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Research Article

The Role of Government Expenditure and Economic Indicators in Mathematics Achievement: A Longitudinal Bayesian SEM Analysis of TIMSS in Jordan

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Abstract:

In this study, 8th-grade performance records for the Trend International Mathematics and Science Study (TIMSS) for the period between the years 1999 and 2023 was used as a secondary source of data. Investigating these trends requires long-term analysis, as substantial changes on the system level are rarely observed regarding student outcomes in short periods. The study is grounded in several theoretical perspectives, including Human Capital Theory, Socioeconomic Status and Educational Outcomes, Educational Policy and Reform Theory, and Systems Theory in Education. These perspectives provide a comprehensive lens through which the interplay between economic factors, educational policies, and student achievement can be analyzed. Bayesian Structural Equation Model (SEM) was implemented to adequately take care of the sampling estimation Employing item response theory, we perform a concurrent calibration of item parameters was perform to link the eight studies onto a common scale spanning the period from 2019 to 2024 using data from empirical research. The results from the analysis yielded a strong association between Wage_and_Salaried_Workers and GDP. The regression loading of Wage_and_Salaried_Workers on its latent variable was estimated at 3.351 with a posterior standard deviation of 0.330, indicating a robust and highly significant association. However, the estimated covariances between the latent variable associated with economic factors (GDP and wage_and_salaried_workers) and other endogenous variables like Gov_Exp_Secondary and TIMSS_Achievement were notably low (Estimates of -0.008 and -0.277 respectively). These findings imply that while each construct significantly impacts its respective domain, their interactions are limited, indicating potential independence in their effects within the model structure. Overall, TIMSS results shows that the quality of education in Jordan is relatively low compared to the international landscape.

1. Introduction

The education system in Jordan includes and not limited to basic secondary school and higher education. Overtime, the role played by the good system of education in Jordan has significantly improve Jordan from predominantly agrerarian to a more industrialized nation. The importance of mathematics in the economic growth of any country cannot be emphasized, as a foundational subject, mathematics is essential in fostering the critical thinking, problem solving skills among the students. The Jordan government has continue to participate in all TIMSS cycles since 1999, part of the principal goals is to evaluate the curriculum with reference to international standard and also measure the capabilities of Jordanian students in terms of achievement compared with their international peers. Overtime, Jordan policy makers used the TIMSS results in achievements to compare Jordan with the best performing countrues in the world, such as Singapore, Chinese, Japan, Korea and Finland. Therefore the aim of this study is to provide an overview on the Jordanian government investiment in shaping Jordan's academic landscape and to determine the relationship between educational achievement (TIMSS Achievement) and government spending on secondary education (gov_exp_secondary) in Jordan

2. Literature Review

2.1 Background

Mathematics education in Jordan is characterized by a comprehensive curriculum, efforts toward pedagogical improvement, ongoing challenges, and a commitment to innovations that enhance teaching and learning outcomes (Al Helih and Nasereddin 2019). The educational landscape in Jordan has witnessed substantial reforms and investments aimed at enhancing the quality and accessibility of education for all its citizens (Al-Khadra, Al-Thani et al. 2022). These efforts are part of the broader vision to prepare a generation capable of contributing to the country's economic development and competing on a global scale (Dagher 2020). Mathematics, being a fundamental discipline, plays a crucial role in this vision, serving as a cornerstone for scientific and technological advancement of Jordan's commitment to improving education (Almuhur 2023). This is usually reflected in its participation in international assessments such as the Trends in International Mathematics and Science Study (TIMSS), which provides comparative data on students' achievements in mathematics and science across different countries (Wardat, Belbase et al. 2022). Historically, Jordan's performance in these assessments has highlighted both achievements and challenges in mathematics education, sparking national conversations on how to address these issues effectively.

Several factors contribute to the complex landscape of mathematics achievement in Jordan. These include the quality of mathematics teaching, the curriculum and its relevance to students' lives and future careers, teacher training and professional development programs, and the integration of technology in the classroom (Sabah and Hammouri 2010). Furthermore, socioeconomic factors, such as family income, parental education levels, and access to educational resources, play a significant role in students' academic achievements. Despite the progress made, fluctuating performances in international assessments and ongoing challenges underscore the need for a detailed exploration of long-term trends in mathematics achievement. Understanding these trends is critical for identifying the underlying factors that contribute to or hinder students' success in mathematics. This, in turn, can inform the development of targeted policies and interventions designed to enhance mathematics education and ensure that all students have the opportunity to succeed.

