December 2023 to January 2024. The study's poll also suggested that closed-ended questions, rather than open-ended ones, be used to prepare questionnaires because closed-ended questions are easier to evaluate. Statistics may be performed because each response can be given a number or numerical value. A 5-point Likert scale was used for the study's measuring parameters (1 strongly disagree, 2 disagree, 3 neutral, 4 agree, and 5 strongly agree). Closed-ended questions are used because they make computer analysis simpler. The qualitative information is converted to code when open-ended questions are quantitatively analyzed, and the responses lose some of their original significance. This kind of loss is frequent since closed-ended questions are so straightforward.

Closed-ended inquiries can be more specific, resulting in a greater likelihood of communicating similar meanings. It is difficult to compare the meanings of open-ended responses since they allow respondents to use their language.

3.5. Data analysis

The study used a quantitative approach to analysis, which allowed statistical software such as Statistical Product and Service Solutions (SPSS) Version 26 to be used. Before entering the data into the computer, the researchers analyzed the completed surveys to make sure they were free of any extraneous responses. Descriptive and inferential statistics were used to analyze the data. The close-ended questionnaire items were examined with the understanding that they would serve as the foundation for drawing conclusions and making recommendations. The distribution was typical, and the respondents were all of the same personality. On this basis, descriptive statistics such as frequency and percentage distribution were used to assess data on the respondents' background characteristics. To examine the data on the study's specific objectives, inferential statistics such as the standard deviation, percentage, and tables were employed.

4. Results and discussions

The study's primary goal is to evaluate the contribution of taxes to Cape Coast metropolis's economic growth and to make recommendations for ways to accelerate that growth. The information regarding the respondents' backgrounds and the study's goals was analyzed using statistical tools like frequency and percentage. The study's findings, which were derived from information gathered from self-administered questionnaires, are presented in this chapter. The interpretation of the finding in light of earlier discoveries is covered in the discussion.

4.1. Background characteristics of the respondents

The distribution of respondents by sex, age, and educational attainment is the main topic of the first section of this study. Data on the respondent's background characteristics were gathered via a variety of items through stratified sampling techniques. The results are depicted as follows:

The gender distribution of respondents' GRA employees in the Cape Coast metropolitan is shown in **Table 1**. According to the analysis's findings, there were 53.6% women on staff compared to 46.4% men.

Table 1. Distribution of respondents' age and gender.

Age of respondents				**Gender of Respondents**				
		Freq	**%**		**GRA**		**Taxpayers**	
GRA	Male	13	46.4		**Freq**	**%**	**Freq**	**%**
	Female	15	53.6	20–25	6	21.4	75	65.2
	Total	28	100	26–30	9	32.1	16	13.9
Taxpayers	Male	58	50.4	31–40	12	42.9	13	11.3
	Female	57	49.6	41 and above	1	3.6	11	9.6
	Total	115	100	Total	28	100	115	100

Source: Fieldwork, 2023.

The statistics on the gender distribution of taxpayers in Cape Coast City are shown in **Table 1** above. The analysis's findings indicate that 50.4% of the staff were male and 49.6% were female.

The findings on the age distribution of taxpayers in the Cape Coast metropolis are shown in **Table 1** above. According to the analysis's findings, 65.2% of taxpayers are between the ages of 20 and 25; 13.9% are between the ages of 26 and 30; 11.3% are between the ages of 31 and 40; and 9.6% are above the age of 41.

Education is the factor that Richardson and Sawyer [58] and Abaitey et al. [59] believe is most likely to increase people's tax compliance. As people advance academically, they become more aware of a variety of social and economic issues, including the importance of paying state taxes on time. The distribution of respondents' greatest educational levels is seen in **Table 2**.

Table 2. Distribution of respondents' level of education.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Basic	0	0	Basic	47	40.9
Secondary	2	7.1	Secondary	30	26.1
Tertiary	26	92.9	Tertiary	38	33.0
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

All of the respondents from GRA who were included in the study are shown to have some form of schooling in **Table 2** above. The majority (92.9%) had at least a bachelor's degree, 7.1 percent had a secondary education, and 0 percent had only a basic education.

Furthermore, according to **Table 2** above, all of the taxpayers who were included in the study had some form of schooling. The majority (40.9%) had completed their basic education, followed by 26.1% for secondary education and 33% for university education.

As can be seen in **Table 3**, the majority of respondents (89.3%) thought that paying taxes was advantageous for the state, while 10.7% disagreed. Respondents were asked to indicate whether they agreed or disagreed with the first study question, which inquired whether taxes had contributed to the growth of the Cape Coast city. **Table 3** presents the findings.

Table 3. Respondents' view on whether they consider the payment of tax is beneficial to the state.

GRA	Frequency	Percentages
Yes	25	89.3
No	3	10.7
Total	28	100

Source: Fieldwork, 2023

As shown in **Table 4** below, the majority of GRA employees (71.4%) strongly disagree with the claim that the usage of taxes has aided in the economic growth of the Cape Coast city, whereas 46.1% of taxpayers share this opinion. This indicates that while taxpayers agree, those who oppose the use of taxes to develop Cape Coast and the country as a whole disagree.

Table 4. Respondents view on whether taxpayers agreed that taxes were one of the main sources of funding for economic growth.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Strongly agree	3	10.7	Strongly agree	26	22.6
Agree	3	10.7	Agree	53	46.1
Strongly disagree	20	71.4	Strongly disagree	22	19.1
Disagree	2	7.1	Disagree	14	12.2
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

We questioned taxpayers if they agreed that taxes were one of the main sources of funding for economic growth. **Table 5** provides the findings. According to **Table 5**, the majority of taxpayers (50.4%) concur that taxes are one of the main methods for raising money for economic growth. While 26.1 percent of respondents strongly agreed that taxes are one of the key instruments for promoting economic growth.

Table 5. Respondents' view on whether they agreed that taxes were one of the major tools for revenue generation for economic development.

Taxpayers	Frequency	Percentages
Strongly agree	30	26.1
Agree	58	50.4
Strongly disagree	18	15.7
Disagree	9	7.8
Total	115	100

Source: Fieldwork, 2023.

In addition, the survey gathered information from respondents about how much they believed taxes have affected the growth of the Cape Coast metropolis's economy. The findings are shown in **Table 6** below.

Table 6. Respondents view on the extent taxation made an impact on the economic development.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Very significantly	2	7.1	Very significantly	32	27.8
Significantly	5	17.9	Significantly	57	49.6
Not significantly	21	75.0	Not significantly	26	22.6
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

According to **Table 6**, the majority of GRA employees (75%) believe that taxes have had little to no influence on economic growth. Regarding taxpayers, the majority (49.6%) believe that taxes have had a considerable impact, and 27.9% believe that taxes have had a very big impact on economic growth. These findings demonstrate that taxpayers' and GRA's perspectives on the importance of taxation differ. According to the GRA findings, the government must find additional sources of funding in order to grow the economy.

From **Table 7**, taxpayers were asked of their view on whether taxes collected are accounted for or not. The results of their response are presented in **Table 7**.

Table 7. Respondents view on what account for their response.

Taxpayers	Frequency	Percentages
Tax money is judiciously used	48	41.7
Tax money is not judiciously used	21	18.3
Poor accountability	37	32.2
Presence of corrupt officials	9	7.8
Total	115	100

Source: Fieldwork, 2023.

According to **Table 8**, the majority of GRA respondents (57.1%) indicated taxes are the second biggest source of income, while 32.1% said taxes are the biggest source of income. Additionally, 10.7% of respondents indicated taxes are the government's third major source of income. Most taxpayers (57.4%) feel taxes are the government's most important source of income, followed by 21.7 percent and 20.9 percent, respectively, who place taxes as the government's second and third sources of income.

Table 8. Respondents view on how they would compare tax revenue with revenue from other sources.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
First source of revenue	9	32.1	First source of revenue	66	57.4
Second source of revenue	16	57.1	Second source of revenue	25	21.7
Third source of revenue	3	10.7	Third source of revenue	24	20.9
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

4.2. Regarding the effect of tax rates on the rate of investment

How tax rates affect the rate of investment in the Cape Coast city was the third study topic. To collect information on the issues, several closed-ended items were used. The rate of investment in the city of Cape Coast was inquired of the respondents. **Table 9** presents the findings. According to **Table 9**, the majority (89.3%) of respondents from GRA believed that the rate of investment was very low, whilst 7.1% thought it was high and another 3.61% thought it was extremely high. On the other hand, the table reveals that a higher percentage (40.9%) of taxpayers believe that the rate of investment is high, compared to 26.1 percent who believe that it is very low and 15.7 percent who believe that it is very high.

Table 9. Respondents' view on the rate of investment in the Cape Coast metropolis.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Very high	1	3.6	Very high	18	15.7
High	2	7.1	High	47	40.9
Very low	25	89.3	Very low	30	26
Low	0	0	Low	20	17.4
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

According to the data, the majority of the GRA personnel do not agree with what the taxpayers are saying. This indicates that, while taxpayers and some GRA personnel both believe that the rate of investment is high, the majority of GRA staff does not.

Further, taxpayers were asked whether an increasing tax rate correlate with the rate of investment. The results are presented in **Table 10**.

Table 10. Respondent on whether an increasing tax rate correlate with the rate of investment.

Taxpayers	Frequency	Percentages
Yes	59	51.3
No	56	48.7
Total	115	100

Source: Fieldwork, 2023.

According to **Table 10** above, 51.3% of taxpayers believe that rising tax rates and investment rates are correlated. Additionally, 48.7% of respondents said that tax rates and investment rates are unrelated to one another. This demonstrates that **Tables 9** and **10** above have a good relationship.

In the survey, participants were also asked to express how they felt about paying taxes. **Table 11** provides the findings.

Table 11. Respondents view on how they react to payment of tax.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Positively	1	3.6	Positively	39	33.9
Moderately	3	7.1	Moderately	33	28.7
Reluctantly	17	89.3	Reluctantly	21	18.3
Negatively	7	25.0	Negatively	22	19.1
Total	28	100	Total	115	100

According to **Table 11** above, the majority (89.3%) of respondents from GRA responded grudgingly, 25% responded adversely, 7.1% responded mildly, and 3.6% responded favorably. From the standpoint of the taxpayer, the majority (33.9%) responded favorably, followed by a moderate (287%), unfavorable (19.1%), and reluctant (18.3%) response rate. It is clear from the table that respondents view paying taxes favorably. While 19.1% of the respondents admitted to engaging in tax avoidance and evasion. Surprisingly, 25% of the GRA workforce also engages in tax evasion and avoidance.

Moreso, the survey also collected information from respondents on their opinions on the impact of tax rates on investment rates. **Table 12** presents the findings. In accordance with **Table 12**, the majority of GRA employees (53.6%) believe that tax rates have little bearing on the rate of investment, while 46.4 percent of respondents concur. Additionally, 55.7 percent of taxpayers agree that tax rates have an impact on the rate of investment, compared to 44.3 percent who disagree.

Table 12. Respondents view on whether tax rates affect the rate if investment.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Yes	13	46.4	Yes	64	55.7
No	15	53.6	No	51	44.3
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

Lastly, taxpayers were asked to share their view on what extent tax rate affect investment decision. The results are presented in **Table 13**.

Table 13. Respondents' view on the extent tax rate affects investment decision.

Taxpayers	Frequency	Percentages
Very significantly	34	29.6
Significantly	54	47.0
Not significantly	27	23.5
Total	115	100

Source: Fieldwork, 2023

From the **Table 13** above, the majority of respondents (47%) believed that tax rates had a considerable impact on their decision to invest, while 29.6% said that tax rates had a very large impact.

4.3. Assess the general desirability of firms to invest because of tax incentive measures

For developing nations like Ghana, exports, foreign direct investment, and aid are the key sources of foreign currency. The world's major product demand is declining, the terms of trade are deteriorating, and aid comes with conditions that include interest and capital repayment. These factors negatively affect exports. The primary source of foreign cash is now left to be foreign investment. The Ghanaian government has taken initiatives to increase Ghana's appeal as a place for investment by providing tax breaks and incentives in order to draw in foreign direct investment (FDI) inflows.

What is the general desirability of enterprises to invest because of tax incentive measures was the fourth research question. To collect information on the issues, several closed-ended questions were employed. Respondents were asked to select the preferred taxation scheme. **Table 14** presents the findings.

Table 14. Respondents view on which system of tax is more acceptable.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Progressive	16	57.1	Progressive	55	47.8
Regressive	6	21.4	Regressive	33	28.7
Proportional	6	21.4	Proportional	27	23.5
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

From **Table 14** above, the majority of respondents from the GRA (57.1%) favor progressive taxes, whereas 21.4% prefer both regressive and proportional tax systems. 47.8% of taxpayers favor progressive taxes, 28.7% want regressive taxes, and 23.5% favor a proportional tax system.

From the information above, it is clear that the majority of tax authorities (57.1%) and taxpayers (47.8%) favor a progressive tax system in which the tax rate rises as the amount subject to taxation rises.

Respondents were also asked in the study if they agreed that tax incentive programs from the government encourage businesses to invest. **Table 15** presents the findings.

Table 15. Respondents view on whether they agree that, government tax incentive measures encourage firms to invest.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Strongly agree	0	0	Strongly agree	25	21.7
Agree	6	21.4	Agree	59	51.3
Strongly disagree	20	71.4	Strongly disagree	15	13.0
Disagree	2	7.2	Disagree	16	13.9
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

According to **Table 15** above, the majority of GRA respondents (20%) strongly disagree that tax incentive programs help businesses to invest, while 21.4 percent do. Regarding taxpayers, the majority (51.3%) agreed that tax incentives encourage businesses to invest. Additionally, 21.7 percent strongly agree that tax incentives encourage businesses to invest, while 13.9 percent disagree and 13 percent strongly disagree.

Furthermore, respondents were asked to rate Ghana's tax structure. The findings are shown in **Table 16** below. **Table 16** shows that the majority of GRA respondents (53.6%) rated the Ghanaian tax system as average, while those who said it was below average received scores of 42.9 percent, and those who thought it was above average received ones of 3.6 percent. The majority (50.4%) of taxpayers believed the system was average, followed by 26.1 and 23.5 percent who said it was below and above average respectively.

Table 16. Respondents' assessment of the Ghana tax system.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Above average	1	3.6	Above average	27	23.5
Average	15	53.6	Average	58	50.4
Below average	12	42.9	Below average	30	26.1
Total	28	100	Total	115	100

In addition, according to **Table 16** above, the Ghanaian tax system is average and, for that reason, requires improvement, according to the tax authorities (53.6%) and taxpayers (50.4%), respectively.

Accordingly, respondents from the taxpayer group were questioned in the survey if they approved of the current tax incentive scheme. **Table 17** below presents the findings.

Table 17. Respondents' view on whether they liked the tax incentive measure in place.

Taxpayers	Frequency	Percentages
Yes	60	52.2
No	55	47.8
Total	115	100

Source: Fieldwork, 2023.

From **Table 17**, the majority of respondents (52.2%) approve of the current tax incentive provision, while 47.8 percent disagree.

Lastly, the study asked respondents whether tax incentive measures were commensurate with the level of input. The results are presented in **Table 18**.

Table 18. Respondents view on whether the tax incentive measure commensurate with the level of input.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Yes	6	21.4	Yes	60	52.2
No	22	78.6	No	55	47.8
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

According to the common consensus, incentives do not correspond to the level of contribution when they are present. Grounded on the results from **Table 18** above, the majority of GRA (78.6%) thinks that incentives do not correspond to the level of input, while just 21.4% think that incentives do. According to taxpayer responses, the majority (52.2%) thinks that rewards are proportionate to the degree of input, while 47.8% think that incentives are not proportionate to the level of input.

4.4. On the issue of the factors that militate against effective mobilization of tax revenue for economic development

Finding out the reasons that prevent the successful mobilization of tax money for economic development was the fifth study question. To collect information on the issues, numerous closed-end questions were used. The GRA staff was questioned about the number of employees needed to complete the revenue mobilization task. **Table 19** presents the findings.

Table 19. Respondents view on whether there are enough workers to carry out the revenue mobilization assignment.

GRA	Frequency	Percentages
Yes	6	21.4
No	22	78.6
Total	28	100

Source: Fieldwork, 2023.

The majority of respondents (78.6%) clearly state in **Table 19** that there are not enough personnel to complete the job, but 21.4% disagree.

In addition, the taxpayers were questioned about the city of Cape Coast's availability of profitable businesses. **Table 20** below presents the findings.

Table 20 shows that the majority (52.2%) of respondents said Cape Coast has enough viable businesses, whereas 47.8% believed the municipality does not have enough viable businesses.

Table 20. Respondents view on whether there are enough viable ventures in the Cape Coast metropolis.

Taxpayers	Frequency	Percentages
Yes	60	52.2
No	55	47.8
Total	115	100

Source: Fieldwork, 2023.

Again, **Table 21** below shows that the majority of respondents (60.7%) believed they lacked motivation, while 39.3 percent believed they had moderate motivation. When an endeavor can meet some personal wants, it might motivate people to put forth a high degree of effort in support of organizational goals.

Table 21. Respondents view on whether the tax collectors are will motivated to perform their duties.

GRA	Frequency	Percentages
Very motivated	0	0
Fairly motivated	11	39.3
Not motivated	17	60.7
Total	28	100

Source: Fieldwork, 2023.

The question of whether taxpayers purposefully understate their income in order to have a lower tax bill was put to the taxpayers. **Table 21** below displays the outcome.

In accordance with **Table 22** below, the majority of respondents (61.7%) from around the world actively understate their income to reduce their tax obligations, as opposed to 38.3 percent who disagree. Because of these findings, the government must implement policies to stop businesses from understating their earnings. This will assist in increasing tax revenue for the government, which will help the economy grow.

Table 22. Respondents view on whether they intentionally understate their revenue to attract less tax liability.

Taxpayers	Frequency	Percentages
Yes	71	61.7
No	44	38.3
Total	115	100

Source: Fieldwork, 2023

The study asked GRA on their view in relation to the fifth research question, whether tax collectors have the adequate logistics to work diligently. The results are presented in **Table 23** below.

Table 23. Respondents view on question whether tax collectors have the adequate logistics diligently.

GRA	Frequency	Percentages
Very resourced	0	0
Fairly resourced	5	17.9
Poorly resourced	23	82.1
Total	28	100

Source: Fieldwork, 2023.

Moreover, the result from **Table 24** below depicts that the majority of respondents (36.5%) strongly agreed that the Cape Coast metropolis had a high unemployment rate, whereas 34.8% agreed with the question.

Table 24. Respondents view on whether they agreed that there was a high rate of unemployment in the Cape Coast metropolis.

Taxpayers	Frequency	Percentages
Strongly agree	42	36.5
Agree	40	34.8
Strongly disagree	21	18.3
Disagree	12	10.4
Total	115	100

Source: Fieldwork, 2023.

Accordingly, taxpayers and GRA staff were asked to comment on whether persons working in the informal sector were paying the proper taxes. **Table 25** provides the findings.

Table 25. Respondents view on whether those in the informal sector were paying appropriate taxes.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Yes	6	21.4	Yes	55	47.8
No	22	78.6	No	60	52.2
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

According to **Table 25**, the majority (78.6%) of GRA respondents believed that individuals working in the informal sector were not paying the proper taxes, while only 21.4% disagreed. Regarding taxpayers, the majority (52.2%) concur with the GRA staff that individuals working in the informal sector do not pay the proper taxes, while 47.8% claimed they do.

In relation to the fifth research question, respondents were asked whether they viewed the current system of tax collection efficient. The results are presented in **Table 26**.

Table 26. Respondents view on whether they viewed the current system of tax collection as efficient.

GRA	Frequency	Percentages	Taxpayers	Frequency	Percentages
Very efficient	1	3.6	Very efficient	27	23.5
Efficient	3	10.7	Efficient	36	31.3
Not efficient	15	53.6	Not efficient	29	25.2
Poor	9	32.1	Poor	23	20.0
Total	28	100	Total	115	100

Source: Fieldwork, 2023.

Only 10.7% of tax collectors said that the existing tax system is effective, and only 3.6 percent agreed that it is extremely effective. However, the majority (53.6%) thought the system was ineffective, and 32.1 percent said it was terrible. According to the majority of taxpayers (31.3%), it was efficient, followed by highly efficient (23.5%), inefficient (25.2%), and poor (20%). Although this claim that the tax system was efficient in the eyes of taxpayers was made, the GRA personnel did not share this opinion. The tax collectors argue that more could be accomplished if more labor and logistics were made available to them, even if they were doing their best under the conditions.

From **Table 27**, the majority of respondents (82.1%) believed that combining the tax institutions under GRA would assure efficiency in revenue mobilization, while only a small proportion (17.9%) disagreed. This finding offers a significant recommendation to the government that all taxing authorities cooperate in order to increase the nation's revenue.

Table 27. Respondents view on whether they thought the amalgamation of the various tax institutions would increase efficiency in the tax collection assignment.

GRA	Frequency	Percentages
Yes	23	82.1
No	5	17.9
Total	28	100

Source: Fieldwork, 2023.

5. Key findings and conclusion

The descriptive survey design was used for the present investigation. Data from a field survey of GRA employees and registered SME owners in the Cape Coast metropolitan were gathered and analyzed in order to meet the specified objectives. Questionnaires were employed as the study tool for data collection. To guarantee a balanced and inclusive sample, the study used the probability and non-probability approaches. The 115 registered proprietors of SMEs in the Cape Coast metropolis's and GRA employees were chosen using these sample procedures. To address the

specific research objectives, the data was analyzed using statistical methods like frequencies and percentages. Our study results revealed the following:

First, to determine how much tax revenue the government has been using for economic growth. The following were the main discoveries: the majority (89.3%) of the staff of GRA considered payment of tax as beneficial to the state, while 10.7 percent did not consider payment of tax as beneficial to the state. In addition, the majority (71.4%) of staff of the GRA and 7.1% of the taxpayers disagreed that the use of taxes has assisted in the economic development of the Cape Coast metropolis. Again, the majority (50.4%) of the taxpayers agreed that taxes are one of the major tools for revenue generation for economic development [19]. While 26.1 percent strongly agreed that taxes are one of the major tools for economic development. The majority (75.0%) of staff from the GRA are of the view that taxation has no significant impact on economic development, while 17.9 percent are of the view that taxation has impacted significantly on economic development. With regards to taxpayers, most (49.6%) of them are of the view that taxation has impacted significantly, while 27.8 percent are also of the view that taxation has impacted very significantly on economic development. Lastly, the majority (41.7%) of respondents believe that tax revenue has made a significant impact on economic development [16,41], while 32.2 percent said the reason why it has not had a had a significant impact on economic development is because of poor accountability, 18.3 percent believe that tax revenue has no significant impact on economic development, and 7.8 percent traced it to the presence of corrupt officials.

Second, to determine how tax rates affected the rate of investment in the Cape Coast metropolis. It was revealed that more (89.3%) of the respondents from GRA said the rate of investment was very low, 7.1 percent said they were high, 3.6 percent said they were very high, and none believed it was low. On the other hand, the table shows that more (40.9%) of taxpayers said the rate of investment was high, while 26.1 percent said the rate of investment was very low. Moreso, most (51.3%) of the taxpayers are of the view that an increasing tax rate correlates with the rate of investment [17]. In addition, 48.7 percent of the respondents were of the view that tax rates do not correlate with the rate of investment. More (89.3%) of the respondents from GRA answered reluctantly, 25 percent answered negatively, 7.1 percent answered moderately, and 3.6 percent of the staff of GRA reacted positively to the payment of tax. From the taxpayer's perspective, most (33.9%) answered positively, 28.7 percent answered moderately, 19.1 percent were negative about paying their taxes, and 18.3 percent answered reluctantly to the question. Lastly, the majority (53.6%) of the staff of GRA are of the view that tax rates do not affect the rate of investment, while 44.3 percent of the taxpayers also agreed with the staff of GRA. 46.4 percent and 55.7 percent of both staff of GRA and taxpayers do think tax rates affect the rate of investment [36].

Third, to determine if it was generally desirable for businesses to invest because of tax incentive programs. The results showed that the majority (57.1%) of the respondents from the GRA prefer a progressive tax, 21.4 percent prefer a regressive tax, and 21.4 percent prefer a proportional tax system. Concerning taxpayers, 47.8 percent prefer progressive tax, 28.7 percent prefer regressive tax, and 23.5 percent prefer the proportional tax system. The majority (71.4%) of the respondents from GRA

disagreed that the tax incentive measures in place encourage them to invest, while 21.4 percent agreed. About taxpayers, the majority (51.3%) also agreed that tax incentive measures in place encourage them to invest, while 21.7 percent strongly agreed and 13% and 13.9% strongly disagreed and disagreed that tax incentive measures encourage them to invest. Furthermore, the majority (53.6%) of the staff of GRA said it is average [41], while those who said the system is below average scored 42.9 percent and those who said it is above average scored 3.6 percent. For taxpayers, the majority (50.4%) said the system was average, 26.1 percent said it was below average, and 23.5 percent said it was above average. Finally, the majority (78.6%) of respondents from GRA believe that the incentives are not commensurate with the level of input, and 21.4 percent from GRA believe that the incentives are commensurate with the level of input.

Lastly, to assess the barriers to the efficient mobilization of tax income for economic development in the Cape Coast metropolis. The majority (78.6%) of the staff of GRA said there are not enough workers to carry out the assignment, while the other 21.4 percent contradict this opinion. Accordingly, the majority (52.2%) of the taxpayers were of the view that there are enough viable ventures in the Cape Coast metropolis, while 47.8 percent said there are not. In addition, the majority (60.7%) of the respondents opined that they were not motivated, with 39.3 percent saying they were motivated. The majority (61.7%) of taxpayers do intentionally understate their revenue to attract less tax liability, while 38.3 percent were of the view that they do not intentionally understate their revenue to attract less tax liability, which aligns with the findings of Ewa et al. [20]. Finally, most (78.6%) of the respondents from GRA were of the view that those in the informal sector are not paying appropriate taxes, while 21.4 percent said those in the informal sector do pay the appropriate taxes. About taxpayers, most (52.2%) agreed with the staff of GRA that those in the informal sector are not paying the appropriate taxes, while 47.8 percent said they do pay the appropriate taxes.

5.1. Recommendations

The present paper offers the following suggestions to evaluate taxation as a support for economic growth in the Ghanaian economy:

It is advised that the head of GRA create a strong regulatory framework to monitor how tax money is used for economic growth. It should also make an effort to ensure that the tax revenue generated will be wisely used for the growth of the metropolis. This will make tax payers appreciate the need to pay their taxes because they know they will benefit from it at the end in the form of economic developments.

Because increasing investment requires lower tax rates, GRA must lower its tax rates. By lowering the tax rates, the city will appear prosperous enough to attract investors from both inside and outside to launch new businesses. This will significantly increase the likelihood of a rapid rate of development.

According to the research's findings, it is best to implement, manage, and effectively regulate the progressive tax system before other types of systems for the metropolis to have a greater rate of investment. The respondents' highly preferred approach, if put into practice, will best suit their way of living.

Considering the nature of the work, the staff members responsible for tax collection should also be very motivated. This can be accomplished by offering incentives to boost staff morale and encourage the completion of quality work. It is possible to provide transportation to aid in their mobilization effort. The GRA ought to have a framework in place to deal with the problem of unreliable tax payments from the informal sector. By requiring all taxpayers to register, background checks on them can be carried out efficiently. There could be an electronic registration to help the staff easily retrieve background information when needed.