Moreover, the global shift towards a knowledge-based economy underscores the importance of mathematics for national development. Proficiency in mathematics is essential not only for individual success in the increasingly technology-driven global job market but also for the country's ability to innovate and compete internationally (Rondinelli, Johnson Jr et al. 1998). Therefore, deciphering long-term trends in students' mathematics achievement and understanding the dynamics at play is not just an academic exercise but a strategic imperative for national development. The present study is set against the backdrop of Jordan's ambitious educational reforms, the critical role of mathematics in the modern world, and the challenges and opportunities inherent in improving mathematics achievement (Dagher 2020). It seeks to contribute valuable insights into how Jordan can build on its successes and address its challenges to create a robust, equitable, and forward-looking mathematics education system.

Furthermore, in order to be able to make correct, evidence-based decisions, it is crucial that educational policy and practice gain knowledge on what school factors are related to these changes. TIMSS data provides a unique opportunity for such investigations. TIMSS, based on the participating countries curricula, is a trend study with representative samples of students, and includes contextual information provided by students, their teachers, and principal (Martin, von Davier et al. 2020). The data collected allow countries to understand, compare, and analyze their students' achievements on an international and national level, as well as by student and school characteristics (Mullis, Martin et al. 2004, Patnam 2013). Thus, results are reliable and credible for both educators and policy makers to use in making evidence-based decisions when implementing solutions for educational reform related to mathematics and science and learning.

To provide an interpretation of the results on the TIMSS achievement scale in relation to the students' performance on the assessment items, TIMSS described achievement at four points along the scale as International Benchmarks: Advanced International Benchmark (625), High International Benchmark (550), Intermediate International Benchmark (475), and Low International Benchmark (400) (Sabbagh 2023). With the exception of the top-performing Countries which were Asian countries, only small percentages of students reached the Advanced International Benchmarks in TIMSS 2019. Although, education is considered by many to be the most effective tool for advancing Arab society (Badran, Baydoun et al. 2022, Rasheed 2023). However, reports by international organizations such as the United Nations and the World Bank have concluded these countries have a deficit in educational attainment

and enrollment(Mondiale 2008, Steer, Ghanem et al. 2014). The low achievement by Arab countries in international assessment tests such as TIMSS has been acknowledged by scholar (Morgan and Ibrahim 2020, Al-Mutawa, Al-Rasheedi et al. 2021).

2.2 Problem Statement

The importance of mathematics has been echored in the literature. Rabab'h (2015) Highlights the importance of mathematics owing to its usefulness in our daily life and decision making. the long-term trends in students' mathematics achievement, particularly in Jordan, presents a critical area of study within the broader educational discourse. Despite various reforms and investments in the educational sector (Nusir, Alsmadi et al. 2012), Jordan faces persistent challenges in consistently enhancing mathematics achievement levels among students (Al Shabibi and Silvennoinen 2018). This is evidenced by fluctuating performances in international assessments like TIMSS(Ababneh, Ababneh et al. 2014), indicating a need for Jordan ministry of education to deeply understand the underlying factors contributing to these outcomes. The study conducted by Rabab'h (2015) showed that Jordanian grade 8 TIMSS performance form 1999, 2003, 2007 and 2011 is low. The problem is further compounded by socioeconomic disparities, varying quality of educational resources, and pedagogical approaches across different regions and schools within the country.

In the face of evolving educational reforms, technological integration, and persistent socioeconomic disparities, there is a significant gap in understanding the long-term trends and underlying factors influencing mathematics achievement among students in Jordan. This research seeks to fill this gap by providing empirical insights into the trends in mathematics achievement over the past two decades, analyzing the impact of GDP, and educational policies, and identifying actionable strategies to enhance mathematics education in Jordan. This study highlights the need for a comprehensive analysis to inform targeted interventions that can improve mathematics education outcomes, contributing to the academic success and future readiness of Jordanian students.

2.3 Theoretical Framework

The present study theoretical framework is aim at understand the long-term trends in mathematics achievement among Jordanian students, particularly as reflected in their performance in the Trends in International Mathematics and Science Study (TIMSS). The study is grounded in several theoretical perspectives, including Human Capital Theory, Socioeconomic Status and Educational Outcomes, Educational Policy and Reform Theory, and Systems Theory in Education. These perspectives provide a comprehensive lens through which the interplay between economic factors, educational policies, and student achievement can be analyzed.

Human Capital Theory posits that investment in education leads to the development of skills and knowledge, it also highlight the enhancement of individual productivity and contributing to broader economic growth. This perspective is particularly relevant to understanding the impact of government expenditure on education in Jordan. As outlined in some of the reviewed recent literature, education is seen as a form of investment that yields returns not only to the individual but also to the state, contributing to employment and economic growth (Huang et al., 2020; Guo et al., 2012). The government's focus on improving mathematics education is therefore, a strategic move to build the human capital that can drive future national growth (Gillies, 2015).

Its important to restate that socioeconomic factors, which includes family income and parental levels of education significantly influence student achievement. In Jordan, disparities in these areas can lead to unequal access to educational resources and opportunities, which inveriably affect students' mathematics achievement. The correlation between economic indicators like GDP and educational outcomes highlights the broader impact of socioeconomic status on student performance (Yaya, 2016). Therefore understanding these dynamics is crucial for developing targeted policies that address educational inequities and promote inclusive growth.

Historically, educational policies in Jordan have undergone significant reforms to improve access and quality. However, fluctuations in TIMSS scores suggest that while reforms have been implemented, they may not be sufficient to sustain long-term improvements in mathematics achievement. The effectiveness of these reforms needs to be assessed in terms of their alignment with the country's broader economic and social broader goals. Recent studies indicate that educational reforms, particularly those integrating technology and modern pedagogical methods, can significantly improve student outcomes if effectively implemented (Alola and Avci, 2018).

Systems Theory views the educational environment as an interconnected system where changes in one component affect the entire system. The use of

Structural Equation Modeling (SEM) in this study reflects this interconnectedness, examining how variables such as government expenditure, GDP, and student achievement interact. This approach allows for a nuanced understanding of the direct and indirect effects of economic and policy variables on educational outcomes, providing insights that are essential for formulating effective interventions (Gillies, 2015). However, the integration of Human Capital Theory, Socioeconomic Perspectives, Educational Policy Analysis, and Systems Theory offers a robust framework for understanding the factors influencing mathematics achievement in Jordan. This comprehensive approach provides valuable insights for policymakers, educators, and researchers interested in enhancing educational outcomes and promoting sustainable national development through strategic investments in education.

2.4 Overview of Trends in International Mathematics and Science Study (TIMSS)

The Trends in International Mathematics and Science Study (TIMSS) is an ongoing international assessment that measures student achievement in mathematics and science at the fourth and eighth grades. Conducted every four years since 1995 (Fishbein 2018), TIMSS provides comprehensive data that helps countries evaluate and improve their educational systems. TIMSS is administered every four years, with major assessments conducted in 1999, 2003, 2007, 2011, 2015, 2019, and 2023. Each cycle assesses students in fourth and eighth grades, allowing for monitoring of trends over time(Fishbein 2018). The assessments are grounded in the national curricula of participating countries, ensuring that the tests are relevant to what students are learning (Bdeir 2019). This approach also includes extensive contextual data about educational practices, resources, and policies. Beginning with TIMSS 2019, the study transitioned to digital formats, which were fully implemented by 2023 (Fishbein 2018, Koršňáková and Dohr 2022). This shift allows for more interactive and engaging assessment methods, including problem-solving tasks that mimic real-world scenarios. TIMSS involves a wide range of countries and educational systems, with participation from over 60 countries in recent cycles(Sabbagh 2023). This broad participation helps to provide a global perspective on educational achievement and practices.

TIMSS in 1999 highlighted significant differences in mathematics and science performance across countries. Asian countries like Singapore, Korea, and Chinese Taipei were among the top performers, demonstrating strong competencies in both subjects (Nilsen, Kaarstein et al. 2022). Also, in 2003-2011, these cycles continued to monitor trends, revealing improvements and persistent challenges. For instance, while some countries showed gains in student performance, others struggled to keep pace, indicating the complexity of educational progress. In 2015, this cycle introduced TIMSS Advanced, assessing students in their final year of secondary school in advanced mathematics and physics. This provided insights into higher-level competencies and preparedness for tertiary education (Mullis, Martin et al. 2004, Martin, von Davier et al. 2020). The 2019 assessment marked a significant step towards digital assessments with eTIMSS, which included new interactive item formats. The data collected offered a nuanced view of how technology integration impacts student learning (Mullis and Martin 2012). TIMSS in 2023 fully transitioned to digital administration and introduced a group adaptive design, aligning assessments more closely with diverse student populations. This cycle also included an optional longitudinal study to track student progress over time, providing deeper insights into educational practices and learning outcomes (Sabbagh 2023).

3. Methodology

3.1 Dataset

In this study, 8th-grade performance records for the Trend International Mathematics and Science Study (TIMSS) for the period between the years 1999 and 2023 are used as a secondary source of data. The dataset was obtained from the World Bank Databank and specially stored in the Educational Statistics Database. Although the study focused on Jordanian records, this type of analysis is typically conducted in Asian nations. Every four years, students' performance is assessed by the TIMSS. Performance for the designated period as measured here, for Jordanian eighth-grade pupils (TIMSS_Achievement).