5.2. Limitations and future research directions

Increasing the aspects of tax policies is essential to the survival and sustainability of SMEs in developing economies. This research study offers valuable insights, but numerous inadequacies need further investigation. First, the research was conducted in Ghana, but it only included one major region of the country; small cities were left out. Second, an executive's opinions about tax reforms and economic advancements procedures and results are constrained by certain industry norms. Hence, we invite academics to replicate our study but from other perspectives and countries to focus on the results' wider generalizability. More facets of stakeholders' viewpoints must be included in future research projects via the lens of market and management innovation. The relationship between tax reforms or policies and societal views may also be influenced by governmental policies or educational policies. Lastly, further investigation into the impacts of moderation of government educational policy is needed.

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Article

Estimating parameters of the CAPM under generalised asymmetric student-*t* distribution—The case of the Warsaw Stock Exchange sectoral indices

Mateusz Pipień

Cracow University of Economics, 31-510 Kraków, Poland; Pipienm@Uek.Krakow.Pl

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Abstract: This paper analyses selected sub-indices listed on the Warsaw Stock Exchange (WSE) covering seven sectors: construction, IT, media, real estate, fuel, food, and telecommunications, from 3 January 2006 to 29 May 2020. We use daily, weekly, monthly, and quarterly data, resulting in 3600 daily, 751 weekly, 172 monthly, and 56 quarterly observations. The WIG index quotations were used to approximate the market portfolio and the Poland 10Y government bond yields for the risk-free rate. We have estimated the parameter β in CAPM regression using three different stochastic assumptions for the error term. The basic stochastic framework of the model utilises the generalised asymmetric student-*t* distribution (GAST). We have also estimated the parameter β based on the symmetric version of the GAST distribution and on the Gaussian one. These models can be treated as special cases of the basic framework. The estimates of the β parameter are influenced by the assumptions made about the error term. The data indicates that except for WIG-Paliwa, the Gaussian error term leads to larger β estimates than other non-Gaussian specifications. The inference about the shape parameters is not very certain, and the data does not strongly support the two-piece mechanism that enforces the asymmetry of the error term distribution. Furthermore, the estimates of the β parameter depend strongly on the frequency of the analysed series.

Keywords: CAPM; asymmetric *t*-distribution; Warsaw Stock Exchange
JEL Classification: C52; C53; C58

1. Introduction

142 years ago, the introduction of probability distributions that differed from the Gaussian case occurred. This can be seen in the works of De Forest [1,2], Edgeworth [3], and Pearson [4,5]. In Genton's book [6], several empirical examples were analysed to illustrate that there has been a quest for more flexible families of distributions than the Gaussian to serve as a sampling model, but this has not been achieved. Over the last four decades, there has been a desire to go beyond normality, as stated in the subtitle of Genton's [6] book, particularly to properly model the empirical distribution of data that represents fluctuations observed in financial markets.

Over the last fifty years, theoretical investigations in finance often assumed that the distributions of financial returns follow a Gaussian distribution. For example, the theory of pricing a European option explicitly assumes normality, as seen in the works of Black and Scholes [7] and Merton [8]. However, the theory of mean-variance portfolio selection, developed by Markovitz [9], does not require Gaussian returns. Still, it does assume that the distribution of asset returns can be characterised by their first and second moments. As a result, the utility function considered by a decision maker is a function dependent only on the mean and variance of portfolio returns.

The Capital Asset Pricing Model (CAPM), developed by Sharpe [10] and

Treynor [11] and further advanced by Lintner [12] and others, stands out as one of the most significant outcomes of the Markovitz theory. Applications of the CAPM yield valuable insights into the risk associated with financial assets. The widespread adoption of the CAPM is primarily attributed to its ability to estimate the cost of equity (COE) capital for a firm or industry within a robust theoretical framework, as highlighted by Graham and Harvey [13]. The COE, representing the return percentage offered by a company or industry to its equity shareholders based on their investments, serves as a critical gauge for investors evaluating investment profitability. Subpar returns may prompt investors to pursue opportunities with higher potential returns. Furthermore, accurate COE estimations are essential for various reasons in industries that significantly impact the economy. In the banking sector, Altavilla et al. [14] emphasised that COE provides essential information for financial stability and the assessment of monetary policy transmission. Consequently, COE serves as a noteworthy measure not only for investors but also for regulatory and supervisory institutions.

Kaplan and Peterson [15] explain that the CAPM-driven approach is popular among practitioners, especially investors, because there are no theoretically justified alternatives. However, in the empirical literature two decades ago, a consensus was established that the CAPM does not hold. As a result, CAPM-β cannot explain expected returns. Fama and French [16] reviewed various attempts to solve this issue. Andrei et al. [17] recently investigated why investors are still reluctant to give up the model despite the widespread rejection of the CAPM theory from an empirical point of view. They propose a theoretical framework that suggests the Capital Asset Pricing Model (CAPM) holds from the investors' perspective. However, it fails to match the empirical evidence in one specific aspect: the securities market line (SML) appears empirically flat but occasionally becomes steeper, for example, when public information reduces investor disagreement. The study explains the results by Savor and Wilson [18], who found a strong correlation between expected returns and CAPM-β on days when news about inflation, unemployment, or FOMC interest rate decisions is scheduled to be announced.

The assumption that financial returns are normally distributed is often assumed in the existing literature on empirical asset pricing, despite evidence showing that this assumption is not empirically relevant. Since the 1960s, empirical analyses have largely failed to support this normality assumption. This has significant implications for the Capital Asset Pricing Model (CAPM). Researchers such as Black [19], Fama and French [20], Zhou and Yin [21], Wei [22], and Urom et al. [23] have found that the results of estimating the CAPM-β parameters can vary across different models, affecting the estimated beta values and the relationship between risks and market returns.

Adcock [24] states that it's unnecessary to assume that returns follow a normal distribution to satisfy the CAPM axioms. He found that the family of skew-normal distributions (described in Azzalini and Dalla Valle [25]) is empirically important for UK stocks, and estimates of the CAPM β parameter change significantly when the sampling distribution allows for skewness. Adcock and Shutes [26] previously analysed the impact of assuming a student-t distribution for returns on the CAPM β estimates and found substantial effects on the estimation outcomes. These two papers

are part of a wide range of research on the empirical relevance of the CAPM theory, considering non-standard stochastic assumptions that explicitly allow for heavy tails and/or asymmetry in the underlying distributions. Other works by Affleck-Graves [27], MacKinlay and Richardson [28], Zhou [29], Harvey and Siddique [30], Li [31], Theodosiou and Theodossiou [32], and more recently, Bao et al. [33], are examples of extensive research on the application of flexible non-Gaussian families of distributions in the problem of risk assessment using the CAPM.

In this paper, we analyse the Capital Asset Pricing Model (CAPM) using a variety of distributions that go beyond the normal family. Specifically, we employ distributions from the generalised asymmetric student-t class developed by Harvey and Lange [34], which accounts for skewness and asymmetric tail thickness. Furthermore, the generalisation by Harvey and Lange [34] combines the student-t family of distributions with the Generalized Error Distributions (GED) class in a streamlined parametrisation. Our study focuses on the Warsaw Stock Exchange (WSE) indices. It examines the estimates of the β parameter for a selection of sector indices, including fuel (WIG-Paliwa), food (WIG-Spozywczy), telecommunications (WIG-Telekom), computers (WIG-Info), real estate (WIG-Nieruchomosci), media (WIG-Media), and construction companies (WIG-Budowlany) listed on the WSE. In our econometric analyses, we follow the main goals of the paper stated as:

1) Analysis of the sensitivity of the CAPM β parameter estimates under a family of distributions allowing for heavy tails, skewness, and tail asymmetry.
2) Analysis of the sensitivity of the performance of the CAPM to the frequency of analysed data (daily, weekly, monthly, and quarterly).

In the following paper, we will first provide an overview of the generalised asymmetric student-t distribution proposed by Harvey and Lange [34]. We will discuss the symmetric version of the H&L distribution and the skewed and tail-asymmetric cases, each as separate sections within the generalised family. Chapter 3 will review some econometric strategies concerning the assumptions of the error term in the CAPM regression model. Finally, Chapter 4 will describe the data, the model framework, and the main empirical results.

2. Parametric representation of skewness and tail asymmetry

In a paper by Li and Nadarajah [35], it is mentioned that student's t distribution and its generalisations have become the most popular models for economic and financial data. Our work will focus on analysing some of the generalisations of the student-*t* distribution proposed by Harvey and Lange [34]. These generalisations unify the family with the Generalized Error Distributions (GED), and the final construct goes beyond previous results by Zhu and Zinde-Walsh [36], Zhu and Galbraith [37], Fernández and Steel [38], and Theodossiou [39], among others. For more information, we refer to the literature overview and discussion by Harvey and Lange [34].

Previous empirical analyses have demonstrated the extraordinary flexibility of generalised families. For instance, Mazur and Pipień [40] studied TV-GARCH models with conditional distribution proposed by Zhu and Galbraith [37], while Mazur and Pipień [41] investigated coordinate-free multivariate distributions obtained based on Harvey and Lange [34] asymmetric-t class.

Consider a random variable with zero mode and unit scale z with the following density, parametrised by $\eta > 0$ and $\upsilon > 0$:

$$p(z|\eta,\upsilon) = K(\eta,\upsilon)\left(1+\frac{1}{\eta}|z|^{\upsilon}\right)^{-\frac{\eta+1}{\upsilon}} \tag{1}$$

where the normalising constant $K(\eta, \upsilon)$ is given by the formula:

$$K(\eta,\upsilon) = \frac{\upsilon}{2\eta^{\frac{1}{\upsilon}}B(\frac{1}{\upsilon},\frac{\eta}{\upsilon})}$$

and $B(.,.)$ is the beta function; see Harvey and Lange [34]. The parameter $\upsilon > 0$ determines the shape around the mode, with $\upsilon = 2$ leading to the student-*t* type shape. The parameter $\eta > 0$ controls the tail behaviour and determines the existence of moments only in the case where $\upsilon = 2$. The advantage of the unification proposed by Harvey and Lange [34] is that it includes a list of well-known distribution families and offers elasticity by parametrising a very broad class of distributions. This links the properties of the student-*t* and GED families in an unconstrained but continuous form. In particular, when $\eta \to +\infty$, the broad GED with shape parameter υ is defined. For $\upsilon = 1$, the Laplace distribution can be obtained, and $\upsilon = 2$ defines the Gaussian distribution, provided that $\eta \to +\infty$.

To introduce skewness in a distribution, one may use inverse scale factors as explained in Ferreira and Steel's [42] work. The resulting density accounts for possible skewness around the mode in a manner proposed by Fernández and Steel [38], and similarly by Hansen [43] for a student-*t* distribution:

$$p(z|\eta,\upsilon,\alpha) = K(\eta,\upsilon)\begin{cases}\left(1+\frac{1}{\eta}\left|\frac{z}{2\alpha}\right|^{\upsilon}\right)^{-\frac{\eta+1}{\upsilon}}, z \le 0\\ \left(1+\frac{1}{\eta}\left|\frac{z}{2(1-\alpha)}\right|^{\upsilon}\right)^{-\frac{\eta+1}{\upsilon}}, z > 0\end{cases} \tag{2}$$

Harvey and Lange [34] alternatively parametrised Equation (2) by $\alpha \in (0, 1)$, with $\alpha = 0.5$ restoring symmetry. The Arnold and Groeneveld [44] measure of skewness to the mode is referenced here. The distribution given by Equation (2) has an elegant property:

$$P(z \le 0) = \alpha \tag{3}$$

It is important to note that the distribution of *z*, defined by Equation (2), may no longer have a zero mean, even though it remains unimodal; see Harvey and Lange [34].

It is possible to disrupt the symmetry in Equation (1) by implementing a two-piece mechanism as demonstrated by Zhu and Galbraith [37] when they extended the student-*t* distribution. The resulting density distribution is a member of the two-piece skew family.

$$p(z|\eta_L,\upsilon_L,\eta_R,\upsilon_R) = K_{LR}\begin{cases}\left(1+\frac{1}{\eta_L}|z|^{\upsilon_L}\right)^{-\frac{\eta_L+1}{\upsilon_L}}, z \le 0\\ \left(1+\frac{1}{\eta_R}|z|^{\upsilon_R}\right)^{-\frac{\eta_R+1}{\upsilon_R}}, z > 0\end{cases} \tag{4}$$

where the normalising constant KLR is given by the formula:

$$K_{LR} = \frac{1}{\frac{0.5}{K(\eta_L, \upsilon_L)} + \frac{0.5}{K(\eta_R, \upsilon_R)}}$$

It is possible to consider a variable distributed according to the density in Equation (4) as a mixture of two distributions in Equation (1) with different parameters υ and η. These distributions are also renormalised to ensure that the resulting probability density function is continuous at the mode (which is zero). As with the construct defined by Equation (2), the expected value of the distribution given by Equation (4) may not be equal to zero (if it exists). The probability mass around the mode (which is zero) is not equally spaced. In their work, Harvey and Lange [34] provide the following function, which describes the probability that z is not positive:

$$P(z \leq 0) = \frac{K(\eta_L, \upsilon_L)}{K(\eta_L, \upsilon_L) + K(\eta_R, \upsilon_R)} \tag{5}$$

Combining both distributions presented in Equations (2) and (4), the following density for z can be considered:

$$p(z|\eta_L, \upsilon_L, \eta_R, \upsilon_R, \alpha) = H_{LR} \cdot \begin{cases} \left(1 + \frac{1}{\eta_L}\left|\frac{z}{2\alpha}\right|^{\upsilon_L}\right)^{-\frac{\eta_L+1}{\upsilon_L}}, z \leq 0 \\ \left(1 + \frac{1}{\eta_R}\left|\frac{z}{2(1-\alpha)}\right|^{\upsilon_R}\right)^{-\frac{\eta_R+1}{\upsilon_R}}, z > 0 \end{cases} \tag{6}$$

where the following formula gives the normalising constant HLR:

$$H_{LR} = \frac{1}{\frac{\alpha}{K(\eta_L, \upsilon_L)} + \frac{1-\alpha}{K(\eta_R, \upsilon_R)}}$$

The density function in Equation (6) has a unit scale parameter and a zero mode. The probability that a random variable z is not positive is defined as follows (Harvey and Lange [34]):

$$P(z \leq 0) = \frac{\frac{\alpha}{K(\eta_L, \upsilon_L)}}{\frac{\alpha}{K(\eta_L, \upsilon_L)} + \frac{1-\alpha}{K(\eta_R, \upsilon_R)}} \tag{7}$$

3. Empirical insights into CAPM regression

The most important outcome from the CAPM, namely the β, is typically estimated by regressing the returns of individual stocks, portfolios of instruments, or branch indices on the overall market index, both adjusted for the risk-free return proxy. This is done according to the following regression model:

$$r_t - r_t^f = \beta(r_t^m - r_t^f) + \sqrt{\sigma^2} z_t, t = 1, \ldots, T \tag{8}$$

where r_t denotes the return on an asset (it can also be a branch sub-index or a portfolio), r_t^m denotes the return on the market portfolio, and r_t^f denotes the return on a risk-free asset. Additionally, t refers to the time the observations were taken, $\sqrt{\sigma^2}$ is the scale parameter of the error term, and z_t is a sequence of i.i.d. random variables with zero location and unit scale.

The model framework presented by Equation (8) has been widely used in empirical papers and has influenced other methods such as Fama-MacBeth

regressions. The sequence of z_t can be assumed to follow a standardised Gaussian distribution, where σ^2 refers to the variance. Furthermore, Equation (8) can be improved by adding an intercept in order to evaluate standard statistical tests for the CAPM theory. The CAPM theory, which imposes a zero restriction on the intercept in the null hypothesis, has been studied for decades, as detailed by Jensen et al. [45]. It's worth noting that the assumptions behind the CAPM theory do not require returns to be normally distributed, as stated by Adcock [24].

Chamberlain [46] pointed out that the mean-variance optimisation criterion, the basis of portfolio optimisation and CAPM, is consistent with an investor's portfolio decision-making only if the returns are elliptically distributed. Empirical asset pricing tests proposed by Gibbons et al. [47] are valid only under the normality assumption, which is a special case of elliptical distributions. Consequently, studies have been conducted to develop tests for cases where the distribution of returns is generally elliptical, including work by Affleck-Graves and McDonald [27], MacKinlay and Richardson [28], and Zhou [29].

However, the empirical distributions of financial returns do not fit the Gaussian case and, in many instances, the entire elliptical class. As a result, it is possible to relax the assumptions regarding *zt* and use richer parametrisation and more flexible sampling distributions for $r_t - r_t^f$ in Equation (8) that allow for asymmetry and heavy tails. This research direction has recently gained significant attention and is a viable alternative to estimating the conditional β using the M-GARCH framework or general multivariate volatility models.

Numerous attempts have been made to explicitly define the distribution of financial returns. Harvey and Siddique [30] stressed the importance of integrating distributional asymmetry into the asset pricing model, emphasizing the economic significance of systematic skewness and its influence on risk premium. Adcock [24] examined the ramifications of assuming the Azzalini skew-normal distribution of returns in the CAPM model. Li et al. [31], Bao et al. [33], and others modelled the distribution of the error term in Equation (8) using asymmetric power distributions or asymmetric exponential power distributions. Theodossiou and Theodossiou [32] analyzed the sensitivity of β parameter estimates in light of outliers in the series of stock market returns, revealing substantial bias in OLS estimates in the case of non-normal empirical distributions of financial returns. While Theodossiou and Theodossiou's [32] feasible estimation procedure does not explicitly define the distribution of the error term in CAPM regressions, it is equivalent to the OLS procedure (under the Gaussian model) and, importantly, yields significantly different β estimates in the case of heavy-tailed and asymmetric data. The pursuit of reliable inference in linear regression models with heavy-tailed errors has a longstanding tradition in the empirical sciences and has been of particular interest in financial economics for decades. Shephard [48] has recently detailed consistent and asymptotically normal estimators of regression parameters in the context of heavy-tailed predictors with heteroscedastic outcomes. The empirical illustration demonstrating the accuracy and utility of Shephard's [49] method mainly focuses on the estimation of β coefficients within CAPM regressions.

4. Empirical results—Selected branch indices from WSE

4.1. Data description and model specification

In the empirical part of the paper, we analyse a set of selected sub-indices listed on the Warsaw Stock Exchange (WSE). The examined time series concern the indices of the construction (WIG-Budow), IT (WIG-Info), media (WIG-Media), real estate (WIG-Nrchom), fuel (WIG-Paliwa), food (WIG-Spozyw), and telecommunications sectors (WIG-Telekom). The time range of the data covers observations from 3 January 2006 to 29 May 2020. In empirical research, we analyse daily, weekly, monthly, and quarterly data, giving 3600 daily, 751 weekly, 172 monthly, and 56 quarterly observations, respectively. WIG index quotations were used to approximate the market portfolio, and the risk-free rate was based on the yields of the Poland 10Y government bonds.

We have estimated the parameter β in regression Equation (8) using stochastic assumptions for z_t as given by Equation (6). Our general model utilises the generalised asymmetric student-*t* distribution proposed by Harvey and Lange [35], and we refer to this specification as MFullHL. We have also estimated the parameter β using two special cases regarding the distribution of z_t in Equation (8). The first one, MSymHL, is based on the distribution of z_t given by Equation (1). It is a special case of MHL resulting from imposing three restrictions: $\alpha = 0.5$, $\eta L = \eta R = \eta$, and $\upsilon L = \upsilon R = \upsilon$ in Equation (6). The second special case of MHL, denoted by MG, is the limiting one, referring to the case of the Gaussian distribution of z_t. We can obtain it through the following set of restrictions: $\alpha = 0.5$, $\upsilon L = 2$, $\upsilon R = 2$, $\eta L \to +\infty$, and $\eta R \to +\infty$.

The models MG and MSymHL ensure that the expected value of the error term, denoted ε_t, equals zero (if it exists in the latter case). However, the model MHL is different in that possible skewness or asymmetry (or both) may distort the expectation of ε_t from having a zero modal value in Equation (8). As a result, the model Equation (8) complemented by an intercept is not identifiable. This implies that from a statistical perspective, there is no difference between an intercept and a non-zero expected value of ε_t. Therefore, the researcher must decide whether to include an intercept in Equation (8) and ensure that $E(\varepsilon_t) = 0$, or not include an intercept and find observational opportunities that would allow for $E(\varepsilon_t) \neq 0$. The latter alternative can be exploited within the environments given by models that allow for skewness and/or asymmetry. Furthermore, within these models, it is possible to perform simple likelihood ratio tests of the Capital Asset Pricing Model (CAPM) theory, which posits that $E(\varepsilon_t) = 0$, against the alternative hypothesis of skewness, asymmetry, or both.

4.2. Empirical analyses

We have presented the results of the Maximu Likelihood (ML) estimation of parameters in **Table 1**. We have also reported the values of P ($z_t < 0$) obtained considering all competing sampling distributions when analysing daily data. Additionally, we have calculated the log-likelihood values at the ML estimates. We want to highlight that the estimates of the β parameter are sensitive to the choice of assumptions regarding the error term. However, we expected differences to be much stronger than those reported. The analyses suggest that, except for WIG-Paliwa, β is

estimated to be larger in the case of the Gaussian error term (MG), compared to MSymHL or MHL. However, the risk assessment based on β is almost the same for both non-Gaussian specifications, as the β parameter is estimated to be almost the same value. Estimating parameter σ^2 differs among models due to different interpretations, since it is the variance only in the case of MG. The inference about shape parameters is uncertain in all analysed sub-indices. The data clearly indicates that the error term departs from the Gaussian case. However, there is strong uncertainty about parameters *v* and η. The data does not strongly support the two-piece mechanism enforcing asymmetry in model MHL. Although we report differences between *vL* and *vR* or ηL and ηR, the range of uncertainty determined by the standard errors suggests that these differences may not be statistically significant. Specifically, for the WIG-Info subindex, according to model MHL, the tail behaviour is definitely of a different nature on the left ($\eta\hat{L} \approx 8.83$) than on the right ($\eta\hat{R} \approx 17.47$). However, the standard errors, reaching 4.32 in the case of parameter ηR, indicate that a symmetric tails case is also supported. Additionally, shape parameters *vL* and *vR* are estimated to be less than 2 ($\eta^* = 2$ indicates student-*t* shape), but the huge standard errors disable precise inference about this feature of the distribution of the error term. The same results are obtained for the WIG-Paliwa index.

The *p*-values of the likelihood ratio (LR) tests, which are shown in **Table 1**, indicate that the Gaussian error term is not supported by the data. The null hypothesis is rejected for both MSymHL and MHL alternatives. However, differences between MSymHL and MHL are unclear. Only in the case of WIG-Nrchom and WIG-Media does the unconstrained model MHL receive stronger data support, and the restriction to the symmetric case (MSymHL) is rejected at a reasonable level of statistical significance. The *p*-values of the appropriate LR test are 0.0034 and 0.0255 for WIG-Nrchom and WIG-Media, respectively. All remaining time series do not support the asymmetry obtained by the two-piece mechanism.

There is another source of asymmetry in MHL, referring to the inverse scale factors mechanism, with skewness measure $\alpha \in (0, 1)$; see Equation (2). Empirical analyses conducted here yield a little data support against $\alpha = 0.5$ (assuring symmetry in Equation (2)). With regard to the point estimates of the α parameter, it can be stated that WIG-Budow, WIG-Info, WIG-Media and WIG-Telekom indicate negative skewness ($\hat{\alpha} < 0.5$), while WIG-Nrchom, WIG-Paliwa and WIG-Spozyw support positive skewness, but in case of the latter one, very weak.

The mechanisms of the two-pierce and inverse scale factors are different in nature. Hence, the data may support different directions of asymmetry generated by both mechanisms. In the case of the two-piece mechanism, a heavier left tail indicates asymmetry to the left of z_t in Equation (8), while a heavier right tail—indicates asymmetry to the right. A quantity of interest that summarises information of the scale of departure of the distribution of the error term from the symmetric case is the $P(z_t < 0)$; see Equation (7) for MHL. Models MG and MSymHL are built on the basis of the error term with symmetric distribution, and hence they assure that $P(z_t < 0) = P(z_t \geq 0) = 0.5$. Consequently, formal statistical inference about $P(z_t < 0)$ is the possible only condition to the model MHL. The point estimates and standard errors of this function of interest are presented in **Table 1**. Except for WIG-Info, analysed sub-indices

support negative asymmetry of the error term in CAPM regression. As described previously, the results of inference about the shape and tails of the distribution of z_t in Equation (8) were quite different when comparing estimation outcomes from different datasets. Great uncertainty about η and ν was in common. The estimation of $P(z_t < 0)$ seems to be characterised by the same level of statistical uncertainty in each analysed time series. The deviation from the symmetric case is not big but precisely estimated since the approximated standard error is not greater than 0.0046.

The empirical analysis presented above was replicated for data on weekly, monthly, and quarterly frequency for each analysed sub-index. The resulting outcome is summarised in **Figures 1** and **2**, which show the estimated CAPM lines against the data points for WIG-Nrchom and WIG-Paliwa, respectively. The complete set of estimated CAPM lines is presented in Appendix in **Figures A1–A3**. The black line represents a hypothetical CAPM with the slope $\beta = 1$. The blue line corresponds to the estimated β under MG, while the red line is the case of MHL, which is almost the same as in the case of model MSymHL. WIG-Nrchom and WIG-Paliwa were chosen to demonstrate the sensitivity of the inference about β with respect to the frequency of the analysed time series.

Table 1. ML estimates and asymptotic standard errors (in brackets) of parameters and of $P(z_t < 0)$, natural logarithm of the ML likelihood values with the results of the LR test; the case of the daily data.

Index	Model	β	σ^2	ηL	υL	ηR	υR	α	$P(z_t < 0)$	Loglik	p-value of LR test	
											MG	MSymHL
	MG	0.7408 (0.0136)	1.0508 (0.0004)	+∞	2	+∞	2	0.5	0.5	−5150.716		
WIG-Budow	MSymHL	0.7077 (0.0326)	0.6469 (0.2002)	6.91 (0.48)	1.71 (1.02)	ηL	υL	0.5	0.5	−5068.580	$p < 10{-}20$	
	MHL	0.6998 (0.0560)	0.6474 (0.3155)	5.78 (1.06)	1.89 (3.01)	8.70 (4.87)	1.55 (0.24)	0.4984 (0.0713)	0.5130 (0.0044)	−5066.44	$p < 10{-}20$	0.1177
	MG	0.6751 (0.0129)	0.9538 (0.000374)	+∞	2	+∞	2	0.5	0.5	−4994.399		
WIG-Info	MSymHL	0.6566 (0.0449)	0.6559 (0.3306)	11.01 (0.98)	1.64 (1.52)	ηL	υL	0.5	0.5	−4944.953	$p < 10{-}20$	
	MHL	0.6569 (0.0149)	0.6580 (0.5375)	8.03 (1.03)	1.79 (2.10)	17.47 (4.32)	1.52 (5.19)	0.4869 (0.0542)	0.4995 (0.0043)	−4943.265	$p < 10{-}20$	0.1849
	MG	0.7268 (0.0159)	1.4507 (0.000570)	+∞	2	+∞	2	0.5	0.5	−5710.793		
WIG-Media	MSymHL	0.7111 (0.0217)	0.9420 (0.1099)	4.89 (1.89)	2.23 (0.09)	ηL	υL	0.5	0.5	−5633.865	$p < 10{-}20$	
	MHL	0.7125 (0.0159)	0.9517 (0.1842)	3.86 (3.82)	2.55 (0.17)	8.47 (3.99)	1.86 (0.36)	0.4835 (0.0363)	0.5047 (0.0042)	−5630.197	$p < 10{-}20$	0.0255
	MG	0.8617 (0.0138)	1.0862 (0.000427)	+∞	2	+∞	2	0.5	0.5	−5152.197		
WIG-Nrchom	MSymHL	0.8244 (0.1070)	0.4692 (0.3888)	5.30 (0.15)	1.42 (2.37)	ηL	υL	0.5	0.5	−4906.878	$p < 10{-}20$	
	MHL	0.8213 (0.0672)	0.4652 (0.2757)	6.87 (15.83)	1.33 (0.18)	3.75 (0.27)	1.64 (0.59)	0.5273 (0.0626)	0.5038 (0.0046)	−4901.192	$p < 10{-}20$	0.0034

Table 1. (*Continued*).