3.2 Hypotheses for the Model

A triple set of models is analyzed with three pairs of hypothesized hypotheses.

Hypothesis 1:

Null: The latent variable (composed of GDP and wage_and_salaried_workers) has no significant relationship with government expenditure on secondary education.

Hypothesis 2:

Null: The latent variable (composed of GDP and

wage_and_salaried_workers) has no significant relationship with TIMSS achievement.

Hypothesis 3:

Null: Government expenditure on secondary education has no significant relationship with TIMSS achievement.

Figure 1 reflected that these hypotheses encapsulate the idea that neither the labor market dynamics (represented by wage_and_salaried_workers) nor economic output (represented by GDP) significantly influence the relationship between educational achievement (TIMSS Achievement) and government spending on secondary education (gov_exp_secondary) in Jordan. The latent variable, which serves as an overarching economic indicator, is constructed from two observed indicators: GDP and Wage and Salaried Workers. Both GDP and wage and salaried workers positively contribute to the latent variable. More so, the latent variable has a direct, positive influence on gov_exp_secondary, suggesting that improved economic conditions lead to increased investment in secondary education. Furthermore, gov_exp_secondary directly affects TIMSS Achievement, indicating that higher government spending on secondary education correlates with improved student performance.

3.3 Model for the Analysis

The structural equation modelling (SEM) approach is specified in Nilsen, Kaarstein et al. (2022). However, for the few observations to handle, the study implemented Bayesian SEM to adequately take care of the sampling estimation. The Bayesian SEM approach is particularly advantageous for this research examining the relationships between TIMSS Achievement, government expenditure on secondary education, wage and salaried workers, and GDP in Jordan for several compelling reasons:

i. Complex Interactions

SEM allows for the simultaneous examination of multiple dependent relationships. In your study, you are looking at how both government spending and economic factors (wage and salaried workers, GDP) influence educational outcomes. SEM is ideal for testing and estimating causal relationships among these variables, handling complex interdependencies that traditional regression models might not adequately address.

ii. Endogeneity Handling

In your model, both TIMSS Achievement and government expenditure on secondary education are considered endogenous, influenced by wage and salaried workers and GDP. SEM is capable of handling endogeneity within the variables, thereby providing unbiased and consistent estimates of the relationships among the variables. This is crucial for valid inference, especially when testing causal hypotheses.

iii. Model Fit Evaluation

SEM provides comprehensive diagnostics and goodness-of-fit measures that allow researchers to assess how well the model fits the observed data. These metrics (like Chi-square, RMSEA, CFI, and TLI) can guide modifications to the model to better reflect the underlying data structure, something that simpler analytical methods may not offer.

iv. Theory Testing and Confirmation

SEM is not just a predictive modeling technique; it is also used for theory testing and development. It can be used to confirm theories or models that hypothesize specific patterns of relationships among variables, making it suitable for your research where the theoretical relationships between education, economic variables, and workforce structure are being tested.

v. Direct and Indirect Effects

SEM can decompose effects into direct, indirect, and total effects. This is especially useful in your research context where you might want to understand the direct impacts of GDP and labor market dynamics on educational achievements and their indirect effects via government spending on education.

vi. Flexibility in Assumptions

Unlike some other statistical techniques that require strict assumptions about data distribution, SEM can be adapted to various types of data (e.g., non-normal data) and model specifications, including those that handle non-linear relationships or interactions among variables.

Equations for all the Variables under study

$$Latent\_variable = \sim gdp + wage\_and\_salaried\_workers \quad \ldots 2.1$$

$$gov\_exp\_secondary \sim Latent\_variable \quad \ldots 2.2$$

$$TIMSS\_Achievement = \sim gov\_exp\_secondary + Latent\_variable \quad \ldots 2.3$$

where,

i. TIMSS_Achievement is the targeted-response endogenous variable to measure the students' performance;

ii. Gov_exp_secondary is also an endogenous variable that measures

government investment on education in Jordan;

iii. Latent_variable is the composition of $gdp\ and\ wage\_and\_salaried\_workers$ as constuent of the latent varable

iv. wage_and_salaried_workers and gdp are given and do not have equations explaining their variation in this model structure.

This setup provides a clear mathematical expression for the hypothesized relationships. The null hypothesis in SEM context would state broadly the indication of no significant relationships exist among these specified variables as they relate to educational achievements and government expenditures within the model's scope.