Index	Model	β	σ^2	ηL	νL	ηR	νR	α	$P(z_t < 0)$	Loglik	p-value of LR test	
WIG-Paliwa	MG	1.0841 (0.0153)	1.3379 (0.000526)	+∞	2	+∞	2	0.5	0.5	−5590.365		
	MSymHL	1.1061 (0.1051)	0.8803 (0.2611)	8.14 (0.64)	1.73 (0.55)	ηL	νL	0.5	0.5	−5526.729	$p < 10{-}20$	
	MHL	1.1074 (0.0147)	0.8855 (0.0330)	14.86 (2.00)	1.61 (1.23)	6.48 (2.84)	1.76 (2.28)	0.5103 (0.0333)	0.5013 (0.0044)	−5525.163	$p < 10{-}20$	0.2089
WIG-Spozyw	MG	0.6334 (0.0161)	1.4781 (0.000581)	+∞	2	+∞	2	0.5	0.5	−5736.596		
	MSymHL	0.5765 (0.0365)	0.8718 (0.2092)	4.86 (0.43)	2.00 (0.89)	ηL	νL	0.5	0.5	−5629.440	$p < 10{-}20$	
	MHL	0.5774 (0.0582)	0.8711 (0.1165)	4.77 (6.97)	2.13 (0.27)	5.18 (8.44)	1.85 (1.35)	0.5012 (0.2077)	0.5089 (0.0044)	−5627.984	$p < 10{-}20$	0.2332
WIG-Telekom	MG	0.6752 (0.0181)	1.8720 (0.000735)	+∞	2	+∞	2	0.5	0.5	−6014.624		
	MSymHL	0.6536 (0.0480)	1.0100 (0.2053)	4.03 (1.44)	2.40 (1.66)	ηL	νL	0.5	0.5	−5849.315	$p < 10{-}20$	
	MHL	0.6547 (0.0472)	1.0123 (0.0628)	3.70 (2.99)	2.67 (0.19)	4.68 (2.89)	2.10 (0.28)	0.4997 (0.0424)	0.5118 (0.0043)	−5847.148	$p < 10{-}20$	0.1145

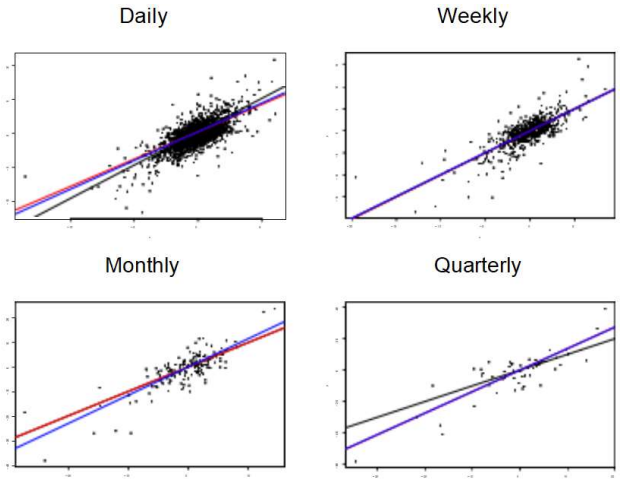

Figure 1. Estimated CAPM lines for WIG-Nrchom against the data of different frequency.

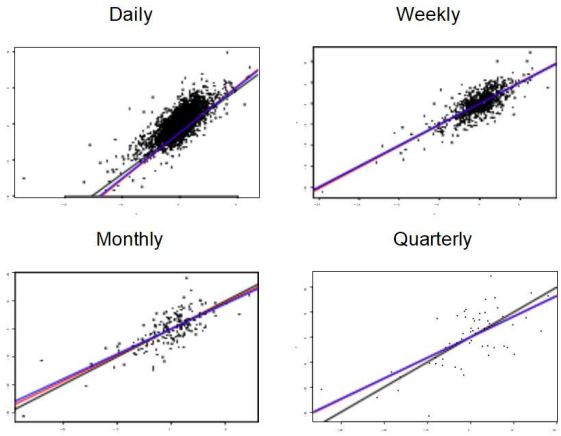

Figure 2. Estimated CAPM lines for WIG-Paliwa against the data of different frequency.

In the case of WIG-Nrchom, depicted in **Figure 1**, the slope of the CAPM line becomes steeper as the frequency of the data decreases. Daily data suggests that $\beta < 1$ for both models, but estimation based on the weekly time series results in $\hat{\beta}$ that is almost equal to one. In the case of monthly data, inference about β differs across models, where model MG yields $\hat{\beta} \approx 1.1560$ (with the standard error 0.0609) and model MHL gives $\hat{\beta} \approx 1.0000$ (with the standard error 0.000885). The quarterly data set supports $\beta < 1$ for both models.

The results of analysis of the second case (WIG-Paliwa) are summarised in **Figure 2**. The point estimates of the β are relatively similar in model MG and MHL for each analysed frequency of the data. However, they decrease as the frequency of data decreases. In particular, the daily data suggests that $\beta > 1$, and the weekly frequency gives a result where β is almost equal to one in both models. The monthly and quarterly series indicate that $\beta < 1$.

5. Conclusion

In this paper, we analysed CAPM regression under a class of distributions allowing for various exceptions from the Normal family. Namely, we assume the error

term belongs to the generalised asymmetric student-*t* class that Harvey and Lange [34] elaborated, allowing for skewness and asymmetric tail thickness. The Harvey and Lange [34] generalisation unifies the student-*t* family of distributions with the GED (Generalised Error Distributions) class in an elegant parametrisation. We focused on the Warsaw Stock Exchange (WSE) indices and analysed estimates of the β parameter for a set of selected branch sub-indices.

For most analysed time series, the data suggests that β is estimated to be larger in the case of the Gaussian error term compared to models with error terms allowing for heavy tails and asymmetry. However, the risk assessment based on β is almost the same for all non-Gaussian specifications, as the β parameter is estimated to be nearly the same value. The data does not strongly support the two-piece mechanism enforcing asymmetry in the distribution of the error term. Only in the case of WIG-Nrchom and WIG-Media does the unconstrained model receive more vital data support, and the restriction to the symmetric distribution is rejected at a reasonable level of statistical significance. All remaining time series do not support the asymmetry obtained by the two-piece mechanism.

In the paper, we also demonstrated how risk assessment—elaborated on the basis of estimation of the β parameter—may change with respect to the frequency of analysed time series. The main conclusion that arises from our research is that estimation of the β parameter may change across models with different assumptions imposed on the distribution of the error term and, more importantly, across different data frequencies. Consequently, the risk assessment resulting from the estimated CAPM model may not correspond to the analysed financial instrument only. The frequency at which the researcher observes the analysed time series plays as important a role as the original choice of the instrument.

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Conflict of interest: The author declares no conflict of interest.

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Appendix

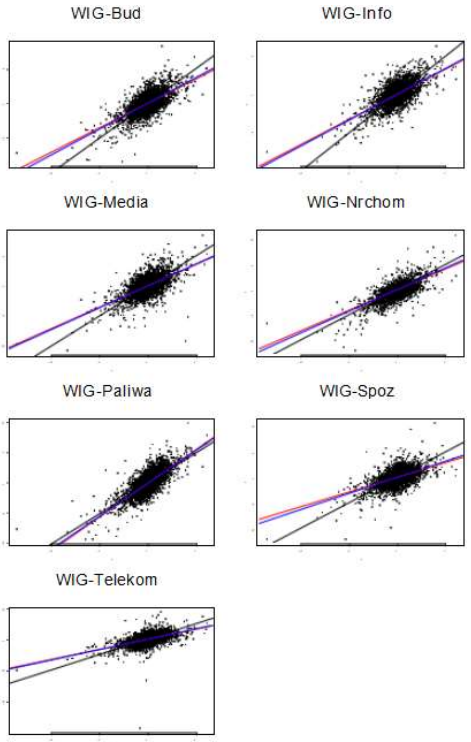

Figure A1. Estimated CAPM lines, the case of daily data.

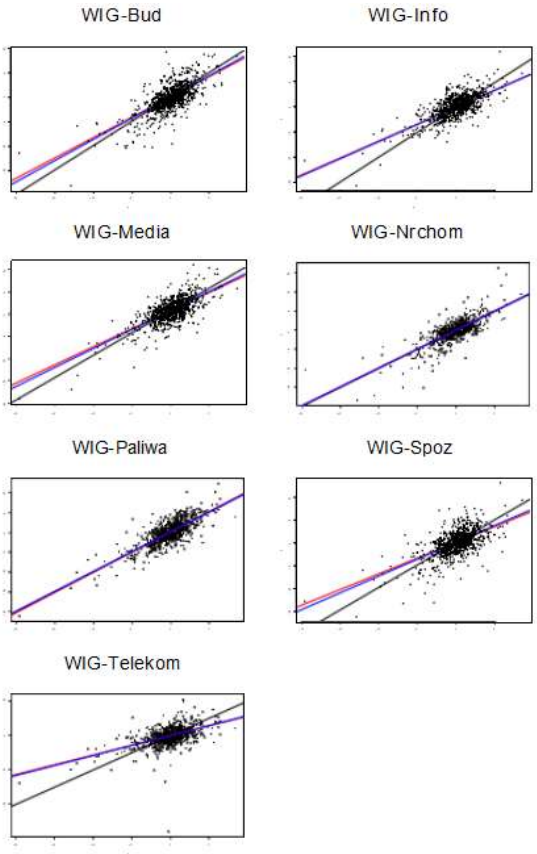

Figure A2. Estimated CAPM lines, the case of weekly data.

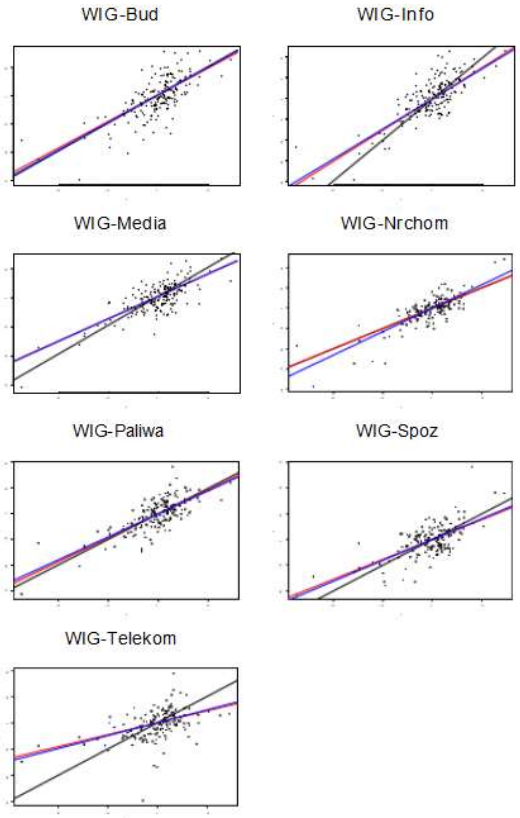

Figure A3. Estimated CAPM lines, the case of monthly data.

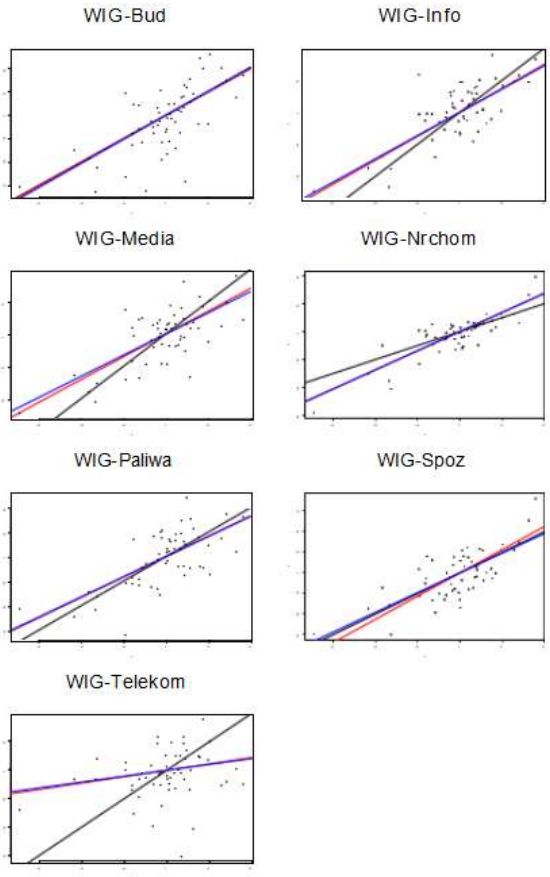

Figure A4. Estimated CAPM lines, the case of quarterly data.

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Article

Inflation-balance of trade nexus in Nigeria: The impact of exchange rate pass-through

Josephine Obiageli Opene-Terry, Benedict Ikemefuna Uzoechina*, Kenechukwu Okezie Okeyika, Ngozi Florence Ezenwobi, Abimbola A. Oladipo, Vincent Chuks Okafor

Department of Economics, Nnamdi Azikiwe University, Awka 420102, Nigeria
*** Corresponding author:** Benedict Ikemefuna Uzoechina, ib.uzoechina@unizik.edu.ng

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Abstract: The relationship between exchange rate (EXR) and foreign trade (FT) in Nigeria has been a contentious issue since Nigeria's independence in 1960. This study investigated the link between exchange rate and foreign trade through the prism of exchange rate pass-through (EXRPT) to domestic prices, utilizing monthly data from 2011 to 2022. The study was built on two models—the base and main models, respectively. Employing the VAR technique and its Vector Error Correction Model (VECM) extension, the paper found that EXRPT to consumer prices is incomplete in the short run, but its effect was found to be higher on imports than on consumer prices. It follows that the impact of EXRPT diminishes along the price chain. Results from the main model indicate that the impact of domestic prices on balance of trade was found to be negative with an elasticity of −0.437541 and is also statistically significant, thus confirming the Marshal-Lenner condition. The Marshal-Lenner condition and findings of this study provide evidence that depreciating exchange rate is not recommended for an import-inelastic country like Nigeria.

Keywords: exchange rate; inflation; foreign trade; depreciation; imports
JEL Classification: F31; E31; F1; F14

1. Introduction

Since no country exists in isolation, foreign trade is, therefore, important for the survival of most economies. Not only does it aid interactions and promote economic growth, employment, exchange, and market expansion, it also enhances economic outcomes or fortunes for countries around the world [1]. The discovery of oil in the early 1970's changed the narrative for Nigeria, which engaged in the exportation of crude oil as her major source of earnings. This huge revenue inflow became overwhelming for Nigeria, which had no plans of how to reinvest the excess revenue but instead resorted to importing everything. Unfortunately, when the windfall from oil ended around 1977, Nigeria had become an import-oriented country and has remained so up until today.

There are basic factors influencing foreign trade among nations, especially that between Nigeria and other countries. They include inflation, national income, world commodity prices, and volume of exports and imports, amongst others. In Nigeria, inflation has been a very strong determinant of our exchange rate since the SAP period owing to the interaction between the domestic economy and the external economy. This interaction can affect the volume of exports and imports and subsequently our balance of trade. More so, in terms of world commodity prices, crude oil is a world commodity that Nigeria exports in large volumes and is not supplied by one country.

Thus, the prevailing oil price supplied by the OPEC affects the balance of trade values since crude oil is a component of both Nigeria's exports and imports. In line with this, one of Nigeria's biggest trading partners is the United States. Since we import a large volume of goods from the United States, it is assumed that the prevailing domestic condition in the US will affect their producer prices. Thus, when importing, we are importing at producers' price index after they have taken into consideration their own domestic inflation. This makes the United States Producers' Price Index more sufficient to substitute import prices since it is evident that we also import not just goods but inflation from them too. Furthermore, another major factor affecting foreign trade is the exchange rate [2]. This is because the extent to which a country's currency is traded against that of the other countries matters so much since, according to Auwal and Hamzat [3], different economies are connected either directly or indirectly through the asset and/or goods markets as well as the currency market. Foreign exchange rate links the price systems of different countries, enabling foreign trade to compare traded goods directly. This makes it possible to compare domestic prices with prices elsewhere. However, at the international trade market, a much sufficient measure empirically for exchange rate is the effective exchange rate, which is a measure of the value of a country's currency against a weighted average of several foreign currencies. When the nominal effective exchange rate (NEER) is divided by a price deflator or index of costs, the result is the real effective exchange rate (REER) [4]. More so, for developing nations, when the nominal index is adjusted for relative changes in consumer prices, the result is the real effective exchange rate index, and as such, an increase represents an appreciation of the local currency and the decrease is depreciation. However, a movement backwards, the magnitude (elasticity) of the increase shows the pass-through of exchange rate changes to the consumer prices. Since the exchange rate influences both export trade and import trade, it therefore follows that it could affect a country's balance of payments position. Therefore, an exchange rate that is well managed offers great economic benefits to countries that engage in international trade. Conversely, if it is not managed well, it contributes a lot to price instability and inflation [5]. In Nigeria, the volatile exchange rate over the years has contributed to price instability and inflation. Bada et al. [6] opines that when the exchange rate depreciates, it brings about a rise in inflation, and this is known as exchange rate pass-through to inflation.

Aliyu [7] defined exchange rate pass-through (EXRPT) as the change in domestic prices that can be attributed to a prior change in the nominal exchange rate. EXRPT measures the portion of inflation in a country caused by depreciation of the domestic exchange rate. When there is a depreciation of the exchange rate, the resulting impact on the balance of trade is largely influenced by the pass-through to the prices in the domestic economy as well as the speed of its transmission to other macroeconomic variables, including the balance of trade. EXRPT increases the cost of production in the domestic country, thereby making export commodities less competitive at the international market and, as such, diminishes the balance of trade. In a normal situation, a depreciating exchange rate should be accompanied by an increase in exports, but in the case of Nigeria, the reverse is obtained. Not only has our exchange rate been depreciating, we have also experienced an increase in importation, majorly owing to the fact that we are import-dependent and goods imported are highly inelastic

and used for domestic production. These two scenarios occurring at the same time have led to an increase in our inflation readings (which can be attributed to a prior change in the nominal exchange rate), leading to a persistent rise in the value of domestically produced goods, which will subsequently make the cost of our exports high, thus leading to a balance of trade deficit in the country. Therefore, it is necessary to empirically investigate the relationship between the portion of domestic prices affected by exchange rate depreciation (through the pass-through) and its impact on the balance of trade in Nigeria.

Previous studies on exchange rate and balance of trade have not sufficiently investigated the impact of exchange rate pass-through to inflation on balance of trade in Nigeria. However, ample studies exist explaining the impact of exchange rate on inflation in Nigeria, such as Aliyu et al. [5], Fatai and Akinbobola [8], Aisen et al. [9], etc. These studies found that exchange rate pass-through had a significant effect on domestic prices. This present study differed from previous empirical studies because it investigates the impact of exchange rate pass-through to inflation on the balance of trade in Nigeria, taking into cognizance the use of CPI instead of inflation. CPI is used as a proxy for inflation because it supports the definition of exchange rate pass-through to domestic prices, and CPI data also help economists measure the total value of goods and services produced by an economy, with the effect of inflation stripped out. The significance of this study lies in the fact that it would shed light on the relationship between exchange rate depreciation and trade balances using the Marshall-Lerner condition of balance of payment (utilizing the elasticity approach) in Nigeria. It will contribute tremendously in answering the question whether the depreciation of the value of Nigeria's currency experienced constantly in Nigeria does improve or worsen Nigeria's trade balances. It would also help in detecting the demand elasticity on imports and exports, thus becoming a tool for recommending appropriate policies to improve Nigeria's trade balance. Furthermore, since this study focuses on balance of trade, it would also become a good framework for further studies to investigate the relationship that exists between EXRPT and other significant macroeconomic variables.

Having concluded the first section of this paper, which is the introduction, the second section reviews related literature and some theoretical foundations for the study. Model specification and the method adopted for data analysis are discussed in Section 3 of this study. Result presentation, interpretation, and discussion of results were taken care of in Section 4. The paper is then concluded in Section 5 and relevant policy recommendations proffered.

2. Literature review

This study is built on two models, the base model and the main model respectively. The base model hangs on the relative purchasing power parity theory while the main model is founded on Marshall-Lerner hypothesis.

2.1. The relative purchasing power parity

Our base model is anchored on the relative purchasing power parity theory, which is a sub-theory from the general theory of the purchasing power parity model

propounded by Swedish economist Professor Gustav Cassel in 1918. The basic concept can be explained with an example such as if $4 buys one carton of milk in the United States, and if 120 Chinese yuan exchanges for $1, then the price of a carton of milk in China should be 480 Chinese yuan (4 × 120). Thus, there should be parity between the purchasing power of one US dollar in the United States and the purchasing power of its exchange value in China.

The theory anchors on the assumptions that there are no transaction costs, no transportation costs, free movement of goods (trading without tariffs or quotas), and that the goods are homogeneous across different markets. Cassel believed that if an exchange rate was not at parity, it was in disequilibrium and that either the exchange rate or the purchasing power would adjust until parity was achieved [10]. The reason is arbitrage. If a carton of milk sold for four dollars in the United States and for six hundred yen in Japan, then arbitragers could buy wheat in the United States and sell it in Japan and would do so until the price differential was eliminated. With this background, our base model will be stated thus:

$$\text{CPI} = F\,(\text{NER, USPPI, OILP}) \tag{1}$$

The econometric form is stated as

$$\text{CPI} = \beta_0 + \beta_1\text{REER} + \beta_2\text{USPPI} + \beta_3\text{OILP} \tag{2}$$

where REER = Real effective exchange rate for the base model (naira to US dollar); CPI = Consumer price index; OILP = World oil prices; USPPI = United States Producers Price Index; β_0 = Constant term (i.e., the intercept); $\beta_1 - \beta_4$ = Coefficients of the explanatory variables.

2.2. Marshall-Lerner condition of balance of payment: The elasticity approach

This study is anchored on the doctrine of the Marshall-Lerner Condition theory of balance of payment espoused in 1890 by Alfred Marshall and Abba Lerner. Jean and Lsabelle [10] assert that the elasticity approach probes how changes in the relative prices of domestic goods and foreign goods due to changes in the rates of exchange affect the trade balances of a country, especially the balance of payment (current account). One of the assumptions of this theory is that income level and domestic prices remain constant within the devaluing country. The second assumption is that the sum of elasticities of demand for a country's imports and exports has to be greater than unity for exchange rate depreciation to have a positive effect on a country's balance of payments (BoPs). On the other hand, where the sum of these elasticities is less than unity, then the country's BoP position is worsened; however, revaluation can make improvements. This condition can be expressed mathematically as follows:

$$\Delta B = KXf\,(\text{e1m} + \text{e2m} > 1) \tag{3}$$

where: ΔB = Change in the trade balance; K = Depreciation in percent; Xf = Value of exports expressed in foreign currency; e1m = First (devaluing) country's demand elasticity for imports; e2m = Second country's demand elasticity for exports from the devaluing country. Thus, e1m + e2m should be greater than 1 for Marshall Lerner condition to be fulfilled.

2.3. Empirical literature review

Various studies have investigated the impact of exchange rates on foreign trade in various locations, some of which include studies on Nigeria. For instance, Duru et al. [11] investigated the impact of exchange rate volatility on exports in Nigeria and found that exchange rate volatility had a positive and insignificant relationship with exports. Similar to the results of Duru et al. [11], Nuraddeen et al. [12] investigated the asymmetric effect of exchange rate volatility on trade balance in Nigeria. Results of the study indicate an insignificant relationship between the real exchange rate and the volume of Nigeria's international trade. The findings above are similar to the works of Ewubare and Merenini [13], who examined the impact of exchange rate fluctuations on foreign trade in Nigeria from 1980–2014 and found that exchange rate fluctuations have a positive but non-significant relationship with trade in Nigeria. The results above contradict the findings of Yakubu et al. [14], who examined the impact of exchange rate volatility on trade flows in Nigeria utilizing monthly time series for the period 1997–2016 and found that fluctuations in the exchange rate impacted negatively on Nigeria's trade flows only in the short run. Similar to the findings of Yakubu et al. [14], Ikechi and Nwadiubu [15] investigated the impact of exchange rate volatility on international trade in Nigeria and found that an inverse relationship exists between export, import, and REER. Apanisile and Oloba [16] utilized the non-linear autoregressive distributed lag technique to determine the asymmetric effect of exchange rate changes on cross-border trade in Nigeria. The study indicated that exchange rate appreciation had a statistically significant but negative relationship with cross-border trade in Nigeria.

Furthermore, Aliyu et al. [5] investigated exchange rate pass-through to consumer price index and import in Nigeria utilizing quarterly time series of 1986Q1 and 2007Q4, anchoring the work on the basis of vector error correction methodology. The findings reveal that exchange rate pass-through in Nigeria is significantly low, but compared to the consumer prices, it is slightly higher in the import prices. Aisen et al. [9] conducted an empirical assessment of exchange rate pass-through on domestic prices in Mozambique. The results suggest that exchange rate variations have an asymmetric effect on domestic prices. Azeez et al. [17] empirically investigated exchange rate pass-through to domestic prices in Nigeria. Results of the study suggest that the exchange rate pass-through is incomplete, low, and fairly slow. In line with this, Fatai and Akinbobola [8] also empirically examined the impact of exchange rate pass-through (ERPT) to import prices, monetary policy, and inflation in Nigeria and found that during the period under review, ERPT in Nigeria is moderate, significant, and persistent in the case of import prices and low and short-lived in the case of inflation.

This present study makes significant theoretical (Marshal-Lenner condition) and empirical contributions by employing the elasticity approach to explaining exchange rate depreciation and balance of trade in Nigeria through the medium of exchange rate pass-through. This study not only examines exchange rate pass through to inflation through the elasticity prism of Marshall-Learner theory (the base model) but takes a step further by investigating the impact of the exchange rate pass through to inflation on Nigeria's trade balances (the main model). In order to achieve this, the residual of

the base model is fed into the main model in order to capture this effect following the work of Chen et al. [18].

3. Methodology

3.1. Data and sources

This work utilized monthly time series data from 2011–2022. Monthly time series empirically is more useful than other frequencies of time series as it is useful for capturing fluctuations in key variables, including exchange rate fluctuations, price fluctuations (inflation), and other variables employed. This is also an improvement in existing studies. Secondary data on relevant variables were sourced from the World Bank database, the Central Bank of Nigeria (CBN), and the United States Statistical Bulletin. US dollars per unit of the Nigerian naira at the black market rate are used to measure the exchange rate. This is because a couple of years ago, the naira was usually bought using black market rates, so the naira's depreciation was expressed as a fall in the value of the naira. Exchange rate data were sourced from the Central Bank of Nigeria statistical bulletin. The United States Producers Price Index was used to measure prices of imports. This is because the United States is Nigeria's biggest trading partner. The data for the United States Producers Price Index were obtained from the US Bureau of Labor statistics. Also, from the Central Bank of Nigeria statistical bulletin, we obtained the consumer price index, which is measured by composite CPI (November 2009 = 100). Data for crude oil prices were sourced from the World Bank commodity price data bank (the pink sheet). The balance of trade and the export data were sourced from the CBN Statistics Database. All variables used for the study had to be seasonally adjusted due to the monthly time series employed to allow for a more meaningful comparison of the economic conditions during the period investigated.