Prior Distributions

For Bayesian estimation, prior distributions are specified from the previous knowledge of the latent variable, in this case, to allow for informative prior, the normal distribution is specified and asides, all the variables are normalized before estimation procedures. For covariance estimation, of all variables, the gamma distribution is specified to capture the linear dependence measures and robustness of the covariance structure.

Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) is carried out to identify and understand the underlying structure of data involving multiple observed variables. EFA helps identify latent constructs (or factors) that may be responsible for correlations between observed variables. It allows researchers to hypothesize or confirm the existence of underlying factors that are not directly observable. EFA reduces the number of variables by grouping related observed variables into fewer latent factors. Most importantly, EFA is often a precursor to Confirmatory Factor Analysis (CFA) or Structural Equation Modelling (SEM) and it helps provide initial insights into how variables cluster together, guiding the development of theoretical models.

Confimatory Factor Analysis

Confimatory Factor Analysis (CFA)Test is used in this study to validate the factor structure identified in the EFA by testing it against a predefined model. This ensures that the hypothesized factor structure holds in the same or different data, providing stronger support for the model's validity. Asides, CFA enhances the reliability and consistency of measurement models.

4. Results and Analysis

4.1 Description of the Data Used

This section describes the data used in this study in their raw forms before the transformation and scaling process where necessary. The results of the description is given in Table 4.1.

The results in Table 3.1 reveals the descriptive statistics of all the variables in the investigation. It is revealed that the maximum amount of GDP($) released stood at forty-one billion, eight hundred twenty-three million, eight hundred and thirty thousand dollars ($41,823,830,000) and its minimum value of seventeen billion, six hundred and thirty-two, and sixty thousand dollars ($17, 632, 060,000) with an average of thirty billion, seven hundred forty-eight million, five hundred and twenty thousand. This amounted to the fact that huge amount of gdp was released for the period investigated nevertheless, the transformation of this to positive hedge-way would be discovered after this investigation.

However, an average of amount released on gov_exp_secondary where 8th grade students belong, was eighteen million dollars which seemed too meagre compared to whole GDP. For wage_and_salaried_workers, about an average of 86% of working-class in Jordan as compared to International Labour Organization were said to be observed during the period investigated.

4.2 Visualization of the Time-plot (Trend) of the Data Used

This section visualizes all the variables point-movement within the period investigated .i.e between the years 1999 and 2023.

The TIMSS_Achievement in Figure 3.1 appears to show variability across the years with no clear long-term trend. There are periods where the achievement scores increase, followed by declines. The fluctuating pattern may suggest that external factors (possibly economic conditions, policy changes, or educational reforms) significantly impact student performance in TIMSS assessments over the years. The GDP plot in Figure 3.2 shows a general upward trend, indicating economic growth over the years. However, there might be periods of stagnation or slight declines, followed by recovery. A growing GDP generally suggests improving economic conditions, which can lead to increased public and private investment, including in sectors such as education and infrastructure.

This plot in Figure 4.3 likely exhibits either a steady increase or significant yearly fluctuations in government spending on secondary education. Increases in expenditure could reflect a governmental focus on improving educational outcomes, possibly in response to the needs for

better educational facilities and resources. Fluctuations might indicate changes in budget allocations or shifts in educational priorities.

The plot in Figure 4.4 shows a general upward trend in the proportion of wage and salaried workers over the years. The trend appears relatively steady with some fluctuations but overall, it indicates an increase. The rising trend suggests a gradual shift towards more formal employment structures within the economy. This can be indicative of economic development, where more individuals are moving into stable, wage-paying jobs away from informal sectors. Such a transition often correlates with improvements in labor regulations, growth in organized sectors, and overall economic stability. An increase in wage and salaried workers is typically a positive sign for the economy. It suggests higher employment quality, which can lead to increased consumer spending, better social security contributions, and improved living standards. For policymakers, this trend could validate the effectiveness of economic policies aimed at job creation and formalization of the labor market.

4.3 Preliminary Analysis

This reveals the results of direct pairwise correlations for preemption of degree of relationship among variables and the results EFA test for all the variables used in this research, this is to to identify and understand the underlying structure of data involving multiple observed variables. See Table 4.4

Pairwise Correlations of the Variables under Study

The results in Table 4.4 revealed that the correlation coefficient of -0.7031 suggests a strong negative relationship between TIMSS_achievement and GDP. This could imply that higher GDP is associated with lower scores in TIMSS (Trends in International Mathematics and Science Study) achievement. This might seem counterintuitive and could warrant further investigation to understand the underlying factors or potential confounders affecting this relationship. The correlation coefficient of -0.3005 indicates a weak to moderate negative relationship. This suggests that higher government expenditure on secondary education might be associated with lower TIMSS achievement scores. Again, this is somewhat unexpected and prompts a deeper look into how these funds are being utilized or other intervening variables. The correlation coefficient of -0.7094 suggests a strong negative relationship, indicating that higher wages and skills levels are associated with lower TIMSS achievement scores.