3.2. Model specification

The study used two models to examine the impact of the pass-through of the exchange rate to inflation on the balance of trade in Nigeria. The base model is a three-variable VAR model used to investigate EXRPT to inflation. The main model is a 5-variable VAR model with reference to Bada et al. [6] and a VECM extension. The baseline model has nominal exchange rates (NER), import prices (USPPI), and oil prices (OILP) as independent variables, while the dependent variable is the consumer price index (CPI). An increase in oil prices leads to higher oil receipts, leading to an appreciation in the rates of exchange and a decline in the rate of inflation [6].

In the main model, the residual of the base model (residual of CPI) and exports were included. The residual of the base model is used to proxy the impact of domestic prices (inflation) on the balance of trade in Nigeria. The residual of CPI in this work consists of other factors affecting trade balances other than exchange rate, oil prices, exports, and import prices. Therefore, when RGDP increases, output increases, which increases domestic commodities for exports and, of course, improves the balance of trade. Also, an increase in money supply, ceteris paribus, will encourage consumption, which will also have a positive impact on GDP and so improve trade balances.

Although, when money supply increases, the demand for imported goods will increase, especially in the case of an import-dependent country like Nigeria, through the income absorption effect, which therefore causes imports to increase accompanied by an unfavorable balance of trade. It is worthy to note that if output increases more than money supply in the long run, it may trade off the negative impact of inflation or domestic prices. Hence, the impact can be positive or negative. Thus, we expect that exchange rate and crude oil prices will have vector coefficients that will be positive or negative on the balance of trade. Import prices will be negative and export prices will be positive.

Thus, the exchange rate pass-through to Nigeria's inflation and the subsequent impact on the balance of trade are stated as follows:

Base model is stated thus:

$$CPI_t = \beta_0 + \beta_1 CPI_{t-1} + \beta_2 REER_{t-1} + \beta_3 USPPI_{t-1} + \beta_4 OILP_{t-1} + \varepsilon_t \quad (4)$$

Main model is stated thus:

$$BOT_t = \beta_0 + \beta_1 BOT_{t-1} + \beta_2 REER_{t-1} + \beta_3 USPPI_{t-1} + \beta_4 OILP_{t-1} + \beta_5 EXPT_{t-1} + \beta_6 RESCPI_{t-1} + \varepsilon_t \quad (5)$$

3.3. Definition of the coefficients in base and alternative models

BOT = Balance of trade; REER = Real effective exchange rate for the base model (naira to US dollar); CPI = Consumer price index; OILP = World oil prices; USPPI = United States Producers Price Index; EXPT = Export; RESCPI = Inflation, proxied by Residual of CPI; ε_t = Stochastic disturbance or error term; β_0 = Constant term (i.e., the intercept); $\beta_1 - \beta_4$ = Coefficients of the explanatory variables.

The VAR and VECM estimation techniques are employed in this study, similar to Bada et al. [6]. The VAR model is stated thus:

$$Y_t = c + \sum \Phi_i Y_{t-1} + \varepsilon_{ti} \quad (6)$$

where: Yt is the endogenous variables vector, c equals constant's vector, Φi equals the autoregressive coefficient's vector. εt stands for white noise processes vector.

The VECM extension of Equation (6) is stated as follows:

$$\Delta y_t = c + \prod Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \, \Delta Y_{t-1} + \varepsilon_t \quad (7)$$

where Δ = Operator differencing and $\Delta y_t = y_t - y_{t-1}$, Y_t = Vector variable endogenous with the 1st lag. ε_t = Vector residual; c = Vector intercept; Π = Matrix coefficient of cointegration. Γ_i = Matrix with order $k \times k$ of coefficient, endogenous of the i-th variable.

To start the analysis of our model, we subjected our variables to descriptive statistics to investigate their individual characteristics. Augmented Dickey Fuller (ADF) tests were employed to check the time series properties of the variables in order to establish the order of integration of the series. The Johansen and Juselius cointegration test was carried out to investigate the existence of long run cointegration. The VAR is advantageous since it gives efficient coefficient estimates.

3.4. Justification of variables for the study

Consumer price index (CPI): According to International Monetary Funds (IMF), consumer price indexes (CPIs) are index numbers that measure changes in the prices of goods and services purchased or otherwise acquired by households, which

households use directly, or indirectly, to satisfy their own needs and wants. The consumer price index serves as a relevant proxy for inflation because it expresses the price level, which measures the current prices of goods and services produced in the economy in a specific region or country at a specific time. According to Zubair et al. [19], the consumer price index (CPI) is the best measure for inflation because it tracks the changes in prices paid by consumers for a basket of goods and services over time. This then justifies using it to investigate exchange rate pass-through to inflation. It is represented as CPI in our base model. This is our dependent variable in the base model.

3.5. Residual inflation (RESCPI)

It is the residual of the consumer price index (residual of the results on CPI gotten from the base model) that is inputted into the main model to investigate the effect of the pass-through of the exchange rate to domestic prices (inflation) on balance of trade. Since it has been established that the pass-through of exchange rate to balance of trade is not a direct relationship, the residual of the base model becomes relevant to the main model to investigate the impact of inflation on balance of trade. From this, we can say that the residual of the base model thus serves as the portion of general inflation affected by exchange rate depreciation or pass-through (which affects the domestic economic variables such as real GDP and money supply, amongst others). One might want to argue that the residual also includes results of the import prices and oil prices, but we were careful to select external variables that are affected by the exchange rate, and thus their residual would have an underlying pass-through of exchange rate implications to all variables that are subsequently inputted into the domestic economy, such as oil and imported goods. We ensured that the residual of the base model passed through all the relevant tests, including multicollinearity, heteroscedasticity, and serial correlation tests, before inputting it in the main model. We did these tests of the residual of our base results to clear suspicion of endogeneity and other residual errors as suggested by Chen et al. [18].

3.6. Balance of trade (BOT)

Foreign trade, or international trade, is the exchange of goods and services between two countries in the international market. Balance of trade (BOT) is the difference between the value of the exports of a country and the value of the imports of that country for a given period. Given this, balance of trade serves as a relevant proxy for foreign trade in this model. When the value of imports is higher than that of exports, it is a balance of trade deficit, and when the value of exports is higher than imports, it is a balance of trade surplus. This is our dependent variable in the main model. It is represented as BOT in our model above.

3.7. Real effective exchange rate (REER)

According to the International Monetary Fund [4], the nominal effective exchange rate is a measure of the value of a country's currency against a weighted average of several foreign currencies. When the nominal effective exchange rate is divided by a price deflator or index of costs, the result is the real effective exchange rate.

The World Bank stressed that when the nominal effective exchange rate index is adjusted for movements (relative) in national price or cost indicators of the home country, selected countries, and the euro area, it results in the real effective exchange rate. The index ratio for the nominal effective exchange rate index (expressed on the basis 2010 = 100) is the index of a currency's period-average exchange rate to a weighted geometric average of exchange rates for currencies of selected countries and the euro area. Advanced countries have their weights derived from trade in industrial or manufactured goods. For developing countries, the goods manufactured and primary products traded with partner or competitor countries set the base for the nominal effective exchange rate. More so, for these developing nations, when the nominal index is adjusted for relative changes in consumer prices, the result is the real effective exchange rate index, and as such, an increase represents an appreciation of the local currency. A market-based economy evidences their choices about resource allocation being influenced by relative prices, including the real exchange rate, real wages, real interest rates, and other prices in the economy. Relative prices also reflect their choices to a large extent. Therefore, relative prices convey vital information about the interaction of economic agents in an economy and with the rest of the world.

Under the fixed exchange rate regime, an upward adjustment of the rate of NEER is termed revaluation, and a downward adjustment reflects devaluation. However, in a flexible exchange rate regime where the forces of demand and supply determine the exchange rate, the upwards and downwards adjustments are called appreciation and depreciation, respectively. It is important to note that in this study on inflation-balance of trade nexus, we adopted the concepts of devaluation and depreciation simultaneously, as we are only interested in the outcome of the policy and not in the definition of the concepts themselves. They both lead to a fall in the exchange rate, whether imposed by the government or enabled by the flexible exchange rate regime.

A depreciating exchange rate or one devalued by the government does not improve the balance of trade for an import-dependent country like Nigeria. This is because it would encourage the importation of necessary goods that aid domestic production and consumption but make export goods too costly due to imported production goods. Therefore, despite the depreciating rate of exchange, there is no improvement in trade surplus due to import inelasticity. This will further increase the prices in the domestic economy, making the production of export goods expensive and thus reducing the volume of export. The response of domestic prices to changes in exchange rates is called exchange rate pass-through. This has profound implications for not only the domestic economy but, subsequently, the balance of trade. Oluyemi and Isaac [20] defined exchange rate pass-through (ERPT) as the percentage change in local currency prices resulting from a one percent change in the exchange rate between the exporting and importing economies. It refers to the changes in domestic prices as a result of the depreciation of the exchange rate. The resulting impact of a pass-through of exchange rate to domestic inflation has a subsequent impact on balance of trade; however, the pass-through effect is not direct. This is why the pass through in the CPI model is inputted in the BOT model. In the CPI model, we would want to see the magnitude of the pass-through of this exchange rate to domestic inflation and if the pass-through elasticity is complete. If it is complete (up to 1), there would be no need to input in the main model as there would be no elasticity to impact

a change; however, if the elasticity is not complete, the residuals of the base model will be inputted to the main model to investigate the pass-through of exchange rate to domestic inflation on balance of trade in Nigeria. In the main model, we are concerned with the direct impact of exchange rate pass through on balance of trade in Nigeria.

The real effective exchange rate is more sufficient than the nominal effective exchange rate or the nominal exchange rate in itself because it is useful for long-term analysis of a country's competitiveness and trade balances by taking into account the impact of inflation on trade.

It is also important to note that the real effective exchange rate is not the same as the exchange rate pass-through. The exchange rate itself is the price of the currency used to trade at the international market; when adjusted for inflation, it is the real effective exchange rate. When it is devalued, it is detrimental to an import-dependent country like Nigeria. This will lead to an increase in the prices of domestic goods and lead to inflation. The pass-through in itself is the transfer of the effect of exchange rate changes to the domestic economy. It shows the portion of the domestic inflation contributed by the devaluing or depreciation of the exchange rate at the international market. If it is complete, this implies that the whole inflation in the domestic country is due to exchange rate changes; however, if it is not complete, the value of the real effective exchange rate elasticity shows us the portion of the domestic inflation attributed to the changes in the exchange rate at the international market.

To stress this, the study by Ikechi and Nwadiubu [15] using the VAR model estimates indicates an inverse relationship between export, import, and REER in current periods. Variance decomposition analysis suggests that the shocks partially explain fluctuations in REER, as well as exports and imports. The impulse response analysis indicates a negative association between exports and the real effective exchange rate, while it was majorly positive for imports throughout the ten periods. This impact on import prices can subsequently be passed into the domestic economy, causing the exchange rate to pass through. Results show evidence of the volatility of REER clustering on import and export trading activities in Nigeria.

However, the study by Fatai and Akinbobola [8] based on SVAR analysis found that ERPT in Nigeria during the period under review is moderate, significant, and persistent in the case of import prices and low and short-lived in the case of inflation. The fact that ERPT was found to be incomplete shows the dependence of exchange rate pass-through on REER.

3.8. The United States Producer Price Index (USPPI)

United States producer price indices in manufacturing measure the rate of change in prices of products sold as they leave the producer. They exclude any taxes, transport, and trade margins that the purchaser may have to pay. It is relevant in the balance of trade model to proxy import prices to Nigeria's trade balances since the United States is one of Nigeria's largest trading partners. In this work, import and export demand elasticities are governed by the demand side of the economy. This makes the import variable relevant to our base model because the responses of aggregate imports to changes in relative prices depend on consumers' willingness to substitute domestic goods for foreign goods. Thus, inputting the import variable in the base model is

expected to give us an elasticity to verify this stance. Therefore, drawing the elasticities of import demand in our base model becomes imminent even for theoretical justification (Marshall-Lerner elasticity condition).

3.9. World oil prices (OILP)

Crude oil is the world's most widely traded and used commodity. Oil and its derivatives still power the bulk of global transportation and serve as cooking and heating sources in developing countries. It is relevant to the models because the world remains so reliant on crude oil, and it accounts for a large portion of Nigeria's receipts on trade. Its price is heavily dependent on the pace of economic growth, which affects demand prospects and domestic inflation. This translates into rising general prices with an attendant decrease in aggregate demand, and in this case, real GDP growth performs negatively as well as trade balances. This is also one of our control variables. It is represented as OILP in both base and main models.

3.10. Exports (EXPT)

Exports are goods and services that are produced in Nigeria and sold to buyers in other countries at the international market. Nigeria's foreign trade is affected by our exports, and the balance of trade is determined by the difference between the exports and imports. When exports are high, it leads to a balance of trade surplus and vice versa. Therefore, it is relevant in the model to investigate the balance of trade movements and values. More so, our theoretical reference hinges on the elasticity of this export variable. According to Danladi et al. [21], the price elasticity of imports is a trade-weighted average of the sectoral elasticities of substitution of the domestic consumer (affecting the consumer price index); the price elasticity of exports is similar, but the average is now taken both across sectors and destination markets (trade balances). The international dispersion in import price elasticities depends mostly on preference parameters, whereas export price elasticity varies with the composition of trade. Thus, to justify the Marshal-Lerner elasticity condition in our work, the export values and elasticity become important.

4. Results and discussion

The descriptive statistics in **Table 1** helps to understand times series data and its properties. It presents the mode, mean, median, standard deviation, skewness, kurtosis, and Jarque-Bera statistics.

Table 1. Descriptive statistics of the variables (main model).

	BOT	REER	USPPI	OILP	EXPT	CPI	RESCPI
Mean	695.91	79.00160	115.4863	74.40736	5398.624	241.3637	-4.75×10^{-16}
Median	627.42	76.90000	111.9000	68.83000	5017.460	214.6400	0.642363
Maximum	5707.68	107.3500	141.0980	117.7900	10906.09	499.4000	15.64076
Minimum	−3726.46	59.01000	103.7000	21.04000	1920.610	115.5900	−18.61756
Std. Dev.	1847.55	11.13770	9.090714	25.58903	2106.435	103.7642	5.700243
Skewness	0.161	0.492554	1.424110	0.069293	0.399680	0.750033	−0.333902
Kurtosi	2.68	2.490818	4.342443	1.645554	2.172574	2.518829	3.733537

Table 1. (*Continued*).

	BOT	REER	USPPI	OILP	EXPT	CPI	RESCPI
J. Bera	1.216	7.378230	59.487	11.122	7.831	14.89	5.822233
Prob	0.544188	0.024994	0.000000	0.003844	0.019927	0.000584	0.054415
Obs	142	144	144	144	142	144	144

Source: Authors' computation, 2024.

The values of the mean of the variables indicate that EXRPT has the highest monthly mean, followed by BOP and CPI. The maximum values are 5707.680, 107.3500, 141.0980, 117.7900, 10906.09, 499.4000, and 15.64076, respectively, for BOT, REER, USPPI, OILP, EXPT, CPI, and RESCPI. The minimum values are −3726.460, 59.01000, 103.7000, 21.04000, 1920.610, 115.5900, and −18.61756 respectively for BOT, REER, USPPI, OILP, EXPT, CPI, and RESCPI. The values of the standard deviation revealed the measure of variability of the variables from their long-term mean values, respectively, every month.

4.1. Stationary test (ADF TEST)

The unit root test (ADF) result of the main model is presented in the **Table 2** below.

Table 2. Summary of unit root test for the variables.

Variables	ADF stat	ADF critical value	Order of integration
CPI	−3.485673	−3.443704	Level (1)
BOT	−9.081032	−3.498692	Level (1)
REER	−11.56742	−3.441777	Level (1)
USPPI	−11.86552	−3.442006	Level (1)
OILP	−8.983128	−3.442006	Level (1)
EXPT	−14.00191	−3.442238	Level (1)
RESCPI	−11.02598	−3.442955	Level (1)

Source: Authors' computation, 2024.

The stationarity test from the table implies that all the variables are stationary at first difference. So, the cointegration test can now be conducted, as this meets the condition under which the test could be applied.

4.2. Co-integration test

Here, we seek to establish the existence of long-run relationships or cointegrating relationships among these variables. The empirical result from the Johansen cointegration analysis is presented in **Table 3** for the main model.

Table 3. Summary of co-integration test for main model.

Hypothesized No of Ces		Trace stat		Max eigen Val		Prob. Val	
	Eigen Val	Stat. Val.	Critical Val.	Sta Val	Critical Val		
						Trace	Max-eigen
None	0.842036	189.5189	95.75366	83.04246	40.07757	0.0000*	0.0000*

Table 3. (*Continued*).

Hypothesized No of Ces		Trace stat		Max eigen Val			Prob. Val
	Eigen Val	Stat. Val.	Critical Val.	Sta Val	Critical Val		
						Trace	Max-eigen
At most 1	0.661345	106.4765	69.81889	48.72480	33.87687	0.0000*	0.0004*
At most 2	0.554852	57.75170	47.85613	36.42073	27.58434	0.0045*	0.0028*
At most 3	0.291240	21.33097	29.79707	15.49074	21.13162	0.3373	0.2560
At most 4	0.113409	5.840230	15.49471	5.416725	14.26460	0.7143	0.6886
At most 5	0.009367	0.423504	3.841466	0.423504	3.841466	0.5152	0.5152

Source: Authors' computation, 2024.

From the outcome of the Johansen cointegration using the trace statistics, we conclude that there is a long-run relationship that exists among the variables for the main model. In this regard, we will investigate the base and main models using VAR to investigate the pass-through of the exchange rate to domestic prices (inflation) on trade balances in the short and long run.

4.3. The vector auto regression (VAR) model of the base model

The relationships between the variables of the base model were investigated using the VAR model to generate the coefficients of the parameters of the model. The result is presented in **Table 4**:

Table 4. Summary of the base model vector auto regression (VAR) results.

	Coefficient	Std. error	*t*-statistic	Prob.
LNCPI (1)	1.257249	0.082905	15.16494	0.0000
LNCPI (2)	−0.263592	0.082484	−3.195677	0.0017
LNREER (3)	0.006219	0.009247	0.672503	0.5024
LNREER (4)	−0.006313	0.009362	−0.674347	0.5013
LNUSPPI (5)	0.042775	0.039943	1.070904	0.2862
LNUSPPI (6)	0.009511	0.039419	0.241273	0.8097
LNOILP (7)	−0.000333	0.003746	−0.088938	0.9293
LNOILP (8)	−0.004545	0.003941	−1.153370	0.2508
C (9)	−0.185194	0.110572	−1.674878	0.0963

Source: Authors' computation, 2024 using E-Views 10.

The short-run pass-through of exchange rate elasticity to domestic prices is 0.006 for REER at lags 1 and 2. It evidenced a value of 0.04 for USPPI at lag 1 and 0.10 at lag 2, however, not statistically significant at the 5 percent level, whereas OILP with values of 0.0003 and 0.005 show incomplete elasticities too. A thorough look at what constitutes the CPI basket on average indicates that the CPI basket includes about 0.19% of goods and services that were produced in the country using locally sourced materials, leaving the balance of about 0.81% to be imported. The consumer price index on food alone was about 0.98% per cent of the total CPI, indicating a high rate of food inflation. Import demand had a positive impact on the domestic price level during the period investigated, implying that, on average, increasing import prices may

lead to an increase in the domestic price level, with values of 0.04 and 0.10 at respective lags despite not being too significant. The positive relationship is in line with theory. As a result, the exchange rate pass-through effect impacted mainly on commodities imported and used in production domestically, due to the fact that foreign currencies are required to import them.

Evidence from the study also shows that the real effective exchange rate (REER) exhibits a positive relationship with domestic prices at lag 1 and a negative relationship at lag 2. Thus, if other variables are held constant, an increase in the real effective exchange rate of 1% will cause, on average, a rise in the domestic price of 0.006% and a decrease by the same value at lag 2. This is also in line with theory, because when the exchange rate of the domestic currency increases, the domestic price level increases too. Also, if a large portion of a country's trade is dominated by the demand for foreign currency, exchange rate fluctuations will strongly affect the rate of inflation. On the other hand, the impact of world oil prices (OILP) is seen to be negative on domestic prices in Nigeria, implying that if other variables are held constant, an increase in world oil prices by 1% leads to a decrease in domestic prices by 0.003% on average at lag 1 and 0.005% at lag 2.

4.4. The main model

The VAR result for the main model is presented in **Table 5**.

Table 5. Summarized VAR for the main model.

	Coefficient	**Std. error**	***t*-statistic**	**Prob.**
C (1)	−0.251882	0.099732	−2.525585*	0.0154
LNBOT (−1)	−0.312191	0.154938	−2.014941*	0.0503
LNBOT (−2)	−0.204830	0.143818	−1.424229	0.1618
LNREER (−1)	−3.706961	3.770808	−0.983068	0.3312
LNREER (−2)	−4.747804	7.434920	−0.638582	0.5266
LNUSPPI (−1)	−3.433536	53.42053	−0.064274	0.9491
LNUSPPI (−2)	−104.0289	58.09037	−1.790811**	0.0805
LNOILP (−1)	1.131309	5.218370	0.216794	0.8294
LNOILPI (−2)	−9.593715	6.278189	−1.528102	0.1340
LNEXPT (−1)	−0.271338	1.103908	−0.245797	0.8070
LNEXPT (−2)	−0.756618	1.026226	−0.737282	0.4651
RESCPI (−1)	−0.157158	0.066137	−2.376262*	0.0221
RESCPI (−2)	−0.035121	0.023858	−1.472102	0.1484
C	0.167690	0.154584	1.084778	0.2842
R-squared	0.501445	Mean dependent var		−0.032063
Adjusted *R*-squared	0.347130	S.D. dependent var		0.882920
S.E. of regression	0.713403	Akaike info criterion		2.374777
Sum squared resid	21.37563	Schwarz criterion		2.881115
Log likelihood	−52.49375	Hannan-Quinn criter.		2.571083
F-statistic	3.249497	Durbin-Watson stat		2.230733
Prob(*F*-statistic)	0.001864			

Source: Authors' computation, 2024; *5% significance, **10% significance.

From **Table 5**, it is observed that the composition of the trade basket indicates that the short-run elasticity of domestic prices on balance of trade is incomplete at 0.15 and 0.04 for lags 1 and 2, respectively, where lag 1 is statistically significant and lag 2 is statistically insignificant at 5%. Evidence from the table also shows that the relationship between BOT and REER is negative at lag one and lag 2, including that of EXPT (RESIDCPI) and import prices (USPPI). However, the relationship between BOT and OILP (oil prices) is positive in lag 1 and negative in lag 2. Post-estimation tests such as autocorrelation, heteroscedasticity, and multicollinearity tests were conducted. The correlation of the VAR residuals reveals that no contemporaneous correlation exists in the model. In general, the results of the residual tests indicate that there is no serial correlation and that we have homoskedastic residuals. We then go ahead and investigate the pass-through effects for the main result using the VECM estimation technique.

4.5. Long run VECM results

For the main model, the long-run elasticity of the VECM results in **Table 6** shows the relationship that each of the independent variables has with the dependent variable. Evidence from the table shows that in the long run, the relationship between BOT and REER is positive in line with that of USPPI and EXPT. However, the relationship between BOT and OILP (oil prices) is negative in line with residual CPI in the long run. Although, for the RESCPI coefficient, the absolute value 0.44 implies that ceteris paribus, when there is a percentage increase in inflation or domestic prices, it will lead to a 0.44% decrease in BOT in the long run. It is statistically significant at 5% in the long run. Post-estimation tests such as autocorrelation, heteroscedasticity, and multi-collinearity tests were conducted. The correlation of the VECM residuals reveals that no contemporaneous correlation exists in the model. In general, the results of the residual tests indicate that there is no serial correlation and that we have homoskedastic residuals.

Table 6. Vector error correction model (VECM) results—The long run results.

	Vector error correction estimates						
CointegratingEq:	**LNBOT (−1)**	**LNREER (−1)**	**LNUSPPI (−1)**	**LNOILP (−1)**	**LNEXPT (−1)**	**RESCPI (−1)**	***C***
CointEq1	1.000000*	1.084098	15.97387*	−1.251063	4.161733**	−0.437541*	−118.3033
		(2.00454)	(6.55787)	(2.95865)	(2.27808)	(0.21713)	
		[0.54082]	[2.43583]	[−0.42285]	[1.82686]	[−2.01507]	

The result in brackets and parenthesis are t-statistics and standard error respectively while 1 and 2 asterisks represent significance at 5% and 10% levels respectively.
Source: Researchers' computation, 2024.

4.6. Impulse response test for the main model

The impulse response plots (**Figure 1**) represent the response of balance of trade given an impulse in other variables. In the first graph, we plot the impulse response of BOT to REER. When REER goes up by 1 unit of measurement, BOT falls by twice the amount, but the next month's witness over 200% increase in balance of trade to a positive value of 2, but the impact of a shock on REER today on future BOT goes to 0 towards the end of the time period. The distance of the responses (red lines) from

the impulse (blue line) shows that this impact is statistically significant in all periods.

More so, when OILP goes up by 1 unit, BOT goes up at a steady rate from 0–1 month. From the second till the third month, there is a steady increase in the response of the balance of trade on the shock of OILP, but a decline is seen from the third till the fourth month, which is still positive. This result is similar to that of the variance decomposition, as the impact of OILP on the balance of trade was steadily increasing till it started experiencing a decline from the third period. This trend has been consistent till the last period, although not in the same magnitude. However, the impact was positive and above 10%. The distance of the responses (red lines) from the impulse (blue line) shows that this impact is statistically significant in all periods.

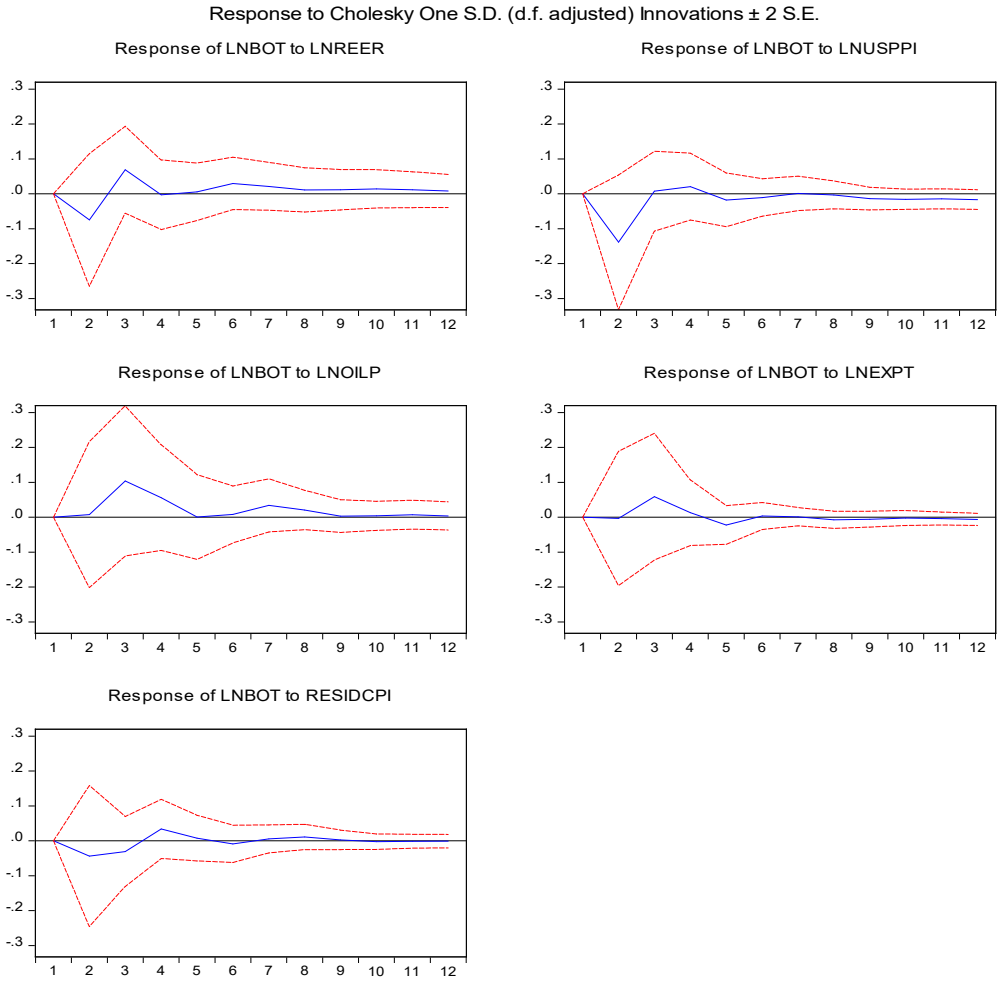

Figure 1. Impulse response test for the responses of balance of trade in Nigeria to the impulses of selected variables from 2011–2022.

Similarly, when USPPI goes up by 1 unit of measurement, BOT falls by over 100% immediately to negative values of −1. The distance of the responses (red lines) from the impulse (blue line) between 0 and −1 shows that this impact is statistically significant in all periods. This is also consistent with our variance decomposition result, as USPPI maintained a wide influence from the first time period till the last. Although witnessing an upward movement in balance of trade response to USPPI shocks within the second to third period, the negative shock on balance of trade to changes in USPPI is steady towards the line till the last period. These changes within

the 2nd–4th periods are consistent with our variance decomposition result breakdown. More so, the negative result is consistent with our regression result, and this explains that the impact of a shock of USPPI today on future BOT remains negative successively in the future time periods with over 100% magnitude.

For the response of BOT to EXPT, when EXPT goes up by 1 unit or there is a unit shock in EXPT, BOT is impacted with little response to this shock. Evidently, successive shocks in the future time period witnessed no significant magnitude or response of BOT to these changes. This is also evident in our variance decomposition result, as EXPT has influence on BOT around 0 to 2. Whereas the influence increased a little over 1% on our variance decomposition table at the third period, it is not strong enough and still maintained such stance till the end of the time period under investigation.

Evidence from the impulse response function also indicates the response of balance of trade (BOT) to RESIDCPI. Thus, a one S.D. shock, or impulse, given to domestic factors that cause inflation will result in a negative impact on the balance of trade (BOT) within the first three months, followed by a sharp increase from the third month, which was steady and remained so till the last period. The distance of the responses (red lines) from the impulse (blue line) shows that this impact is statistically significant in all periods. It is worthy to note that whereas there is a positive response to the shock of RESIDCPI, the magnitude is not too large in successive time periods and remained within the 0 point. This is consistent with our variance decomposition and regression results.

4.7. Variance decomposition

The variance decomposition is useful to us as it demonstrates how significant a shock is in explaining the variations of the variables in the model. It also shows how that shock changes over time. It is relevant in our work because the table plots the composition of the error variance of the variables concerned across shocks at each time period.

Observing **Table 7**, the variance decomposition shows how important each random innovation is to the balance of trade in Nigeria. From the results, 100% of BOT is accounted for in its own variance, but decreases to 58.1% at the 140th month. More so, oil prices and exports are shown to explain about 28% and 21%, respectively, of its historical variations in the 40th month, and declining only to about 0.9% and 0.34% at the 140th month. The massive decline in EXPT and OILP is witnessed after the RESCPI and USPPI took a larger portion of impact at the 60th month for values of 11.1% and 30.2%, respectively, and maintained through till the 140th month at 12.8% and 28% each. However, the real effective exchange rate maintained a small portion of variation in balance of trade during the 144 months. This result, thus, implies that Nigeria's balance of trade is being significantly influenced by import prices and domestic prices, which empirically and historically have been important in explaining Nigeria's balance of trade positions. This result affirms the assertion that the effect of exchange rate changes (exchange rate pass-through) on foreign trade (BOT) in Nigeria is significantly dependent on the country's level of inflation and import.

Table 7. Summary of the variance decomposition of the main model.

Period	S.E.	LNBOT	LNREER	LNUSPPI	LNOILP	EXPT	RESCPI
1	0.713403	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
20	2.357643	51.11635	2.635512	35.44163	1.247321	4.820524	4.738663
40	1.449805	41.80129	2.197307	6.000695	28.26297	21.26608	0.471659
60	5.692852	56.25890	0.556299	30.15001	0.987103	0.998627	11.04905
80	6.946883	57.11729	0.393609	28.97965	0.957815	0.675892	11.87574
100	8.023124	57.58971	0.309236	28.32194	0.941892	0.509283	12.32794
120	8.975201	57.88120	0.258224	27.91327	0.932104	0.408752	12.60646
140	9.836560	58.07700	0.224191	27.63810	0.925537	0.341730	12.79344

Source: Researchers' compilation, 2024.

4.8. Discussion of findings

4.8.1. For exchange rate pass-through to domestic prices

Results from the base model indicate that the exchange rate pass-through elasticity to Nigeria's inflation is found to be incomplete at lags 1 and 2, where the pass-through elasticity is 0.006 at both lags. This supports the results of Bada et al. [6], where the pass-through elasticities in the long run in Nigeria were found to be incomplete at values of 0.24 for the baseline. This result supports Krugman's explanation that "firms do not change prices immediately when exchange rate changes, resulting in lower CPI pass-through". More so, the substitution effect can also explain it in part, whereby there will be an increase in import prices, which leads consumers to import substitute goods. The costs of these substitute goods are lower than their imported counterparts, which explains the lower pass-through to inflation (CPI) from the regression analysis. Therefore, exchange rate pass-through relates positively and has statistical significance with domestic prices in Nigeria.

4.8.2. For RESIDCPI to BOT

The results from the main model show that domestic prices (proxied by residual CPI) have a negative impact on the balance of trade at lag 1 and lag 2, as they decrease it by 0.16% and 0.04%, respectively. It can also be deduced from the estimates that a unit increase in RESIDCPI as a result of depreciation in Nigeria's exchange rate, on average, brings about a decrease of about 0.016% in balance of trade. More so, lag 2 shows a negative impact of 0.04% on the balance of trade in Nigeria. This is in line with economic theory. Also, we explained that RESCPI is the portion of domestic inflation contributed by exchange rate depreciation, affecting domestic factors (such as RGDP, money supply, wage rate, marginal propensity to save, consumption, amongst others) in Nigeria; therefore, the negative impact could imply that the exchange rate depreciation affected the GDP during the period investigated, leading to a reduction in productivity for export and consequently a negative balance of trade. Furthermore, increases in money supply resulting in an increase in importation (Marginal propensity to import), ceteris paribus, offset other efforts to increase exports and instead cause an unfavorable balance of trade.

4.8.3. For real effective exchange rate to BOT

The result from the main model finds the coefficient of the real effective

exchange rate on the balance of trade to be negative but statistically insignificant at 5% and 10% for lags 1 and 2, respectively. The negative result is consistent with economic theory evidencing an unfavorable balance of trade as a result of real exchange rate depreciation for an import-dependent country like Nigeria. This means that when there is an increase in the value of currency (exchange rate) by one unit, there will be a decrease in balance of trade on average by 4% and 5% at lags 1 and 2, respectively, thus making exports expensive and imports of production resources expensive, thus leading to an unfavorable balance of trade. This will discourage domestic production since import substitution industries rely on imported machinery for production, and efforts towards export promotion will be hampered as the cost of domestic goods will become expensive at the international market. The elasticity is high with values greater than one, implying that the magnitude of changes in the real effective exchange rate on the balance of trade in Nigeria is high. However, in the long run, there is a positive relationship between the real effective exchange rate and the balance of trade.

4.8.4. For OILP to BOT

The findings of the study also showed that there is a positive and statistically insignificant relationship between world oil prices and balance of trade in Nigeria at lag 1 but a negative relationship at lag 2 during the period investigated. Thus, since crude oil constitutes the majority of Nigeria's exports, when the prices of oil increase, the receipts will increase through increased values of exports, thereby improving our balance of trade by 1.1% on average. However, since we import refined oil, the increase in value of oil prices will lead to a decrease in balance of trade by 10% on average. This is consistent with economic reality and theory. However, there is a negative long-run relationship that exists between balance of trade and oil prices.

4.8.5. For import and export to BOT

The findings of the study also showed that import and export prices have a negative and statistically insignificant impact on the balance of trade in Nigeria at lag 1, however, at lag 2, there is a negative relationship with the balance of trade and a statistically significant effect at 10% for import prices, and that of exports is statistically insignificant during the period investigated. The negative relationship between imports and balance of trade in Nigeria is consistent with literature. An import-dependent country will have negative trade balances since the value of imports is greater than the value of exports. Evidence from **Table 5** shows that balance of trade decreased by about 3.4% on average relative to export, which was about 0.27 units at lag 1. The difference will have a negative balance, thus reducing the balance of trade. More so at lag 2, with imports having a negative relationship with the balance of trade with a value of 104%. We also observe a negative relationship between exports and balance of trade with a value of 0.76%. This reinforces the balance of trade position for an import-dependent country like Nigeria. This is consistent with the findings of Emehelu and Christopher [22]. However, there is a positive long-run relationship between balance of trade and import and export prices, with both statistically significant at 5% and 10%, respectively. The implication of this finding is that when there is an increase in exports by 1 unit, the appreciation of the currency makes export goods more competitive at the international market, and as such, it becomes cheaper

to import than export, and this subsequently leads to an unfavorable balance of trade. This calls for Nigeria to adopt a fixed exchange rate regime (system) that was dropped in 2014 or a modified/managed floating system in order for exchange rate fluctuations to be controlled and reduce the impact of appreciation on our trade balances using a pegged exchange rate.

From the above findings, we observe that the external sector has a significant impact on our trade balances, and this explains why efforts made by the central authority to control exchange rate volatility in the domestic economy through domestic variables have not yield good results. This calls for appropriate attention on the external sector and the implementation of measures to manoeuvre external fluctuations that significantly impact our trade balances.

4.8.6. Marshal-Lerner elasticity result

In this work, import and export demand elasticities are governed by the demand side of the economy. The response of aggregate imports to changes in relative prices depends on consumers' willingness to substitute domestic goods with foreign goods. For firms, they use these substitutes to produce goods for export (export demand elasticity). With the above justification, we use the import elasticity of the base model and the export elasticity of the main model to justify our Marshal-Lerner condition of BOP in Nigeria to ascertain if depreciation is relevant for an import-elastic country like Nigeria. The absolute values of the import demand elasticities from the base model for lags one and two are 0.039943 and 0.039419, respectively, while those of export demand for lags one and two are 0.271338 and 0.756618, respectively.

BOP = IMP (USPPI) elasticity + EXPT elasticity

Thus,

The sum of elasticity for lag one is 0.0399 + 0.2713 = 0.3112.

The sum of elasticity for lag two is 0.0394 + 0.7566 = 0.7960.

The results of the sum of the elasticities for the two lags shown above are less than 1, which implies that depreciation is not recommended for an import-dependent country like Nigeria. This result is in line with the findings of Ihuoma et al. [23]. Thus, economic conditions that would encourage the depreciation of the naira should be avoided, such as government devaluation of the naira in the fixed exchange rate regime or implementing a flexible exchange rate regime that would encourage depreciation through speculation.

5. Conclusion

This study investigated the impact of exchange rate pass-through to inflation on the balance of trade in Nigeria. As observed, real exchange rate depreciation leading to higher domestic prices could have impacted other sectors of an economy and increased the overall cost of domestic production, causing a rise in inflationary pressures and a subsequent impact on trade balances. This made this work empirically relevant to examine the spillover effect of the pass-through of the exchange rate to inflation on the balance of trade in Nigeria. We first looked at the elasticity and impact of exchange rate pass-through to inflation in the base model and subsequently the impact of this exchange rate pass-through on the balance of trade in Nigeria. We employed a dual model utilizing the VAR and VECM estimation techniques for our

base and main models, anchoring our work on the Marshal-Lerner elasticity approach. With the theoretical framework of the Marshal-Lerner condition, the addition of elasticity of our import and elasticity of our export demand was not up to 1, implying that exchange rate depreciation is not the right policy for Nigeria as it worsens Nigeria's trade balance. More so, while the pass-through of the exchange rate to domestic prices (inflation) was not complete, the study found that exports had a negative impact on the balance of trade in Nigeria. This is theoretically unusual and suggests that the flexible exchange rate is not favorable to exports in Nigeria.

Therefore, it is suggested that Nigeria should adopt a fixed exchange rate that was dropped in 2014 since it will be more favorable for improving the Nigerian economy. This policy should be complemented with an import substitution policy for better results. This will be a good measure because Nigeria is an import-dependent country, and while export promotions are very important, a short-run policy to implement will be import substitution. With time, the demand for foreign currencies will decline and exports will improve, leading to the strengthening of the naira against other currencies. Thus, our findings simply justify that the Nigerian government should fix the exchange rate or peg it at a particular value. The government should not also implement austerity measures as an import-dependent country because it will be detrimental to the economy. It is better to implement austerity measures in the long run when import substitution industries would have improved. This is the steady road to diversification.

Policy recommendations

Based on the findings of this study, our recommendations are as follows:

Although the exchange rate pass-through to domestic prices was not complete (based on Krugman's explanation of price inflexibility and import substitution goods), we recommend a short-run policy of investing more in promoting import substitution industries, which will produce import substitution goods for the domestic economy and reduce the dependence on imported goods.

We also recommend that the borders should not be shut for the importation of various necessary goods, as austerity measures should not be an option for an import-dependent country like Nigeria. This is because instead of improving domestic production and exports, it could lead to policy conflict and cripple the economy since our domestic industries use relevant commodities through joint demand for production and other imported commodities for production, where we have the least comparative and competitive advantage.

In line with the negative relationship between exports and balance of trade in Nigeria, we recommend that the Nigerian policymakers should adopt a fixed exchange rate regime in order to control fluctuations and tackle the spill-over effect of exchange rate pass-through to the domestic economy. This is because Nigeria is import inelastic, and the Marshal-Lenner elasticity condition has given us evidence that the depreciation (flexible exchange rate regime) of the naira is not sufficient in improving our balance of trade. This implies that for an import-dependent country like Nigeria, the exchange rate value is better off pegged to reduce uncertainties/speculations. More so, pegging the exchange rate will mitigate the impact of depreciation and appreciation

of the currency because appreciation will not be favorable as it would discourage exportation, as seen in our result. Thus, a fixed exchange rate will help keep the country's exchange rate value in a favorable position to promote trade and boost the comparative advantage of Nigeria at the international market against the rest of the world while protecting the domestic economy from external fluctuations.

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Article

The nexus between the shadow economy and financial development in Uganda

Stephen Esaku[1,*], Salmon Mugoda[2]

[1] Department of Economics and Statistics, Kyambogo University, Kampala 256, Uganda
[2] School of Economics, Makerere University, Kampala 256, Uganda
*** Corresponding author:** Stephen Esaku, esaku_stephen@yahoo.com

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Abstract: This paper examines the nexus between the shadow economy and financial development in Uganda, making use of yearly time series data over the period 1991 to 2017, and the autoregressive distributed lag (ARDL) method is applied. Findings are quite telling. We find that financial development reduces the shadow economy in a significant manner, in both the long- and short-run. This finding is robust to the use of alternative measures of financial development. Our results have far-reaching implications. Firstly, findings indicate that financial structure plays a key role in mitigating the increase of the shadow economy given that the financial sector can provide access to credit that eases financial constraints faced by entrepreneurs. Thus, a well-functioning financial sector could facilitate access to credit by entrepreneurs, which reduces their motivation to operate underground. These findings seem to suggest that reforming financial institutions to facilitate improved access to domestic credit could help tackle widespread informality in developing economies. Additionally, minimizing informality also requires reforming the political system, institutional framework, and macroeconomic environment to become responsive to the needs of businesses.

Keywords: financial development; informal sector; shadow economy; tax evasion; time series models

1. Introduction

Recently, the financial sector has been viewed as one important variable that could potentially influence the size of the shadow economy (also known as underground economy/sector, informal sector/economy, informality, hidden economy/sector) [1,2]. Consequently, the financial sector facilitates the performance of the overall economy through improved access to the much needed financing for businesses. Furthermore, it provides a means to monitor business transactions for the purpose of taxation [3]. Given its importance, the financial sector can slow down the expansion of shadow activities by raising the opportunity cost of engaging in underground economies [2]. Consequently, this could be a motivation for businesses to operate formally given that banks and/or other financial institutions require these businesses to be visible so as to access financing for their operations [1].

Indeed, the literature reveals that a well-functioning financial sector provides a mechanism through which governments can mitigate the expansion of informal sector activities. For example, Bittencourt et al. [4] advance a theoretical model indicating how poor financial structure increases informality. The above authors examine this theoretical model applying data from 150 economies from 1980 to 2009. They find empirical evidence supporting their theoretical model. Similarly, Berdiev and Saunoris [3] assess the dynamic association between informality and financial

structure in a sample of 161 economies across the world. Their findings show how a developed financial sector is vital in curtailing the expansion of informal sector activities. Additionally, Capasso and Jappelli [2] use a panel vector autoregression framework to study the association between underground economies and financial development, applying data from 161 economies from 1960 to 2009. Their findings reveal that a reduction in the cost of external financing not only reduces the expansion of underground activities but also addresses tax evasion. Additionally, their findings also confirm the conjecture that domestic financial development corresponds with a smaller size of the hidden sector, all else equal. Ridwan et al. [5] investigate the association between financial development and informality in 45 African countries and find no clear effect of financial development on the shadow economy. Their finding seems to contradict previous studies that have shown a negative impact of financial development on informality.

While the bulk of studies indicate a negative impact, some papers have unearthed no clear connection between the two variables. This suggests that the impact of financial development on informality remains a contested issue that is unsettled yet. This paper examines whether there is a relationship between the shadow economy and financial development in the short and long run in Uganda, applying the ARDL method to cointegration to investigate this relationship. The research question we ask is whether an improvement in financial development can reduce informality in Uganda. Uganda is chosen for various reasons. Firstly, this country is characterized as a less developed country that continues to grapple with poverty and inequality. Its financial sector is still evolving but plays a pivotal role in financial intermediation. Investigating whether the financial sector can reduce informal sector activities is meaningful given that informality is wide spread in this country [6,7]. Secondly, Uganda experienced a chaotic economic downturn in the 1970s when the military junta took over power from the elected government of Apollo Milton Obote [8]. The takeover created economic upheaval, which hindered growth of the financial sector, increasing informality in the process. The important question now is whether financial development can reduce wide-spread informality given that explosive shadow activities can be harmful to the official sector [9].

Thirdly, Uganda has undertaken key steps in improving the financial structure over the past 30 years following the introduction of reforms to open up the economy to trade. With these reforms in place, it's plausible to suggest that improvement in the financial sector should negatively affect the shadow economy as credit is expected to be readily available for businesses. Consequently, we investigate whether financial development can dampen citizens' motivation to work in the informal sector.

We make contributions to the literature as follows: Firstly, we investigate the association between the informal sector and financial development in a less studied country. Much of what is known about this relationship is drawn from studies from developed economies. Having another perspective on this relationship from a low-income country goes a long way toward enriching our understanding. Secondly, the findings from this study could help inform policy aimed at mitigating wide-spread informality. The results could also be generalizable to the African context, given that most countries in Africa share common socio-economic characteristics.

The remaining sections of this paper include a literature review, which is

presented in section two; data, which is reported in section three; the methodology presented in section four; the findings and discussion reported in section five; and finally, the conclusion of the study, which is reported in section six.

2. Literature review

The extant literature has indicated that much of the economic activities take place in two sectors: the informal and the formal sectors. Shadow activities show enduring trends over time. Specifically, individuals who survive in informal sector production and distribution activities in the current period were also involved in the same sector (informal) in the previous period [10]. In both the developed and the developing world, informal economy activities are relatively large and difficult to trace because of their hidden nature [7]. Recently, Medina and Schneider [11] show that informal economy activities are increasing in many countries across the world, and the sector's activities are still a substantial part of the production and distribution process in the global economy. The shadow economy continues to contribute to the creation of jobs and generating income for the most vulnerable and disadvantaged segments of the population [8].

Notwithstanding the important contribution of this sector, some analysts argue against its rising pattern. Elbahnasawy et al. [12] reveal that expansion of informality lowers proper use of productive resources and distorts investments of the country since activities in this economy are done clandestinely. Moreover, some studies show that large informality substantially worsens income distribution and impedes economic growth, hence damaging livelihood opportunities for the poor [13]. Consequently, a bulging informal sector seems to be a worrying phenomenon that undermines the effort of governments around the world to improve the livelihoods of their citizens. High levels of informality also worsen efforts to tackle tax evasion and improve revenue collection, hence undermining the provision of social services by the government.

Given the above discourse, the shadow economy has generated concerns from researchers and policymakers over the recent years. This debate is concentrated around four dimensions. First, a number of studies focused their assessment on the size, trends, and causes of informality [11,14]. Second, some have investigated the association between informality and corruption [15]. The third dimension is the interplay between informality and other variables, such as income inequality [13], political stability [12], and democracy [16], among others. The fourth dimension focuses on the relationship between the informal sector and the financial structure of the economy [1,2]. We follow the fourth strand of extant literature that investigates the association between informality and financial development.

3. Data

3.1. Data and data sources

In this paper, we use Uganda's yearly data over the period 1991 to 2017 from a number of data sources. The shadow economy (se17) is from Medina and Schneider [11], financial development (dob), proxied by domestic credit to the private sector by

banks (% of GDP), is the main explanatory variable, while political fractionalization index (govfrac), democracy index (demo), government expenditure (gov/gdp), and GDP per capita growth, or simply growth (gw), are the main control variables to control for economic, fiscal, and institutional factors that influence informality. We also estimate a different equation (alternative specification) where we substitute (dob) for dcf (domestic credit provided by the financial sector) and dcp (domestic credit provided by the private sector), as indicated in the Appendix, **Table A1**.

3.2. Summary statistics

Table 1, panel (a), reports summary statistics, while in panel (b), the correlation matrix is also shown. Average values of the key variables are: shadow economy (Se17), 37.059; financial development (dob), 8.316; fractionalization (govfrac), 0.138; democracy (demo), 0.481; government expenditure (Gov/gdp), 11.473; growth (gw), 3.137; domestic credit provided by the financial sector (dcf) is 9.758; and domestic credit to the private sector (dcp), 9.559. In Panel (b), our main variables of interest (shadow economy and financial development) are negatively connected, indicating a possible relationship between these two variables, an indication that an improvement in financial development is vital in mitigating the spread of shadow activities in Uganda. To confirm this conjecture, we should conduct formal assessments of this association by evaluating how these variables are correlated.

Table 1. Summary statistics and correlation matrix.

	Se17	Dob	Govfrac	Demo	Gov/gdp	Gw	Dcf	Dcp
Panel (a): Summary statistics								
Mean	37.059	8.316	0.138	0.481	11.473	3.137	9.758	9.559
Median	40.300	8.269	0.000	0.000	11.745	3.020	8.861	8.400
Maximum	43.700	13.785	0.588	1.000	16.792	8.140	18.015	16.512
Minimum	28.000	3.528	0.000	0.000	6.636	0.030	2.584	4.001
Std. Dev.	5.778	3.290	0.243	0.509	3.086	2.286	4.783	4.511
Skewness	−0.471	0.121	1.197	0.074	−0.034	0.436	0.252	0.300
Kurtosis	1.518	1.602	2.543	1.005	1.730	2.271	1.933	1.574
#Obs.	27	27	27	27	27	27	27	27
Panel (b): Correlation matrix								
Se17	1.000							
Dob	−0.847	1.000						
Govfrac	−0.451	−0.494	1.000					
Demo	−0.868	0.878	−0.561	1.000				
Gov/gdp	0.719	−0.332	0.354	−0.471	1.000			
Gw	0.293	−0.142	0.025	−0.102	0.443	1.000		
Dcf	−0.731	0.761	−0.260	0.607	−0.308	−0.317	1.000	
Dcp	−0.915	0.968	−0.495	0.881	−0.433	−0.222	0.831	1.000

Source: Authors' calculations.

4. Methodology

4.1. Specification of model for testing the relationship

We predict that informality is a function of variables expressed as follows:

$$se17 = F(dob, govfrac, demo, Gov/gdp, gw) \quad (1)$$

where se17 is a measure of informality, F represents the function, dob is a measure of domestic credit to the private sector by banks, govfrac denotes fractionalization, demo is a measure of democracy, Gov/gdp denotes government spending or expenditure, and gw denotes GDP per capita growth. As a robustness check, we also specify two alternative equations (Equations (2) and (3)), where we use other measures of financial development. In Equation (2), we use credit provided by the financial sector (% of GDP), which we denote as (dcf), while in Equation (3), we use credit provided by the private sector (% of GDP), which we denote as (dcp). We formally express the two equations as follows:

$$se17 = F(dcf, govfrac, demo, Gov/gdp, gw) \quad (2)$$

$$se17 = F(dcp, govfrac, demo, Gov/gdp, gw) \quad (3)$$

As indicated in the literature review, there is reason to believe that the informal economy and financial development are interlinked. As shown in the study of Berdiev and Saunoris [3], a well-functioning financial sector significantly reduces underground activities. In line with the literature, we include political fractionalization. Elbahnasawy et al. [12] and Esaku [8] emphasized that political processes do influence enacted policies, which in turn determine resource allocation. Given the above, resource allocations are usually influenced by the political system, which is crucial in determining the welfare system in place, hence affecting the spread of shadow activities. Furthermore, we also control the state of institutional quality, as this is crucial for the operation of the economy. We capture this by the index of democracy. Extant literature reveals the significance of democracy in influencing informal sector activities [16]. Correspondingly, development has also been indicated to be important in shaping informality [9]. Relatedly, extant literature reveals that government expenditure bears significant influence on informality.

4.2. Estimation strategy

This paper makes use of the ARDL approach proposed by Pesaran et al. [17], which is widely used for testing cointegration as opposed to traditional approaches to cointegration. This approach is acknowledged as a flexible and robust econometric method for investigating cointegration or relationships in time series data [17]. Furthermore, this approach is able to accommodate sufficient lags, allowing for the capture of the data-generating process as a result. Moreover, it can be used regardless of whether the time series are integrated of order zero, I(0s), or order one, I(1s), or even fractionally integrated, but not of order two, I(2s). Additionally, the ARDL approach can also accommodate any sample size, both small and large, and provides reliable estimates regardless of the problem of endogeneity among explanatory variables [18,19]. Moreover, ARDL is able to eliminate residual correlation [20] and has the ability to correct for outliers using impulse dummies [21].