This could be due to a variety of socio-economic factors or perhaps the migration of higher-skilled individuals away from regions with low educational outcomes. The correlation of 0.1003 is very weak, showing almost no relationship between GDP and government spending on secondary education. This might indicate that GDP levels do not directly influence how much a government spends on secondary education, or that this spending is influenced more by policy decisions rather than economic capacity. The correlation coefficient of 0.9935 indicates a very strong positive relationship, suggesting that higher GDP is closely linked to higher wages and salaried workers levels, which is expected as economic growth typically leads to higher income levels and better employment opportunities. The correlation of 0.0237 is negligible, suggesting no significant relationship between government spending on secondary education and the wages and skills in the economy.

Explanatory Factor Analysis

The results in Table 5.4 showed that each variable loads strongly on one factor, indicating distinct factor groupings: GDP and wage data load on MR1, government expenditure on education on MR2, and TIMSS achievement scores on MR3. All variables have high communalities, indicating that the factors account for most of the variance in each variable.

Results in Table 6.4 reflected that MR1 explains 50% of the variance, suggesting it is the most significant factor, followed by MR2 and MR3.The Tucker Lewis Index in Table 7.4 is unusually high, suggesting excellent model fit, though this may need scrutiny given the negative degrees of freedom in the model fit statistic (typically indicating a potential issue in the model specification or sample size). An RMSR of 0 indicates a perfect fit, but in conjunction with other fit statistics, especially with negative degrees of freedom, this might warrant a re-evaluation or validation with a larger dataset.

Comfirmatory Factor Analysis (CFA)

The GDP and gov_exp_secondary in Table 8.4 were both constrained to an estimate of 1.000, serving as reference indicators within their respective latent constructs. This standard practice stabilizes the scale of the latent variables. More so, wg_nd_slrd_wrk demonstrated a robust effect size with an estimate of 3.397 and a posterior standard deviation (Post. SD) of 0.367. The 95% posterior interval ranged from 2.765 to 4.311, indicating a strong and precise effect on its associated latent variable. Conversely, Latent_variable, linked to

TIMSS Achievement, exhibited considerable uncertainty in its impact, with an estimate of -0.294 and a Post. SD of 5.508. The wide 95% posterior interval from -13.192 to 11.290 highlights substantial uncertainty in the measurement.

The regression of Government Expenditure on Secondary Education (Gov_Exp_Secondary) on the latent variable Latent_variabl yielded an estimate of 0.230 with a Post. SD of 1.503. The broad 95% posterior interval from -2.615 to 3.471 underscores the uncertainty regarding the magnitude and direction of this effect, suggesting that further research is necessary to clarify this relationship and would be clarifed by Bayesian SEM. Furthermore, variances of the indicators like GDP, wage_and_salaried_workers, and Gov_Exp_Secondary were well-estimated with low posterior standard deviations, indicating reliable measurements within the model framework. However, the latent variables themselves, particularly TIMSS Achievement, showed higher variability, as evidenced by the wider 95% posterior intervals. This variability indicates potential model instability or the need for additional data to enhance the robustness of these estimates.

Nevertheless, regarding three null hypothesis posed, it is evident that there are no evidences to reject the null hypothesis 1 -2.615 to 3.471 underscores the uncertainty regarding the magnitude and direction of the effect of the regression of Government Expenditure on Secondary Education (Gov_Exp_Secondary) on the latent variable Latent_variable. In a similar manner, hypotheses 2 and 3 may not likely be rejected since TIMSS Achievement showed higher variability, as evidenced by the wider 95% posterior intervals. This indicates potential model instability or the need for additional data to enhance the robustness of the estimates. However, further results in the in the Bayesian estimation procedures would clarify the validity of the relationship.

Bayesian SEM

The results in 9.4 depicted that the convergence and reliability of the chain of estimation is valid and reliable since the Rhat values are mostly around 1.001, suggesting that the chains have converged well for most parameters, indicating reliable estimates.