Therefore, we formally express the ARDL model for the empirical estimation of

Equation (1) as follows:

$$\Delta se17 = \beta_0 + \sum_{i=1}^{n} \beta_{1i}\, \Delta se17_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta\, dob_{t-i} + \sum_{i=0}^{n} \beta_{3i}\, \Delta govfrac_{t-i} + \sum_{i=0}^{n} \beta_{4i}\, \Delta demo_{t-i} + \sum_{i=0}^{n} \beta_{5i}\, \Delta gov/gdp_{t-i} + \sum_{i=0}^{n} \beta_{6i} \Delta\, gw_{t-i} + \lambda_1 se17_{t-1} + \lambda_2 dob_{t-1} + \lambda_3 frac_{t-1} + \lambda_4 demo_{t-1} + \lambda_5 gov/gdp_{t-1} + \lambda_6 gw_{t-1} + \mu_t \quad (4)$$

where, β_0 denotes the constant term while $\beta_1, \ldots, \beta_6$ and $\lambda_1, \ldots, \lambda_6$ are the short- and long-run coefficients, and μ_t denotes the error term. Note that Equations (2) and (3) can analogously be expressed as in Equation (4), but with dcf and dcp replacing dob.

Using the *F*-statistic, we first test for cointegration to determine the presence of a long-run relationship among the variables. We express the null hypothesis of no cointegration as $(H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0)$, as opposed to the alternative hypothesis of the presence of cointegration, which is expressed as $(H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq 0)$. The *F*-statistic is assessed against the critical values specified in the study of Pesaran et al. [17]. If the *F*-statistic values are higher than the upper critical bound values, the H_0 (the null hypothesis) is rejected; otherwise, the alternative is accepted. However, there are also cases where the calculated *F*-statistic values are within the bounds; if this is the case, then the test result can be considered undetermined.

We first determine the optimal lag length, ascertained based on the appropriate lag length selection criteria using the Schwartz-Bayesian criterion (SBC), for the ARDL model before conducting ARDL bounds testing procedure. The result of the ARDL testing is shown in the Appendix, **Table A2**.

The error correction model (ECM) for a long-run association is indicated as:

$$\Delta \mathrm{se17}_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i}\, \Delta \mathrm{se17}_{t-i} + \sum_{i=0}^{n} \beta_{2i}\, \Delta \mathrm{dob}_{t-\mathrm{i}} + \sum_{i=0}^{n} \beta_{3i}\, \Delta \mathrm{govfrac}_{t-\mathrm{i}} + \sum_{i=0}^{n} \beta_{4i}\, \mathrm{demo}_{t-i} + \sum_{i=0}^{n} \beta_{5i}\, \Delta \mathrm{gov/gdp}_{t-\mathrm{i}} + \sum_{i=0}^{n} \beta_{6i}\, \Delta \mathrm{gw}_{t-\mathrm{i}} + \gamma \mathrm{ECT}_{t-1} + \mu_t \quad (5)$$

With γ representing the coefficient of the ECT (error correction term), capturing long-run adjustment to the equilibrium after disturbance. Correspondingly, μ_t represents residual error term. ECT coefficient validity is in its magnitude and sign. Enders [22] emphasized that the coefficient of the error correction term (γ) ought to be negative, equal to or below 1 and statistically significant. Similarly, if the results of the cointegration test indicate a long-run relationship, the alternative specifications can also be expressed as in Equation (5).

5. Findings and discussion

5.1. Stationarity tests

Before conducting ARDL tests, we first implemented unit root tests to determine the stationarity and order of integration using the Augmented-Dickey-Fuller test (ADF) and Phillip-Perron (PP), with intercept and with trend and intercept. Appendix, **Table A2,** indicates the outcome of these tests, which also shows that variables are

either stationary at levels or after first differencing.

From **Table 2**, we can note that calculated *F*-statistics are higher than the asymptotic critical value bounds shown in the study of Pesaran et al. [17]. With the outcome of the *F*-statistic indicating possibility of cointegration, we fail to accept the null hypothesis and conclude that variables are cointegrated. Furthermore, we conducted residual diagnostic tests to ensure the reliability of the bounds test results. Specifically, Breusch-Godfrey Serial Correlation LM, heteroskedasticity (Breusch-Pagan-Godfrey), and normality tests were employed, which indicated that the bounds test results are reliable, confirming the validity of calculated F-statistics. Following the above tests, the long- and short-run coefficients of the ARDL model were then estimated. According to the Schwartz information criterion (SIC), the optimal lag length selected is ARDL (1,0,0,0,0,0) for all three equations.

Table 2. ARDL Bounds test results.

	ARDL model	***F*-stat.**	**Residual diagnostics**		
			X^2 **(Heterosce.)**	X^2 **(Corr.)**	X^2 **(Normality)**
Equation (1)	(1,0,0,0,0,0)	8.071	0.899	0.684	0.339
Equation (2)	(1,0,0,0,0,0)	6.336	0.468	0.565	0.503
Equation (3)	(1,0,0,0,0,0)	8.586	0.589	0.228	0.476
	Actual sample size (T = 26)				
	Critical values				
	Lower bound I (0)			**Upper bound I (1)**	
10%	2.26			3.35	
5%	2.62			3.79	
2.5	2.96			4.18	
1%	3.41			4.68	

Source: Authors' estimation.

5.2. Informality and financial development in the long-run

We carried out the empirical analysis using the ARDL approach, but also to ensure the robustness of our findings, the fully modified ordinary least squares (FMOLS) and dynamic least squares (DOLS) methods were used. The results are reported in **Table 3**. Column 2 reports ARDL values, while FMOLS and DOLS values are reported in columns 5 and 8, respectively. We first present and discuss the results of the ARDL model, which are reported in column 2. From column 2, we observe a connection between two variables of our interest, informality and financial development. Specifically, findings provide proof of cointegration in the long run. The coefficient on financial development (dob) is negative and highly significant, implying that an improvement in the availability of domestic credit mitigates informality by 0.446 units. This finding bodes well with previous studies indicating the effect of financial development on shadow production of goods and services [1]. As rightly emphasized by Berdiev and Saunoris [3] in their investigation of the dynamic link between shadow activities and financial development across 161 economies, improvement in financial development significantly mitigates informality. Similarly, Bayar and Ozturk [23] find a negative correlation between informality and financial

development in the long run. On the same note, Capasso and Japelli [2] provide another empirical suggestion of a negative association between financial development and informality. Their finding suggests that access to domestic credit that leads to a decrease in costs of borrowing could be significant in reducing the shadow economy. Correspondingly, when firms choose to invest with internal financing with lower interest rates compared to external financing charging higher interest rates, improvement in financial development lowers tax evasion, which has a negative effect on informality by reducing the informal economy.

Table 3. Shadow economy and financial development in the long-run.

Explanatory	**Dependent variable: Shadow economy**								
	ARDL model			**Fully-Modified OLS**			**Dynamic OLS**		
	Coeff.	***t*-stat.**	**Prob.**	**Coeff**	***t*-stat**	**Prob.**	**Coeff.**	***t*-stat.**	**Prob.**
Dob	−0.446***	−3.650	0.002	−0.446***	−8.653	0.000	−0.446***	−3.434	0.003
Frac	−1.125*	−1.906	0.072	−1.255***	−3.590	0.002	−1.125	−1.316	0.204
Demo	−1.435**	−2.215	0.039	−1.460***	−5.064	0.000	−1.435*	−1.887	0.075
Gov/GDP	0.459***	6.968	0.000	0.457***	12.939	0.000	0.459***	4.935	0.000
Gw	−0.178***	−3.502	0.002	−0.185***	−5.565	0.000	−0.178**	−2.166	0.043
Constant	16.131***	6.497	0.000	16.282***	13.794	0.000	16.131***	5.255	0.000

Source: Authors' estimation.
Note: *, statistical significance at 10% level.
**, statistical significance at 5% level.
***, statistical significance at 1% level.

The above results have major implications. Firstly, the results indicate that when access to credit is eased, a substantial number of businesses are able to access the much-needed financing, which improves the production processes of the said businesses. Relaxing credit constraints implies that entrepreneurs facing hurdles in accessing finance can now borrow to expand their production or to acquire the much-needed technology. Improving production technology lowers the per-unit cost of production, which improves the firm's productivity and profitability [24]. This is crucial for smaller and or start-up firms which face challenges in upgrading of their production technology. Secondly, tackling widespread informality in the long run requires improving access to financing for entrepreneurs who face financing constraints. These findings confirm our postulation that any improvement in the availability of domestic credit is effective in reducing informality in the economy. Additionally, column 2 also shows fractionalization hinders the increase of shadow activities since the coefficient on (govfrac) is negative and highly significant, meaning that an increase in fractionalization reduces informality by 1.125 units, which seems to support the view that the political system is crucial in shaping the business platform [8]. Democracy significantly reduces the shadow economy, as can be observed from the coefficient on (demo), which is negative and statistically significant at 5% level. This seems to agree with Teobaldelli and Schneider [16], who find a negative association between informality and the financial sector. Accordingly, our empirical results indicate good democracy reduces the shadow economy by 1.435 units.

We also find evidence of the positive effect of government spending or

expenditure on informality, which is statistically significant at the 1% level. This implies that an increase in government expenditure seems to be a main driver of the shadow activities, especially in Africa [25]. This suggests that more public spending requires that the government levies taxes and collects revenue to finance the provision of public services. If this is the case, then more revenue collection requires tighter regulation and closing up any available loopholes in the tax system. Tighter regulation has a positive impact on revenue collection but a negative one on the formalization of businesses, hence driving entrepreneurs to operate underground to evade tax or reduce tax liability. Additionally, a country's development is critical in influencing informality since the coefficient on (gw) is negative and statistically significant at the 1% level. Following the suggestion of Menegaki [26], we use FMOLS and DOLS to validate the ADRL model results shown in **Table 3** columns 5 and 8. Accordingly, FMOLS and DOLS results seem to provide a similar picture to the ARDL model results, suggesting that improving financial development significantly reduces informality in the long run for the case of Uganda.

In summary, this paper provides further evidence that better financial development substantially reduces the shadow economy in Uganda. Additionally, fractionalization, democracy, and growth significantly reduce the expansion of informality in the country.

5.3. Shadow economy and financial development in short-run

From **Table 4**, the coefficient on financial development (dob) is negative and highly significant, meaning that informality and financial development are negatively correlated in the short run, all else equal. We note that an improvement in access to domestic credit reduces shadow economy activities by 0.365 units, confirming a long- and short-run relationship between financial development and the shadow economy in Uganda. This relationship largely agrees with the literature, which has demonstrated that an improvement in financial development reduces the informal economy [3]. This is because more access to credit provides an opportunity for financially constrained businesses to borrow so as to improve and/or expand their operations [1].

Table 4. Shadow economy and financial development in short-run.

Explanatory variable	**Outcome variable: ΔShadow economy**		
	Equation (1)		
	Coefficient	***t*-statistic**	**Probability**
ΔDob	−0.365***	−7.231	0.000
ΔGovfrac	−2.453***	−5.857	0.000
ΔDemo	−0.878***	−3.381	0.004
ΔGov/gdp	0.502***	8.439	0.000
ΔGwc	−0.136**	−2.719	0.015
ECT (−1)	−0.590***	−3.163	0.006
Constant	−0.118	−0.631	0.537

Source: Authors' estimation.
Note: *, statistical significance at 10% level.
**, statistical significance at 5% level.
***, statistical significance at 1% level.

In other results, column 2 indicates that the political environment is a crucial determinant of informality in the short run, suggesting that in the short run, any improvement in fractionalization reduces informality by 2.453 units, statistically significant at the 1% level. These findings are in line with the notion that the political environment determines the government's incentives to invest in enforcement of revenue collection, which influences the government's capability to enact measures and policies that curb informality in the economy [12]. Correspondingly, the 'politics of the day' also influence the democracy in the country [8]. Correspondingly, this paper finds evidence of the importance of the country's growth in curbing the spread of shadow activities. The findings indicate that improvement in the country's development reduces informality by 0.136 units, statistically significant at the 1% level, agreeing with other studies that have shown how the country's development curbs wide-spread informality [9]. Furthermore, these findings also indicate that public spending requires that tax enforcement measures be strengthened, which action will further drive businesses underground. From the findings, we can note that the coefficient on government expenditure is highly significant, implying that a rise in government expenditure also raises informality by 0.502 units, statistically significant at the 1% level consistent with previous studies [25].

Finally, we evaluated the speed of adjustment of the informal economy to departure from long-run equilibrium, which is assessed by examining the sign, magnitude, and significance level of the error correction term (ECT). Accordingly, the coefficient on ECM is negative and statistically significant at 1% level, indicating that the shadow economy adjusts to any departures from long-run equilibrium at a speed of adjustment of 59%, statistically significant at 1% level, as shown in the study of Enders [22].

Taken together, this paper establishes a negative long- and short-run relationship between the shadow economy and financial development, all else equal, suggesting that financial development is an important component of the policy framework that could be used to address informality in Uganda. This postulation is acceptable given the fact that more access to domestic credit relaxes financial constraints faced by businesses, especially small and start-ups, since they can now borrow to finance available business opportunities. Furthermore, improved access to domestic credit allows borrowers to procure the much-needed production equipment, which, if deployed, might improve efficiency by cutting down the marginal costs of production, as shown by Esaku [8]. Consequently, the above findings emphasize that reforming financial institutions to facilitate improved access to domestic credit could help tackle widespread informality in developing economies. Additionally, the findings also reveal that minimizing the informal sector also requires reforming not only the financial sector but also the institutional, macroeconomic, and political environment so that these become responsive to the needs of businesses.

5.4. Stability tests

To ascertain the stability of the ARDL model, diagnostic tests were implemented by evaluating recursive estimates, especially cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMQ) plots.

The CUSUM and CUSUMQ plots are reported in **Figures 1** and **2**. As the figures report, we can observe that the plots lie within the boundaries at the 5% level of significance and give further proof indicating that the ARDL models are stable. Conclusively, these findings suggest and confirm a statistically significant negative connection between the shadow economy and financial development in both horizons.

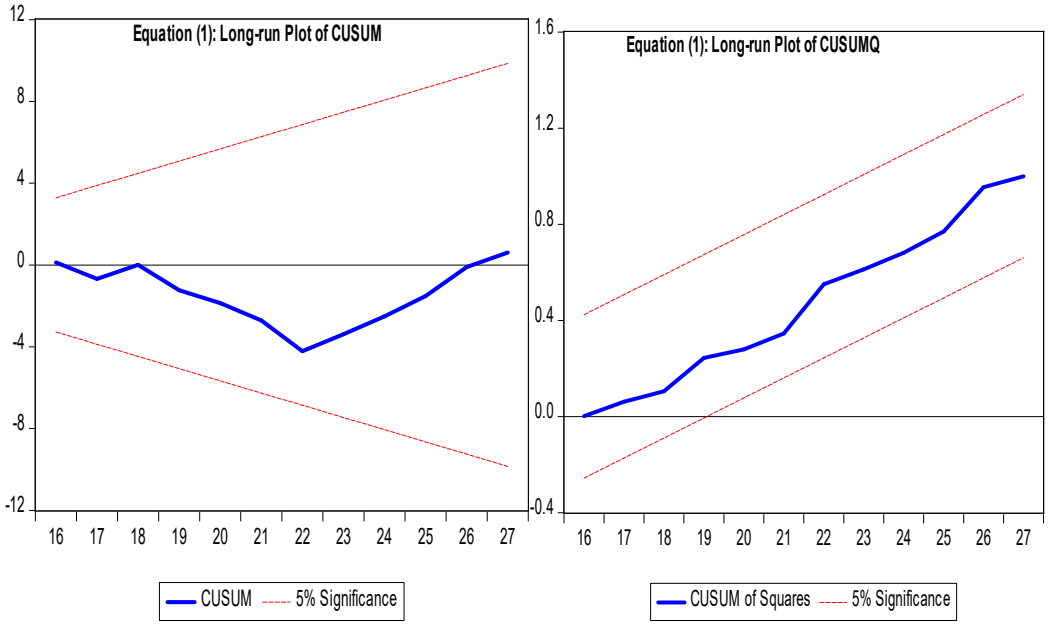

Figure 1. CUSUM and CUSUMQ plots for ARDL model in the long-run.

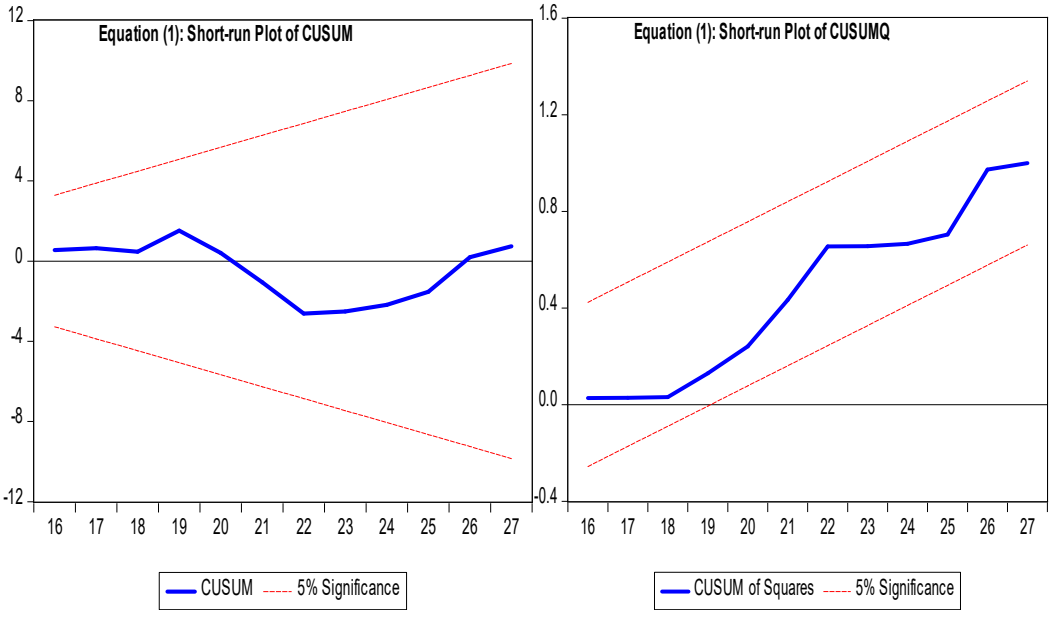

Figure 2. CUSUM and CUSUMQ plots for ARDL model in the short-run.

5.5. Additional robustness checks

As an additional robustness check, we estimate Equations (2) and (3), where we use an alternative index of financial development. In other words, we use domestic credit provided by the financial sector (dcf) and domestic credit to the private sector (dcp) as our measure of financial development to give credence to the ARDL model

results. We present the results of these estimations in **Tables 5** and **6**. In **Table 5**, we present the long-run results, which show a negative and statistically significant relationship between the shadow economy and financial development (regardless of the measure of financial development used). Next, the short-run results of this relationship are in **Table 6**. As **Table 6** shows, informality and financial development are highly correlated in the short run as well. Correspondingly, this paper also conducted stability tests by examining recursive estimates, especially CUSUM and CUSUMQ plots, which are reported in **Figures 3–6**. We still find that the results of the alternative specification are robust. Overall, this paper shows a negative and robust association between the variables of interest and the inclusion of alternative estimation methods and indices of financial development.

Table 5. Shadow economy and financial development in long-run.

Explanatory variables	**Dependent variable: Shadow economy**					
	Model (1)			**Model (2)**		
	Coefficient	***t*-statistics**	**Probability**	**Coefficient**	***t*-statistics**	**Probability**
DCF	−0.156**	−2.270	0.035	-	-	-
DCP	-	-	-	−0.502***	−3.963	0.000
Frac	−0.577	−0.910	0.374	−1.572**	−2.825	0.011
Demo	−2.891***	−3.648	0.002	−1.650***	−2.979	0.008
Gfce	0.391***	5.755	0.000	0.543***	6.699	0.000
Gw	−0.209***	−4.286	0.000	−0.178***	−3.443	0.003
Constant	14.438***	5.549	0.000	23.691***	7.744	0.000

Source: Authors' estimation.
Note: Model (1) uses dcf as measure of financial development, while Model (2) uses dcp as the measure of financial development.
Note: *, statistical significance at 10% level.
**, statistical significance at 5% level.
***, statistical significance at 1% level.

Table 6. Shadow economy and financial development in short-run (alternative specification).

Explanatory variables	**Dependent variable: Shadow economy**					
	Model (1)			**Model (2)**		
	Coefficient	***t*-statistics**	**Probability**	**Coefficient**	***t*-statistics**	**Probability**
ΔDCF	−0.081	−1.219	0.240	-	-	-
ΔDCP	-	-	-	−0.482***	−7.977	0.000
ΔGovfrac	−1.674**	−2.853	0.011	−2.633***	−4.389	0.000
ΔDemo	−1.479***	−6.019	0.000	−1.054***	−6.071	0.000
ΔGfce	0.468***	7.639	0.000	0.571***	10.481	0.000
ΔGw	−0.160***	−2.944	0.009	−0.115**	−2.354	0.031
ECT (−1)	0.731***	−5.409	0.000	−0.585***	−3.530	0.003
Constant	−0.144	−0.797	0.437	−0.059	1.0349	0.732

Source: Authors' estimation.
Note: *, statistical significance at 10% level.
**, statistical significance at 5% level.
***, statistical significance at 1% level.

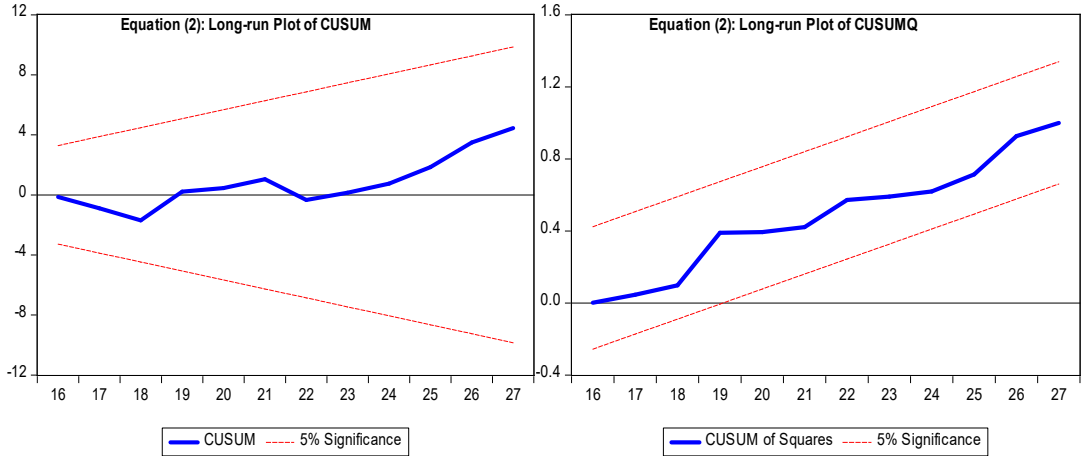

Figure 3. CUSUM and CUSUMQ plots for ARDL model in the long-run for Equation (2).

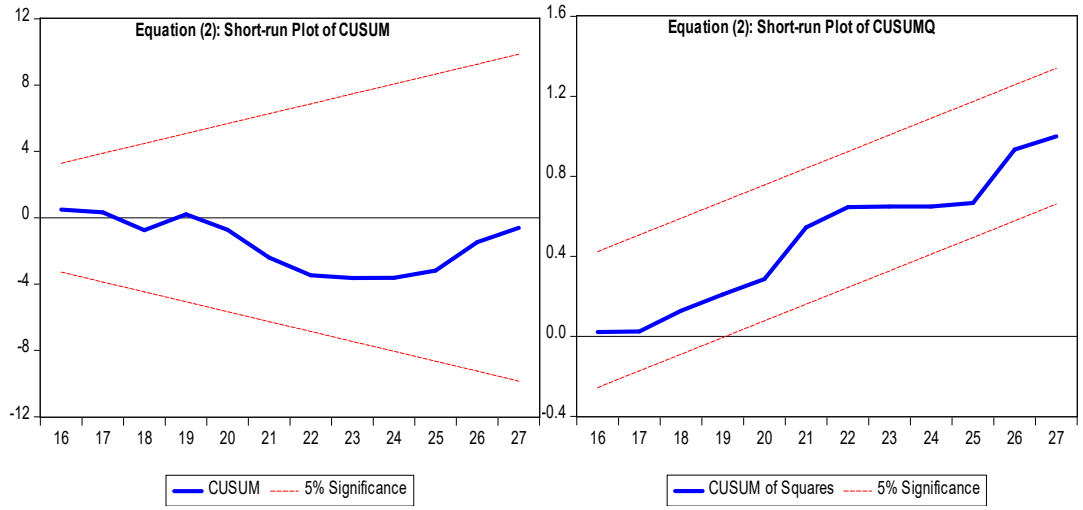

Figure 4. CUSUM and CUSUMQ plots for ARDL model in the short-run for Equation (2).

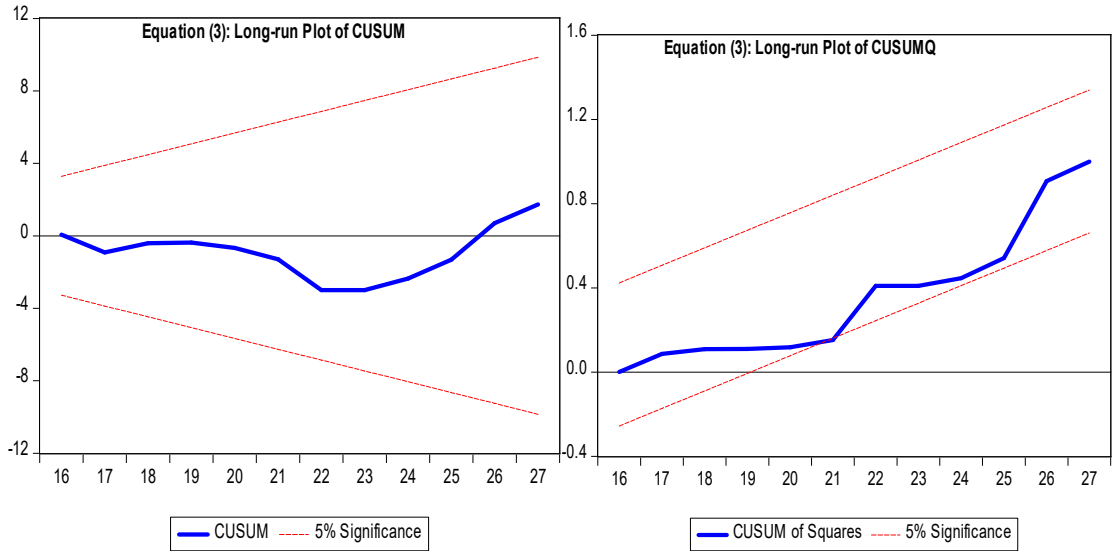

Figure 5. CUSUM and CUSUMQ plots for ARDL model in the long-run for Equation (3).

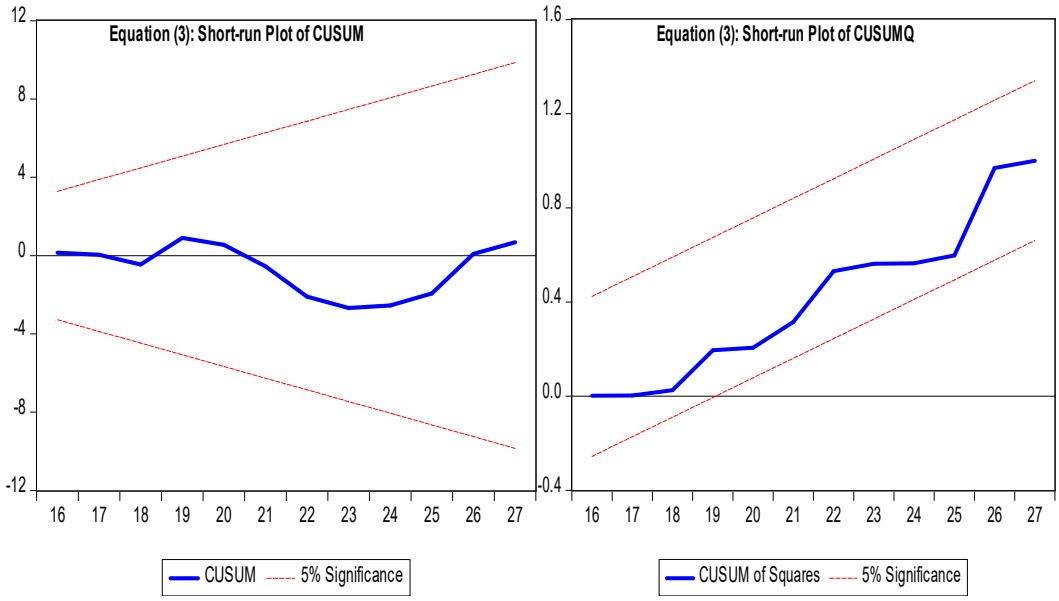

Figure 6. CUSUM and CUSUMQ plots for ARDL model in the short-run for Equation (3).

6. Conclusion

We investigate the short- and long-run relationship between the size of the shadow economy and financial development in Uganda, making use of the available time series data from 1991 to 2017. Employing the ARDL approach, a negative long- and short-run relationship between the above variables is unearthed. Our findings show that financial development mitigates the expansion of the underground economy in both the short- and long-run. The above results have important implications. First, these findings seem to reveal that improving access to credit helps a number of businesses access the much-needed business financing. Improving access to credit means that businesses can now borrow to revamp their activities in order to survive in a turbulent business environment. This helps credit-constrained businesses secure loans to expand their businesses as a result. Secondly, these findings reveal that financial development does matter and is a is a crucial component of the policy framework that can be used to hinder informality. This is because improving access to domestic credit relaxes financial constraints faced by businesses, which can now borrow to finance available business opportunities.

Taking policy into account, these results reveal that reforming financial institutions to facilitate improved access to domestic credit could help tackle hidden economic activities in low-income economies. Additionally, minimizing informality requires reforming the macroeconomic, political, financial, and institutional framework to be able to respond to the needs of businesses. Moving forward, developing a tractable theoretical model to provide the channels through which financial development could potentially impact the underground economy are possible areas for future research.

Author contributions: Conceptualization, SE and SM; methodology, SE and SM; data curation, SE and SM; writing—original draft preparation, SE and SM; writing—review and editing, SE and SM. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest: The authors declare no conflict of interest.

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Appendix

Table A1. Data and sources.

Variable	Definition	Source
Se17	The size of the shadow economy	[11]
Financial development (dob)	Domestic credit to private sector by Banks (% of GDP).	[27]
Govfrac	Fractionalization index	[28]
Demo	Institutionalized democracy, measures the existence of political institutions and processes which provide citizens avenues to express views about the type of leadership they prefer.	[29]
Gov/gdp	General government final consumption expenditure (% of GDP)	[27]
Growth	GDP per capita growth (annual %)	[27]
Financial development (dcf)	Domestic credit to private sector by financial sector (% of GDP)	[27]
Financial development (dcp)	Domestic credit to private sector by financial sector (% of GDP)	[27]

Source: Author's elaboration.

Table A2. Results of stationarity tests for all the variables.

	In levels				**First difference**			
	ADF		**PP**		**ADF**		**PP**	
	Intercept	**Trend & Intercept**	**Intercept**	**Trend & Intercept**	**Intercept**	**Trend & Intercept**	**Intercept**	**Trend & Intercept**
Se17	−0.116	−1.715	−0.327	−1.862	−3.830***	−3.731**	−3.841***	−3.754**
Dob	−0.957	−4.734***	−1.040	−4.733***	−8.972***	−8.824***	−21.383***	−23.228***
Govfrac	−1.598	−2.144	−1.752	−2.176	−5.099***	−5.072***	−5.099***	−5.072***
Demo	−1.036	−1.919	−1.034	−1.986	−5.292***	−5.194***	−5.292***	−5.193***
Gov/gdp	−2.275	−2.983	−2.129	−2.983	−5.932***	−5.954***	−7.004***	−10.036***
Gw	−3.894***	−4.363***	−3.953***	−4.363***	−5.982***	−5.934***	−9.107***	−9.241***
Dcf	0.764	−2.217	−0.506	−2.286	−7.820***	−3.215	−7.884***	−8.209***
DCP	−1.063	−2.187	−0.984	−2.245	−7.030***	−7.001***	−7.250***	−7.085***

Source: Authors' estimation.
Note: *, statistical significance at 10% level.
**, statistical significance at 5% level.
***, statistical significance at 1% level.

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Article

Tehran Stock Market efficiency: A quantile autoregression approach

Masoud Alizadeh Chamazkoti, Mehdi Fathabadi*, Saleh Ghavidel Doostkouei, Mahmood Mahmoodzadeh

Department of Economics, Firoozkooh Branch, Islamic Azad Universsity, Firoozkooh 3981838381, Iran
*** Corresponding author:** Mehdi Fathabadi, Mehdi_fa88@yahoo.com

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Abstract: The purpose of this paper is to evaluate the price efficiency of the Tehran Stock Market. For this aim, we used daily stock prices of 30 large companies on the Stock Exchange. In the first stage, a unit root test with the endogenous break and without a structural break was performed using augmented dickey-fuller test (ADF) tests and Phillips-perron (PP) tests. The results indicate that the price of 9 companies has a random walk process with intercept and 21 companies follow a random walk without intercept and trend component process which is known as the pure random walk process. Thus, considering the ADF and PP tests, most companies' stock prices are efficient. Quantile autoregression results in the second stage show that the stock prices in the middle price deciles have weak efficiency, but in the lower and upper price deciles, the stock price does not follow the weak efficiency conditions. So, if the stock price deviates (up or down) from the long-term mean, the market becomes inefficient, but when the stock price is at the median level, the market is efficient. The general conclusion is that median prices are the long-term average prices that change over time, and stock prices tend to move toward that price.

Keywords: market efficiency; quantile autoregression; random walk; Tehran Stock Market
JEL Classification: C21; C22; G14

1. Introduction

Economic and financial analysts have sought to find ways to predict macroeconomic and financial variables, including stock prices, since the 1950s. Stock prices reflect the future economic prospects of a firm. Thus, it is possible to plan for the future conditions of the firm by achieving the pattern of stock price changes. Testing a hypothesis, Kendall [1] noticed that stock prices seemed to move randomly over time and there is no pattern for predicting stock price changes. The stock market does not follow any rules and is irregular according to the results of the analysis. The irregularity in stock price changes is not due to irrationality but to market performance or market efficiency according to other researchers [2–5].

It is important for stock market investors and analysts to understand how the stock price process works. There are two types of processes in the econometric literature on time series, including stochastic processes (unit root) and stationary processes or mean-reversion processes. If stock prices follow the mean reversion process, with each shock, the price level will revert to its long-term trend over time. In other words, the effect of shocks on stationary time series is always temporary and these effects disappear over time and the series returns to its long-run average. In this case, it is possible to predict future changes in stock prices based on past stock behavior. On the contrary, stochastic volatility assumes that the price volatility of stock varies and is not constant over time; then, any kind of a shock to the price will be permanent. This means that the occurrence of shocks will have a permanent effect on the time series,

and this effect is directly reflected in the prediction of the variable. Therefore, it is not possible to predict future stock prices based on past behaviors, which means that the market is efficient [6].

"Capital market efficiency" means "information efficiency". Though the efficient market hypothesis theorizes the market is generally efficient, the theory is offered in three different versions: weak, semi-strong, and strong. The weak form suggests that it is not possible to gain additional returns (other than luck) using historical information. If you have access to the general information of the company, you can get additional returns in this type of market. The semi-strong form submits that because public information is part of a stock's current price, investors cannot utilize either technical or fundamental analysis, though information not available to the public can help investors. The strong form version states that public and not public information, other than luck, can't give an investor an advantage in the market to gain additional returns.

There are at least two reasons why evaluating the efficient market hypothesis remains crucial [7]. Firstly, according to Bose [8], the significant interplay between the stock market and the real economy underscores its pivotal role in shaping economic policies. Secondly, Mauro [9] suggests that the rapid availability of stock market prices positions it as a valuable leading indicator for predicting economic growth. Furthermore, identifying which stock price changes, not explained by fundamentals, actually influence output raises pertinent policy issues, particularly relevant for emerging markets.

This paper aims to examine the weak efficiency in which the nature of stock price change is following the random walk model [2]. If this type of efficiency exists, stock prices would be very unpredictable and thus would follow a random walk. The randomness of stock prices is the logical result of keen competition between investors to discern new information so that they can decide whether to buy, sell or hold stock before the market is aware of it and reacts to the changes.

Many studies have examined the efficiency of stock prices, predominantly using parametric approaches. These include independence tests, variance ratio tests, various time series and panel unit root tests, autoregressive models, GARCH models, and Markov switching models. A few studies have also utilized quantile models, which have the capability to measure efficiency dynamics and determine the degree of efficiency at different price levels.

Additionally, it is important to clarify that weak efficiency implies that stock prices follow a random walk process. However, a pure random walk excludes both intercept and trend components. The presence of these components in a random walk model suggests a trend or additional return, which contradicts the concept of efficiency. This nuance is often overlooked in many studies, casting doubt on their results.

Random data entry causes price changes to be random (sometimes positive and sometimes negative). Price changes are the result of investors making new decisions about buying or selling stock relying on re-evaluating the future status of stocks. The paper investigated the weak efficiency of stock prices of 30 large companies registered at the Tehran stock exchange using the unit root quantile autoregression approach. The remainder of the paper is structured as follows. Section 2 presents the model. Section

3 displays the data. Section 4 is devoted to the empirical results while section 5 discusses them and concludes.

2. Literature review

When discussing market efficiency, it specifically refers to the relationship between stock prices and information. The important question is how quickly the market can obtain and adjust prices based on new information about a particular company. If prices react quickly and accurately to all important and effective information, the market can be considered relatively efficient. However, if this information reaches the market slowly and investors cannot quickly analyze and react to it, prices are likely to deviate from their true value. Such a market is relatively inefficient or lacks efficiency [10]. This raises the question: since investors do not receive clear and complete information about securities or specific stocks, how can the market ensure that security prices reflect all important and effective information? The answer is that prices are not determined by the consensus of all investors but by those actively present in the stock market. The market comprises expert analysts and highly knowledgeable traders who spend most of their time seeking out securities they believe are mispriced based on their information.

Investigating efficiency in the stock market is crucial. Paradoxically, the market is efficient if enough knowledgeable analysts believe it is not. This apparent contradiction is clear: careful investor analysis makes security prices reflect the true value of investments. However, if people believe the market is efficient, they see no point in searching for mispriced securities and will not incur the cost of acquiring new information. Consequently, security prices do not incorporate newly released information promptly, and prices adjust slowly, leading to an inefficient market. Conversely, if investors believe the market is inefficient, they find opportunities for abnormal returns, rush to new information, adjust prices accordingly, and inadvertently contribute to market efficiency, albeit poor performance [11]. In the context of weak efficiency, stock price changes follow a random walk model [2], meaning they are random and unpredictable. This randomness results from intelligent competition among investors to discover new information and make decisions before the market reacts. As information enters randomly, price changes are also random—sometimes positive, sometimes negative [2]. However, these changes are due to investors re-evaluating the future state of stocks and making new buy or sell decisions.

Fama [2] believed that an efficient market is one where stock prices fully reflect all available information, eliminating the possibility of making unusual profits, achievable through the random walk model. The question then arises: which random walk model can confirm the efficient market hypothesis? In the pure random walk model, without a constant component and trend, the expected mean is constant, indicating no trend in the mean. However, in random walk models with trend and constant components, a time trend is observed in the expected mean, and the mean is not constant. Additionally, in all three models, the variance is not constant and shows a time trend. If a trend exists in these models (except for the pure random walk model), it might imply additional returns, thus market inefficiency. If it can be proven that a stock follows a random walk model with a constant component, one could expect to

earn returns equivalent to the trend coefficient daily, indicating inefficiency. Fama [2] implies that confirming market efficiency requires the pure random walk model, excluding constant and trend components, where the mean is constant, and stock price changes are entirely random and influenced by random shocks [12].

Some studies have evaluated different states of capital market efficiency. Rönkkö et al. [13] found that small market size alone does not make a market less efficient; opening a market to foreign investors improves its efficiency after a delay; and the correlation between market volatility and return varies over time in the Finnish stock market, usually being negative. Campisi et al. [14] showed that machine learning models perform better than classic linear regression models in predicting the returns of the American stock market. Gil-Alana et al. [15] found that all individual time series are highly stable, with most cases having an order of integration close to one. Zebende et al. [16] stated that in the short term (less than 5 days), stock markets tend to be efficient, while in the long term (greater than 10 days), they tend to be inefficient. Diallo et al. [17] concluded that the dynamics of indicators reveal characteristics of short-term memory or, in some cases, long-term memory, leading to the rejection of the efficient market hypothesis. Nartea et al. [7] found that stock prices are stationary at higher quantiles, with evidence of asymmetry in dynamic stock price adjustments at these quantiles; larger shocks are associated with faster mean reversion, while smaller shocks are linked to increased volatility. Jansen [18] discovered that market efficiency is not time-invariant and that stock markets have become more efficient over the sample period. Durusu-Ciftci et al. [19] provided strong evidence for the weak efficiency of stock markets.

According to the literature review, the hypothesis of this research is expressed as follows:

The stock prices of large Iranian companies exhibit weak efficiency.

3. Methodology

Koenker and Xiao [20] introduced unit root quantile autoregression which is a type of an augmented dickey-fuller test (ADF). The simulation results show that the unit root quantile autoregression test works better than the standard ADF test when a shock has heavy tail behavior. This test provides a variety of correction mechanisms for long-term equilibrium in different quantities which can be considered an advantage over the ADF test. The Standard ADF test which is used for the unit root quantile autoregression is as follows:

$$p_t = \beta_1 p_{t-1} + \varepsilon_t \quad (1)$$

here, p_t is the index price at time *t*. In Equation (1), the autoregressive coefficient β_1 plays an important role in measuring the stability of economic and financial series. If this coefficient value is 1, the stock price has a unit root or follows a random walk process. In this case, it is not possible to predict future stock prices based on past events because the effect of any kind of shock on prices will be permanent which means that the market is efficient. Conversely, if β_1 is less than one, the stock price is a stationary process and follows the mean-reversion process. The effect of shocks on stochastic (unit root) time series is continually temporary and these effects disappear over time and the series returns to its long-term mean. So, it is possible to predict the

stock price based on its past behavior. Koenker and Xiao [20] denote the τ-th conditional quantile of p_t as follows:

$$Q_{p_t}(\tau|\mathrm{p}_{t-1}) = \beta_\varepsilon(\tau) + \beta_1(\tau)p_{t-1} \tag{2}$$

where $Q_{p_t}(\tau|p_{t-1})$ is τ-th conditional quantile on the past information and $\beta_\varepsilon(\tau)$ is τ-th conditional quantile of ε_t where $\{\varepsilon_t\}$ is a random variable i.i.d with mean zero and σ^2 variance. The coefficients of the linear quantile autoregressive model are estimated by minimizing the sum of asymmetric weight deviations.

$$\min_{\beta \in R^2} \sum_{t=1}^{n} \rho_\tau(p_t - x_t\beta) \tag{3}$$

Koenker and Bassett [21] introduced this formula as a check function:

$$\rho_\tau(\varepsilon) = \varepsilon(\tau - I(\varepsilon < 0))$$

In Equation (3), $\beta(\tau) = (\beta_0(\tau), \beta_1(\tau))$ and $x_t = (1, p_{t-1})$. By estimating Equation (3), It is possible to test the random properties of p_t of τ-th quantile of using the following *t*-statistic:

$$t_n^*(\tau_\mathrm{i}) = \frac{\hat{f}\left(F^{-1}(\tau_i)\right)}{\sqrt{\tau_i(1-\tau_i)}} (P'_{-1}E_xP_{-1})^{1/2}\left(\widehat{\beta_1}(\tau_i) - 1\right) \tag{4}$$

P_{-1} in Equation (4) is the dependent variable vector with p_{t-1} ،(E_x) lag on projection matrix on the orthogonal space *x* and $\hat{f}\left(\mathrm{F}^{-1}(\tau_i)\right)$ is the consistent estimator as follows [20]:

$$\hat{f}\left(F^{-1}(\tau_i)\right) = \frac{(\tau_i - \tau_{i-1})}{x'\left(\beta(\tau_i) - \beta(\tau_{i-1})\right)} \tag{5}$$

Using $t_n^*(\tau_i)$ statistics, the unit root hypothesis can be tested in any quantile. It is noteworthy that $t_n^*(\tau_i)$ is the abnormal distributions and unite root hypothesis cannot be tested using conventional distributions. Therefore, Koenker and Xiao [20] measured the critical values of the quantiles using the "Resampling Method" and "Bootstrap procedure".

Introduced by Ito et al. [22,23] and Noda [24], the degree of efficiency of quantiles is introduced as follows:

$$\hat{\delta}(\tau) = \left|\frac{1 - \hat{\beta}_1(\tau)}{\hat{\beta}_1(\tau)}\right| \tag{6}$$

Since the estimated coefficient $\hat{\beta}_1$ is different in each quantile, the degree of efficiency ($\hat{\delta}(\tau)$) in each quantile change. If the autoregressive coefficient $\hat{\beta}_1$ is equal to 1 in the τ-th quantile, $\hat{\delta}(\tau)$ is zero, which means that the stock price is efficient in the τ-th quantile. As mentioned above, when the stock price follows a random walk process, $\hat{\beta}_1 = 1$, it is not possible to predict the stock price according to the previous information and this suggests the stock efficiency ($\hat{\delta} = 0$). However, if the stock price follows the mean reversion process ($\hat{\beta}_1 < 1$), the stock price can be predicted based on past data, and this indicates the inefficiency ($\hat{\delta} > 0$). The higher the degree of efficiency deviation from zero, the lower the efficiency is. In Quantile Autoregression, the autoregression coefficients may be different in different quantiles. In this case, the degree of efficiency can be measured for different quantiles. That is, the efficiency of the stock price is different in the range of different prices. In other words, the efficiency of the stock price is dynamic.

4. Data

The daily stock price data of 30 large companies on the Tehran Stock Exchange (TSE) have been used in this paper. The data was collected when these companies were listed to the stock market until 1 February 2022. The data are collected from the TSE website (www.tse.ir).

Table 1 shows the descriptive summarized statistics about the stock prices of 30 large companies listed on the TSE. These companies have 30 percent of the TSE value. Here are some crucial points: As shown in **Table 1**, the period under consideration for each stock is different because the period was chosen based on the availability of data. Since the increase in capital causes a price adjustment, the price has been adjusted. That is why the prices of some stocks in **Table 1** are very high, such as the stock of KEGOL Company which is 6,064,156 IRR at maximum. The highest number of observations is related to Qadir Holding Company, which covers 2996 days, and the lowest number is related to Social Security Investment Company (SHASTA), which covers 337 days.

Table 1. Daily price returns descriptive statistics, %.

Name	Index	Period	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis	Obs
Telecommunication company of Iran	AKHABER	2009/3/16 2022/2/1	0.15	−0.05	51.1	−11.5	2.1	664	144.3	2807
Khozestan steel company	FAKHOZ	2008/12/6 2022/2/1	0.2	−0.02	31.3	−30.3	2.3	30.3	389.4	2694
Copper company of Iran	FAMELI	2008/12/6 2022/2/1	0.2	−0.03	20.0	−12.5	2.1	688.4	987.6	2948
Persian Gulf petrochemical industries	FARS	2013/3/18 2022/2/1	0.2	−0.1	11.4	−13.9	1.9	11.7	704.4	1992
Isfahan steel company	FILAD	2008/12/6 2022/2/1	0.19	−0.05	16.0	−16.1	2.1	28.5	755.6	2933
Golgohar industrial and mining company	KEGOL	2008/12/6 2022/2/1	0.2	−0.04	21.1	−13.5	2.0	89.1	1067.2	2827
Mobile communications company of Iran	HAMRAH	2013/8/20 2022/2/1	0.16	−0.02	9.2	−5.1	1.6	44.9	683.7	1985
Chadormalo industrial and mining company	KACHAD	2008/12/6 2022/2/1	0.19	−0.06	23.0	−24.2	2.1	73.2	1827.6	2894
Shipping of the Islamic Republic of Iran	HAKESHTI	2008/12/6 2022/2/1	0.12	−0.02	115.9	−20.8	3.1	1984	7313.3	2769
Saipa car company	KHASAPA	2008/12/6 2022/2/1	0.17	0.00	71.0	−25.8	3.2	505.2	1113.4	2824
Irankhodro car company	KHODRO	2008/12/6 2022/2/1	0.17	0.00	69.3	−12.2	3.1	515.8	1085	2750
Mapna Group	MAPNA	2008/12/6 2022/2/1	0.21	0.00	21.2	−15.4	2.5	33.8	778.1	2642
Mellat Bank	VEBMELAT	2009/2/1 2022/2/1	0.15	0.00	38.1	−47.0	2.4	189.2	8729	2690
Nori petrochemical	NORI	2019/7/13 2022/2/1	0.45	0.13	13.4	−5.1	3.1	17.4	270.5	590
Omid investment management group	OMID	2008/12/6 2022/2/1	0.2	−0.02	11.2	−9.1	1.6	59.7	640.7	2865

Table 1. (*Continued*).

Name	Index	Period	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis	Obs
Parsian oil and gas development	PARSAN	2012/2/15 2022/2/1	0.19	−0.04	17.1	−11.8	2.2	32.03	598.4	2234
Parsian Bank	PARSIAN	2008/12/6 2022/2/1	0.17	−0.07	28.3	−10.8	2.3	116.7	1496.9	2517
Pars petrochemical	PARS	2018/7/11 2022/2/1	0.31	0.04	9.6	−5.1	2.5	7.8	280.9	838
Qadir holding	VEQADIR	2009/2/1 2022/2/1	0.19	−0.06	23.4	−6.1	2.1	88.1	1020	2996
Pardis Petrochemical	SHAPDIS	2011/11/26 2022/2/1	0.2	−0.04	9.6	−5.2	1.9	32.4	447.8	2252
Isfahan oil company	SHAPNA	2008/12/6 2022/2/1	0.22	−0.02	22.3	−14.01	2.5	65.7	866.0	2411
Social security investment company	SHASTA	2020/4/15 2022/2/1	0.66	0.6	26.5	−19.7	4.4	56.7	1077	337
Bandar abbas oil company	SHEBANDAR	2012/6/24 2022/2/1	0.27	0.01	19.5	−19.3	2.8	12.1	701.6	1817
Tehran oil company	SHETRAN	2016/10/30 2022/2/1	0.28	0.00	23.9	−12.3	2.9	71.3	793.7	1182
Tamin Petrochemical, oil and gas company	TAPIKO	2013/7/9 2022/2/1	0.14	−0.01	16.3	−10.1	2.2	35.5	576.4	1890
Mining and metals development company	VEMADEN	2008/12/6 2022/2/1	0.19	−0.05	11.7	−20.0	2.3	7.4	672.2	2779
Pasargad Bank	VAPASAR	2011/8/16 2022/2/1	0.17	−0.03	28.5	−8.2	2.1	169.5	2251	1884
Pension fund investment company	VASANDOQ	2008/12/6 2022/2/1	0.18	−0.04	28.3	−10.3	2.0	156.6	2111.3	2885
Tejarat Bank	VATEJARAT	2009/6/13 2022/2/1	0.18	0.00	25.7	−41.2	2.3	139.9	511.2	2613
Saderat Bank	VEBASADER	2009/6/9 2022/2/1	0.15	0.00	14.0	−67.8	2.6	801.1	219.1	2463

Source: www.tse.ir.

Descriptive statistics

The average return of these 30 companies is positive, ranging from 0.12 percent (HAKESHTI stock symbol) to 0.45 percent (NORI stock symbol) daily. The negative median for some companies suggests that the number of days with negative returns exceeds the number of days with positive returns. Among these 30 companies, Nouri, Pars, Shasta, and Shebandar companies have positive medians, indicating that the number of days with positive returns is greater than the number of days with negative returns, though they also experienced higher volatility. Shasta company, in particular, is the most volatile, with a standard deviation of 4.4. Additionally, all return series exhibit positive skewness, which indicates that large positive returns are more frequent than large negative returns. In other words, the positive skewness implies that the market experiences more fluctuations and that the stock prices of these 30 companies react more strongly to positive news than to negative news. All kurtosis values are very high, clearly indicating a "skewed distribution".

5. Empirical results

5.1. Random walk hypothesis and structural break tests

Dickey and Fuller [25,26] proposed a reliable process for testing the unite root. It is important to note that the critical values of the t-statistic depend on the presence or absence of a fixed component or trend, as well as the sample size and the optimal lags. The premise of ADF tests is that the error statements are independent of each other and have a constant variance. However, care must be taken when running the unite root test, as the actual process of data generation is unknown. To this end, the approach of Dolado et al. [27] and Hamilton [28] was used to test the unite root. Furthermore, conventional unit root tests are biased toward a false unit root null when the data are trend-stationary but contain a structural break. In short, the presence of structural changes induces a bias in favor of a unit root representation that empirically researchers ought to take into account which has been proven by Monte Carlo studies. Since the time of occurrence of structural break is not known in the stock price data mentioned in **Table 1**, endogenous Perron [29] and Vogelsang and Perron [30] tests have been used the results show that all 30 large companies on the TSE follow a random walk process. Among these, 21 companies follow a pure random walk (without intercept and trend) and 9 companies follow a random walk with an intercept (**Table 2**).

Table 2. Random walk hypothesis and structural break tests.