GDP and wage_and_salaried_workers show strong loadings on their respective latent variables, standardized loadings close to 1.0 indicate that these variables are well represented by their latent constructs. The latent variable wage_and_salaried_workers is estimated at 3.351 with a tight posterior interval, reflecting a strong and consistent effect. The covariances between latent variables and response variables are close to zero, suggesting little to no linear association. This is important as it suggests potential non-linear relationships or the absence of direct effects between these variables. The variances of observed variables like GDP and wage_and_salaried_workers are very low, indicating minimal residual variance and high reliability of these measurements. Latent and response variables exhibit higher variability, as reflected in their wider posterior intervals, suggesting more uncertainty in these estimates which could be due to the small number of observations. However, the model's Marginal Log Likelihood (MargLogLik) is -31.337, and the Posterior Predictive P-value (PPP) is 0.380. The PPP value suggests a moderate fit; values closer to 0.5 are typically indicative of a better fit.

Added Value of the Manuscript

This manuscript provides a comprehensive analysis of long-term trends in mathematics achievement among Jordanian students, focusing on the period between 1999 and 2023. Unlike previous studies that primarily analyze short-term data or isolated educational reforms, this research employs a robust Bayesian Structural Equation Modeling (SEM) framework to explore the complex interplay between economic indicators (GDP and labor market dynamics) and educational outcomes (TIMSS achievement and government expenditure on secondary education). By integrating Human Capital Theory, Socioeconomic Status and Educational Outcomes, Educational Policy and Reform Theory, and Systems Theory in Education, the study offers a multidimensional perspective on how economic conditions and policy initiatives collectively influence student performance in mathematics.

Unique Contributions to the Existing Body of Knowledge:

Holistic Theoretical Framework: It synthesizes multiple theoretical perspectives to provide a nuanced understanding of the factors affecting mathematics achievement. This integrative approach allows for a more comprehensive interpretation of how economic and educational variables interact, offering insights that can guide policymakers in aligning educational reforms with broader socio-economic goals.

Bayesian SEM Approach: The use of Bayesian SEM enables the handling of complex interdependencies and endogeneity among variables, offering more precise estimates of causal relationships. This methodological rigor not only enhances the validity of the findings but also sets a

precedent for future research in educational outcomes using advanced statistical techniques.

Longitudinal Analysis: The study examines trends over a 24-year period, providing a unique longitudinal perspective that captures both the successes and challenges of Jordan's educational reforms. This long-term view is critical for understanding the sustainability of policy impacts and identifying areas where further intervention is needed.

Policy Relevance: The findings have significant implications for educational policy in Jordan and similar contexts. By highlighting the influence of government expenditure and socio-economic factors on student performance, the research offers actionable recommendations for targeted interventions aimed at improving educational equity and effectiveness.

Global Contextualization: The manuscript situates Jordan's educational challenges within a global context, comparing its TIMSS performance with other countries. This comparative analysis not only underscores the unique challenges faced by Jordan but also identifies best practices from high-performing education systems that could be adapted to the Jordanian context.

5. Discussion

This study examined long-term trends in mathematical achievement among Jordanian students using TIMSS data from 1999 to 2023. My findings specifically looked at the relationships between economic factors (GDP, labor market conditions), government spending on secondary education, and student performance. The study shows a weak relationship between GDP and educational results, but a significant correlation between wage and salaried workers and economic growth using Bayesian Structural Equation Modelling (SEM), this finding is consistent with findings of Morgan and Ibrahim (2020), Al-Mutawa, Al-Rasheedi et al. (2021) who acknowledge the low achievement by Arab countries (Jordan inclusive) in international assessment tests such as TIMSS.

My findings shows that raising education budgets alone does not always translate into higher academic achievement, as evidenced by the fact that government spending on education has no direct bearing on student achievement. This finding is consistent with the work of Al Shabibi and Silvennoinen (2018) who report the fact that despite various reforms and investments in the educational sector, Jordan faces persistent challenges in consistently enhancing mathematics achievement levels among students These findings are consistent with the research of Sabah and Hammouri (2010) that has highlighted the relevance of strengthening non-economic factors such as teacher quality and curriculum alignment for higher learning outcomes. The findings raise questions about the assumption that growth in GDP and investment by the government directly boost achievement in education, implying that socioeconomic disparities and resource allocation inefficiencies are significant barriers. This study argues that Jordanian authorities should prioritize teacher training, pedagogical innovations, and addressing educational disparities over just increasing spending. Furthermore, long-term, sustainable reforms are essential to improve educational quality, but short-term improvements have had mixed results on student accomplishment. These findings make crucial recommendations for Jordan's educational policy and practice.