Company	K	Unit root; No break			Unit root; with the endogenous break				Inference Random walk
		Random walk			$y_t = \mu + \alpha y_{t-1} + \theta DU_t(T_B) + \omega D_t(T_B) + \sum_{i=1}^{k} c_i \Delta y_{t-i} + U_t$				
		Pure	Constant	Constant & trend	T_B	$\widehat{\theta}$	$\widehat{\omega}$	ADF statistic	
AKHABER	3	−2.3	−0.3	−1.6	2019/2/4	0.006*	−0.005	−2.9	Pure
FAKHOZ	3	−3.3	−0.4	−1.5	2017/6/24	0.004*	−0.01	−2.4	With constant
FAMELI	5	−2.9	0.03	−1.1	2018/7/15	0.005*	−0.01	−2.5	Pure
FARS	2	−2.6	0.7	−0.6	2019/3/6	0.007*	−0.007	−2.7	With constant
FILAD	3	−3.6	0.4	−0.9	2017/6/17	0.004*	−0.001	−2.3	With constant
KEGOL	3	−3.5	0.4	−1.1	2017/7/8	0.004*	−0.007	−1.9	Pure
HAMRAH	5	−2.4	−0.5	−2.04	2019/3/17	0.004*	−0.004	−2.4	With constant
KACHAD	2	−3.4	0.8	−0.7	2018/5/21	0.005*	−0.001	−2.1	Pure
HAKESHTI	2	−1.5	−0.2	−1.8	2013/8/26	0.006*	0.006	−2.4	Pure
KHASAPA	3	−1.9	0.1	−1.7	2019/12/29	0.009*	−0.01	−2.2	Pure
KHODRO	3	−2.1	0.2	−1.2	2019/3/12	0.009*	−0.01	−2.8	Pure
MAPNA	3	−2.8	−0.6	−1.8	2018/7/30	0.006*	−0.02	−3.03	Pure
VEBMELAT	2	−2.5	0.5	−0.98	2018/8/7	0.009*	−0.004	−3.4	Pure
NORI	2	−2.2	−1.3	−0.95	2020/5/12	0.02*	−0.06**	−3.6	Pure
OMID	3	−3.9	1.5	−0.8	2018/6/12	0.003*	−0.02	−1.3	With constant
PARSAN	5	−2.6	−0.2	−1.3	2018/6/12	0.01*	−0.01	−3.6	Pure
PARSIAN	3	−2.2	0.1	−0.99	2020/1/11	0.006*	−0.006	−2.6	Pure
PARS	2	−2.3	−1.3	−1.9	2020/3/25	0.01*	0.02	−2.8	Pure
VEQADIR	3	−3.3	−0.9	−1.8	2018/6/11	0.004*	−0.004	−2.9	With constant
SHAPDIS	3	−3.7	0.3	0.7	2018/6/12	0.006*	−0.005	−1.9	With constant
SHAPNA	1	−2.2	0.3	−2.04	2018/6/12	0.007*	−0.006	−2.7	Pure
SHASTA	1	−1.1	−2.6	−1.7	2020/5/26	0.01*	−0.06	−2.6	Pure
SHEBANDAR	1	−2.4	−1.6	−1.9	2018/7/17	0.01*	−0.009	−2.2	With constant
SHETRAN	3	−1.7	−0.9	−2.6	2018/7/17	0.007*	−0.002	−2.9	Pure
TAPIKO	3	−1.7	0.04	−1.1	2019/7/16	0.009*	−0.05**	−2.9	Pure
VEMADEN	5	−2.9	0.09	−1.4	2018/5/23	0.005*	−0.003	−2.3	Pure
VAPASAR	3	−2.3	1.5	0.65	2020/1/8	0.01*	−0.02	−3.1	Pure
VASANDOQ	1	−2.4	0.5	−1.5	2018/6/12	0.003*	−0.002	−1.7	With constant
VATEJARAT	1	−2.9	0.7	−0.7	2018/8/6	0.007*	−0.04	−2.9	Pure
VEBASADER	1	−2.2	0.001	−1.5	2020/1/8	0.009*	−0.02	−2.6	Pure

The inference is based on tests for the presence of deterministic components ($\emptyset_i$) Dickey and Fuller [26] and structural break test; break time is endogenously calculated from the data; critical values of ADF with break are −4.95, −4.44, −4.19 respectively at levels of %1, %5 and %10; * and ** indicate the significance of level at %1and %5 respectively.

According to Fama [2], the prices of those companies that follow the pure random walk process have weak efficiency. In fact, the stock price of these companies the next day will be the same as the previous day, in addition to the shocks that will occur on the current day. But the data generation process in companies whose price follows a

random walk with intecept, there is a constant component, which is the additional return that accrues to the buyer of stocks.

Therefore, according to the results of these two tests, Akhaber, Femeli, Kegol, Kachad, Hakeshti, Khasapa, Khodro, Mapna, Vebmelat, Nouri, Parsan, Parsian, Pars, Shapna, Shasta, Shetran, Tapiko, Vemaden, Vepasar, and Vetejarat and Vebsader companies have weak efficiency. On the other hand, Fakhuz, Fars, Foulad, Hamrah, Omid, Veqadir, Shapdis, Shebandar, and Vasaondoq companies did not have weak efficiency.

5.2. Quantile random walk hypothesis test

In **Table 2**, we performed a unit root test on the price logarithms of 30 companies on the TSE. Results based on ADF statistics show that 9 companies have a random walk process with an interception and 21 companies followed price based on a random walk without intercept and trend components which are known as the pure random walk process. For a time series process, if this process is a random walk with no intercept and no trend when testing the unit root, then the process is completely random (pure random). If a process is a random walk with intercept or trend components the process has predictable by these components. Therefore, the process is not completely random, because the intercept component and trend are predictable.

On the other hand, according to efficient markets theory, the price must be a completely random walk to investors cannot use information from past prices to predict future prices. This concept is consistent with the above-mentioned purely random walks. Therefore, a company's stock exchange is efficient with a purely random process. In **Table 2**, the stock prices of 21 companies have a pure random walk process, so the stock prices of these companies are traded in the efficient market. The stock price trend of the other 9 companies including FAKHOZ, FARS, FOLAD, HAMRAH, OMID, VEQADIR, SHAPDIS, SHEBANDAR, and VASANDOQ consists of a random walk with the intercept, which is a predictable component of the intercept. So, it cannot be claimed that the stock prices of these companies are trading in an efficient market. Another question is whether the market is efficient at all levels of stock prices. The quantile unit root test was used for this purpose. **Table 3** shows the results of the quantile unit root estimates of the stock price of 30 companies of 9 deciles. As the autoregressive coefficient is close to one, the efficient market claim is strengthened. In most cases, it is observed that the autoregressive coefficient is close to or equal to 1. However, there are subtle differences between deciles. For almost all stocks, the autoregressive coefficient is very close to 1 for middle deciles such as 5 and 6, and far from 1 for upper and lower deciles. That is, performing a regression on the lower or upper decile reduces the efficient stock price hypothesis, and performing a regression on the middle decile strengthens the efficient market hypothesis.

Equation (6) was defined to better identify various decile performance situations. If the autoregressive coefficient is equal to 1, the index value of $\hat{\delta}(\tau)$ will be zero. This means that the market is efficient.

Table 3. Quantile random walk hypothesis test.

Company	Quantiles	0/1	0/2	0/3	0/4	0/5	0/6	0/7	0/8	0/9
AKHABER	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.998(−15.1) −18.6***	0.999(−16.3) −18.01***	0.999(−16.2) −17.1***	0.999(−11.9) −12.9***	0.999(−3.4) −5.2***	1.000(3.9) 5.1***	1.000(10.1) 11.5***	1.001(13.6) 14.3***	1.002(17.1) 23.8***
FAKHOZ	$\hat{\beta}_0(\tau)$ $\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.05(13.2) 0.994(−15.5) −14.3***	0.03(13.7) 0.997(−15.5) −16.8***	0.02(7.4) 0.998(−8.4) −14.6***	0.01(4.03) 0.999(−4.7) −12.2***	0.002(0.99) 0.999(−1.2) −4.02***	−0.01(−2.6) 1.001(3.01) 6.4***	−0.02(−6.3) 1.002(7.8) 9.01***	−0.03(−8.7) 1.004(11.3) 8.9***	−0.02(−2.7) 1.005(5.4) 5.8***
FAMELI	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.998(−21.3) −24.2***	0.999(−22.7) −25.01***	0.999(−18.5) −17.7***	1.000(−12.1) −13.6***	1.000(−2.1) −2.8**	1.000(7.7) 8.1***	1.001(12.9) 13.1***	1.001(19.1) 21.1***	1.002(33.5) 37.1***
FARS	$\hat{\beta}_0(\tau)$ $\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.1(11.8) 0.988(−13.3) −17.4***	0.08(7.8) 0.991(−8.3 −23.5***	0.04(3.9) 0.995(−4.1) −18.8***	0.02(2.8) 0.998(−3.00) −15.03***	0.0005(0.09) 0.999(−0.2) −0.75	−0.03(−2.7) 1.003(2.8) 22.6***	−0.07(−10.8) 1.008(11.1) 21.6***	−0.08(−7.9) 1.009(8.9) 15.8***	−0.08(−6.2) 1.009(8.1) 8.3***
FILAD	$\hat{\beta}_0(\tau)$ $\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.1(2.4) 0.997(−5.9) −6.1***	0.009(2.6) 0.998(−5.4) −6.4***	0.01(5.3) 0.998(−7.4) −9.6***	0.006(1.9) 0.999(−2.7) −6.1***	0.0009(0.35) 0.999(−0.4) −0.8	−0.003(−0.9) 1.000(1.8) 2.4*	−0.006(−1.6) 1.001(3.5) 4.2***	−0.01(−2.9) 1.003(6.7) 6.3***	0.0009(0.2) 1.003(5.7) 5.4***
KEGOL	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.998(−16.7) −17.2***	0.999(−17.7) −19.2***	0.999(−17.4) −19.1***	0.999(−10.9) −11.8***	0.999(−1.7) −3.3***	1.000(5.7) 6.3***	1.000(11.4) 13.1***	1.001(17.6) 20.3***	1.002(25.9) 31.8***
HAMRAH	$\hat{\beta}_0(\tau)$ $\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.1(15.3) 0.99 (−16.0) −27.5***	0.06(9.7) 0.994(−10.1) −23.1***	0.03(6.1) 0.997(−6.5) −19.8***	0.01(3.4) 0.999(−3.6) −11.5***	0.0003(0.1) 0.999(−0.1) −0.5	−0.01(−3.33) 1.001(3.5) 10.04*	−0.03(−7.2) 1.003(7.5) 14.2***	−0.06(−13.7) 1.006(14.4) 15.7***	−0. 1(−13.2) 1.009(14.1) 15.2***
KACHAD	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.998(−19.4) −18.4***	0.999(−17.0) −18. 9***	0.999(−18.7) −19.4***	0.999(−12.1) −15.3***	0.999(−2.9) −4.8**	1.000(3.9) 5.0***	1.000(10.2) 10.8***	1.001(17.5) 17.5***	1.002(22.8) 40.2***
HAKESHTI	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.998(−15.6) −16.6***	0.999(−13.7) −15. 9***	0.999(−12.2) −15.3***	0.999(−10.8) −12.3***	0.999(−3.4) −4.7**	1.000(1.9) 3.2***	1.000(6.6) 8.7***	1.001(6.3) 11.3***	1.002(16.9) 27.5***
KHASAPA	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.996(−47.5) −62.1***	0.997(−25.3) −26. 5***	0.998(−15.4) −17.4***	0.999(−7.3) −7.6***	1.000(0.04) 0.1	1.000(8.9) 7.9***	1.001(18.9) 20.7***	1.002(26.7) 38.3***	1.004(51.9) 96.8***
KHODRO	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.996(−43.8) −43.7***	0.997(−18.1) −17. 4***	0.998(−14.8) −14.6***	0.999(−8.5) −8.9***	1.000(0.4) 1.1	1.000(9.1) 6.5***	1.001(15.8) 14.8***	1.002(28.9) 31.2***	1.004(56.2) 70.7***
MAPNA	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.997(−31.0) −28.7***	0.998(−20.3) −21. 6***	0.999(−15.6) −15.9***	0.999(−8.8) −9.9***	1.000(0.01) 0.01	1.000(8.4) 8.2***	1.001(15.9) 15.5***	1.002(21.4) 26.1***	1.004(38.2) 68.1***

Table 3. (*Continued*).

Company	Quantiles	0/1	0/2	0/3	0/4	0/5	0/6	0/7	0/8	0/9
VEBMELAT	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.997(−26.3) −24.2***	0.998(−17.4) −18. 4***	0.999(−13.9) −14.9***	0.999(−7.7) −8.2***	1.000(0.00) 0.00	1.000(7.2) 7.1***	1.001(11.6) 12.2***	1.002(18.5) 22.0***	1.003(31.2) 38.7***
NORI	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.997(−14.9) −16.2***	0.998(−11.1) −12. 3***	0.999(−7.5) −8.5***	0.999(−3.5) −4.2***	1.000(0.2) 0.2	1.000(4.8) 5.5***	1.001(8.4) 10.6***	1.002(10.7) 13.9***	1.003(20.7) 43.4***
OMID	$\hat{\beta}_0(\tau)$ $\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.02(5.6) 0.997(−8.8) −7.7***	0.01(6.2) 0.998(−7.6) −10.1***	0.004(3.1) 0.999(−4.4) −6.3***	0.001(1.3) 0.999(−2.1) −3.7***	−0.001(−0.6) 1.000(0.4) 1.8	−0.003(−2.3) 1.000(2.6) 6.7*	−0.009(−4.7) 1.001(5.3) 8.7***	−0.02(−6.1) 1.002(7.7) 8.7***	−0.02(−4.7) 1.004(8.4) 6.5***
PARSAN	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.998(−19.7) −21.8***	0.999(−17.5) −18. 2***	0.999(−15.1) −13.9***	0.999(−8.4) −10.9***	0.999(−1.0) −1.2	1.000(7.3) 7.7***	1.001(13.8) 15.4***	1.002(21.6) 22.2***	1.003(25.3) 35.5***
PARSIAN	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.997(−21.9) −22.0***	0.999(−18.9) −20. 4***	0.999(−13.4) −14.8***	0.999(−8.4) −9.5***	0.999(−0.7) −1.3	1.000(6.2) 7.0***	1.001(11.1) 12.4***	1.001(18.6) 21.7***	1.003(18.7) 36.8***
PARS	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.998(−16.7) −19.2***	0.999(−12.2) −10. 5***	0.999(−7.9) −8.4***	0.999(−3.1) −3.8***	1.000(0.2) 0.3	1.000(5.1) 4.9***	1.001(9.5) 9.5***	1.002(12.9) 12.5***	1.003(18.4) 29.2***
VEQADIR	$\hat{\beta}_0(\tau)$ $\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.01(1.5) 0.997(−5.0) −4.9***	0.01(3.9) 0.998(−7.0) −6.4***	0.01(2.5) 0.999(−4.2) −5.2***	0.004(1.5) 0.999(−2.4) −4.1***	0.004(1.2) 0.999(−1.3) −3.1**	0.004(1.2) 0.999(−0.6) −0.9	0.002(0.4) 1.000(0.8) 1.1	−0.001(−0.3) 1.002(3.8) 3.2**	0.003(0.8) 1.003(6.8) 4.9***
SHAPDIS	$\hat{\beta}_0(\tau)$ $\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.08(8.5) 0.992(−9.9) −11.3***	0.04(5.9) 0.996(−6.8) −10.4***	0.03(5.2) 0.997(−5.7) −13.0***	0.02(2.9) 0.998(−3.3) −11.2***	0.002(0.4) 0.999(−0.5) −2.0	−0.02(−2.2) 1.002(2.3) 6.9*	−0.04(−5.9) 1.004(6.4) 8.9***	−0.06(−9.1) 1.006(10.7) 10.2***	−0.06(−7.4) 1.007(10.7) 7.5***
SHAPNA	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.997(−26.5) −29.1***	0.999(−18.5) −17. 4***	0.999(−14.8) −16.2***	0.999(−8.5) −10.2***	0.999(−0.6) −1.6	1.000(6.3) 6.7***	1.001(13.4) 14.0***	1.002(18.4) 19.2***	1.003(42.2) 67.3***
SHASTA	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.996(−12.4) −17.9***	0.997(−7.6) −8.5***	0.998(−4.3) −4.8***	0.999(−2.0) −2.7**	1.000(0.5) 0.4	1.001(2.8) 3.9***	1.002(3.3) 9.7***	1.004(7.3) 37.7***	1.005(13.8) 44.6***
SHEBANDAR	$\hat{\beta}_0(\tau)$ $\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.01(0.9) 0.996(−4.7) −4.8***	0.04(4.0) 0.994(−6.1) −6.6***	0.03(3.0) 0.996(−4.0) −5.7***	0.03(2.9) 0.997(−3.2) −6.1***	0.01(1.0) 0.999(−0.9) −2.0	0.01(0.7) 0.999(−0.02) −0.03	0.004(0.4) 1.001(1.2) 1.4	0.005(0.9) 1.002(3.4) 2.4	0.02(3.8) 1.002(5.6) 4.5***
SHETRAN	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.997(−19.4) −26.6***	0.998(−17.1) −17.0***	0.999(−11.3) −14.6***	0.999(−6.5) −7.5***	0.999(−0.5) −0.6	1.000(5.5) 6.9***	1.001(11.0) 12.8***	1.002(14.6) 20.2***	1.003(20.3) 28.6***
TAPIKO	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.997(−18.6) −20.4***	0.998(−18.3) −20.4***	0.999(−15.0) −16.0***	0.999(−9.2) −11.8***	0.999(−2.3) −3.9***	1.000(5.2) 5.6***	1.001(10.8) 11.8***	1.002(13.7) 15.4***	1.003(26.5) 34.1***

Table 3. (*Continued*).

Company	Quantiles	0/1	0/2	0/3	0/4	0/5	0/6	0/7	0/8	0/9
VEMADEN	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.998(−20.0) −22.4***	0.999(−21.5) −21.7***	0.999(−16.9) −18.6***	0.999(−10.3) −11.5***	0.999(−1.1) −2.03	1.000(6.6) 7.5***	1.001(12.2) 12.8***	1.002(19.8) 24.3***	1.003(36.0) 46.3***
VAPASAR	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.997(−17.8) −18.3***	0.999(−16.0) −17.7***	0.999(−12.9) −13.1***	0.999(−8.2) −10.4***	0.999(−1.5) −2.3*	1.000(4.2) 5.3***	1.001(8.9) 8.9***	1.002(14.1) 13.8***	1.003(21.9) 24.8***
VASANDOQ	$\hat{\beta}_0(\tau)$ $\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.03(5.0) 0.995(−7.9) −8.0***	0.02(6.4) 0.997(−7.7) −10.6***	0.01(6.5) 0.999(−7.8) −9.5***	0.005(4.7) 0.999(−5.6) −13.5***	0.001(1.0) 0.999(−1.2) −7.1***	−0.003(−2.3) 1.000(2.6) 7.7***	−0.01(−6.0) 1.002(6.4) 12.5***	−0.03(−9.1) 1.004(10.9) 9.9***	−0.02(−3.0) 1.004(8.2) 6.6***
VATEJARAT	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.998(−21.3) −19.8***	0.999(−15.9) −19.4***	0.999(−11.2) −11.7***	0.999(−6.4) −7.2***	1.000(0.00) 0.00	1.000(5.5) 6.7***	1.001(9.3) 9.9***	1.002(13.4) 13.3***	1.003(17.3) 37.7***
VEBASADER	$\hat{\beta}_1(\tau)$ $t_n^*(\tau_i)$	0.997(−20.7) −22.6***	0.999(−16.3) −17.4***	0.999(−11.4) −11.4***	0.999(−5.6) −8.8***	1.000(0.00) 0.00	1.000(5.4) 5.9***	1.001(9.0) 9.2***	1.002(17.4) 16.0***	1.003(26.1) 41.9***
$t_n^*(\tau_i)$ Critical Values	%1	−2.78	−2.91	−3.06	−3.14	−3.19	−3.24	−3.3	−3.36	−3.39
	%5	−2.12	−2.28	−2.4	−2.51	−2.58	−2.64	−2.72	−2.75	−2.81
	%10	−1.75	−1.92	−2.06	−2.17	−2.25	−2.32	−2.41	−2.46	−2.5

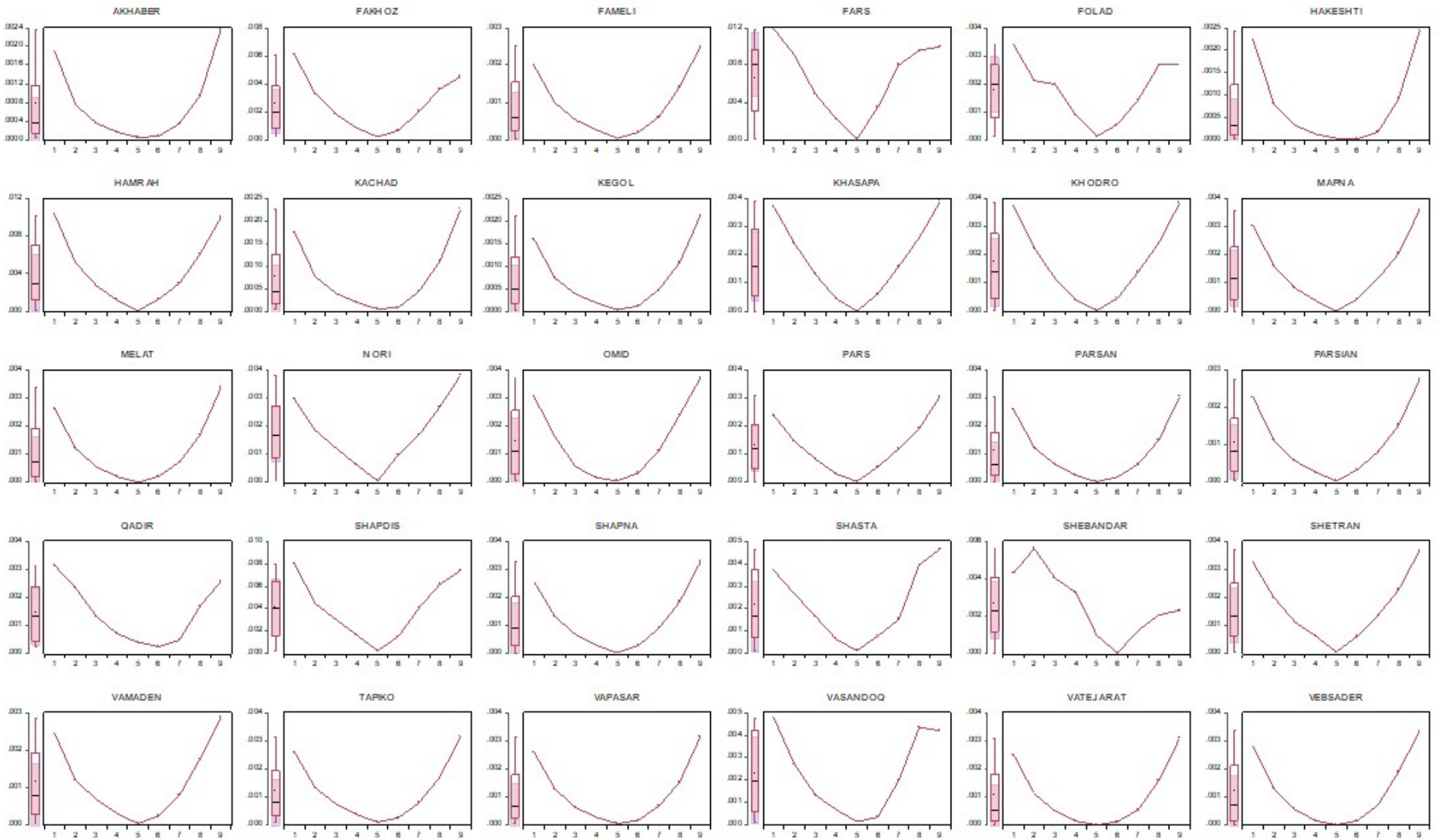

Figure 1. Efficiency degree [$\hat{\delta}(\tau)$ in Equation (6)] of 30 large companies of TSE in 9 deciles.

According to Equation (6) as the autoregressive coefficient moves away from one, the value of $\hat{\delta}(\tau)$ also moves away from zero (**Figure 1**). This means that the market will be less efficient. The results show that running the autoregressive model in the lower or upper decile reduces market efficiency for all companies (**Figure 1**). However, running the autoregressive model in the middle decile increases the market efficiency. When the regression basis of the first decile is considered, according to the result, the market efficiency is lower than that of the middle regression basis. Likewise, if the regression basis of the upper decile is considered, for example, the ninth decile, the market efficiency will be less than the case where the regression basis is average or median.

The practical implication of the above is that market efficiency drops at very high and very low prices. At average and median prices, the market is more efficient. When prices are very low, investors can often predict that stocks will return to average prices to some extent. Investors can, to some extent, predict that stock prices will return to average, even if prices are high. However, if the stock price is on a long-term average, it is difficult to predict that trend, and the best prediction is the current price (That is, a random walk process). The market efficiency trend for most stocks of companies such as AKHABER, KACHAD, and KEGOL increases slowly and with a gentle trend, moving from the first to the fifth decile (**Figure 1**). However, for some stocks of companies such as FARS, FOLAD, NORI, and SHETRAN, the market efficiency increases with a steady trend. No company can increase efficiency on sharp trends. This trend continues with the inefficient transition from the 5th to the 9th decile. As a result, the market efficiency of most stocks of the companies surveyed in this study has increased slightly with the move toward the mean of price.

As a general result, the stock market moves towards efficiency if there are no positive and negative shocks that keep stock prices off average, or if the effects of positive and negative shocks are neutralized. In the case of a positive shock when the stock price rises sharply and a negative shock when the stock price falls sharply, the market efficiency decreases. Market efficiency is highest in stable positions where prices are close to the long-term average. The random walk hypothesis is the basis of the efficient market hypothesis, which states that the information available in the market is random and unpredictable (either with directed or undirected expectations). Therefore, random stock price changes are required in efficient markets. The efficient market has no memory. In other words, you cannot predict tomorrow's price from yesterday's price. Therefore, the only way to achieve high profits is to buy high-risk stocks, according to the definitions provided in the efficient market. Stock prices are not always going to be the same as their intrinsic value, according to this hypothesis. Sometimes prices may be higher or lower than intrinsic value. Eventually, prices will return to their median or intrinsic value.

6. Conclusion

This study aims to examine the efficiency of the Tehran Stock Exchange using the stock prices of large companies. In this research, instead of using the stock price index of the stock exchange, the stock prices of large companies have been used to examine the market efficiency. For this purpose, 30 large companies on the Tehran

Stock Exchange were selected. The stock prices of these companies were first examined using the unit root test in two cases, one with no structural break and one with an endogenous structural break. As a result, it was found that the stock prices of 21 companies adopted the pure random walk method, had no intercept and were a component of the random walk method.

Therefore, if we disaggregate the market, most stock prices show market efficiency, but the prices of all companies don't. In other words, the stock prices of some companies show the efficiency of the market, while others do not. Therefore, one of the reasons for the inefficiency of the capital markets as a whole is the inefficiency of the stock prices of some large companies.

In this study, we used quantile regression to find that the stock prices of the low, medium, and high-level differ in terms of efficiency. It is less efficient at low and high price levels, but more efficient at medium price levels. In other words, if the stock price deviates (up or down) from the long-term average, the market becomes inefficient, and when the stock price is at the middle level, which is almost the intrinsic value of the stock, the market efficiency is higher.

Since the results of this article show both efficient and inefficient outcomes, they align with the findings of all reviewed articles. Articles that have found weak efficiency include those by Gil-Alana et al. [15], Zebende et al. [16], Durusu-Ciftci et al. [19], Lu et al. [11], Narayan and Narayan [31], and Chaudhuri and Wu [6]. In contrast, articles that have rejected the efficient market hypothesis include those by Diallo et al. [17], Nartea et al. [7], Hamid et al. [32], and Narayan and Smyth [10]. While previous studies have focused on testing the random walk hypothesis for common indices in developed, developing, and emerging countries, it is crucial to test this hypothesis using various types of data, markets, indices, and time periods. Although weak market efficiency has been examined in many global stock markets, results have varied due to differences in study methodologies, data availability, and study periods.

To address these inconsistencies, future research should consider the following suggestions: Expand data sources to include different asset classes and market segments, broaden market coverage to include less frequently studied markets, and extend the periods analyzed to capture a wider range of market conditions. Additionally, refining methodologies and statistical techniques, as well as investigating how different market conditions impact efficiency, can provide a more nuanced and comprehensive understanding of market efficiency.

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