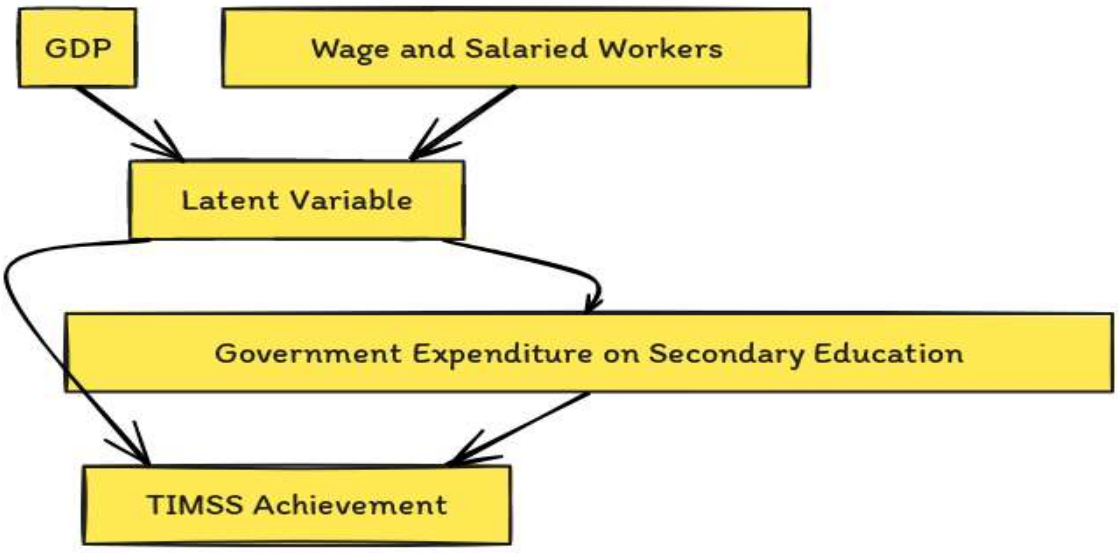

***Figure 1**: Bayesian SEM Path Diagram Showing interactions between variables*

***Table 4.1:** Results of the Descriptive Statistics of the Data Used*

Variable /Parameter	TIMSS_Achievement	gov_exp_secondary	gdp	wage_and_salaried_workers
Mean	7.037143×10^{70}	1.827543×10^{1}	3.074852×10^{10}	8.604160×10^{1}
Variance	4.032769×10^{70}	8.243451×10^{-1}	8.792836×10^{9}	1.2114829
Minimum	6.760000×10^{69}	1.388748×10^{1}	1.763206×10^{10}	8.444390×10^{1}
Maximum	1.150000×10^{71}	1.659573×10^{1}	4.182383×10^{10}	8.758663×10^{1}
Skewness	0.522890	0.871261	0.316901	0.234138
Kurtosis	1.786111	0.600678	1.160152	1.333500
Observations	7.0	7.0	7.0	7.0

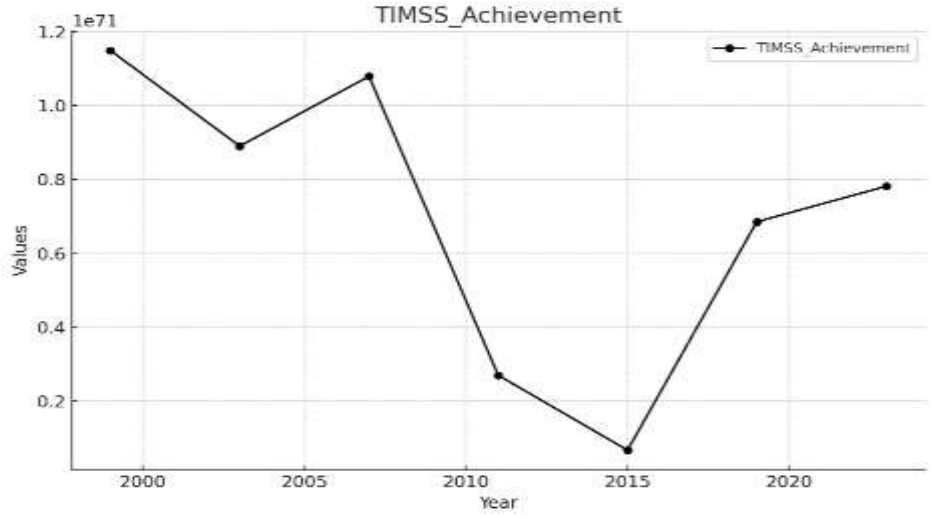

***Figure 4.1:** Time-plot of the TIMSS_Achievement in Jordan from 1999 to 2023*

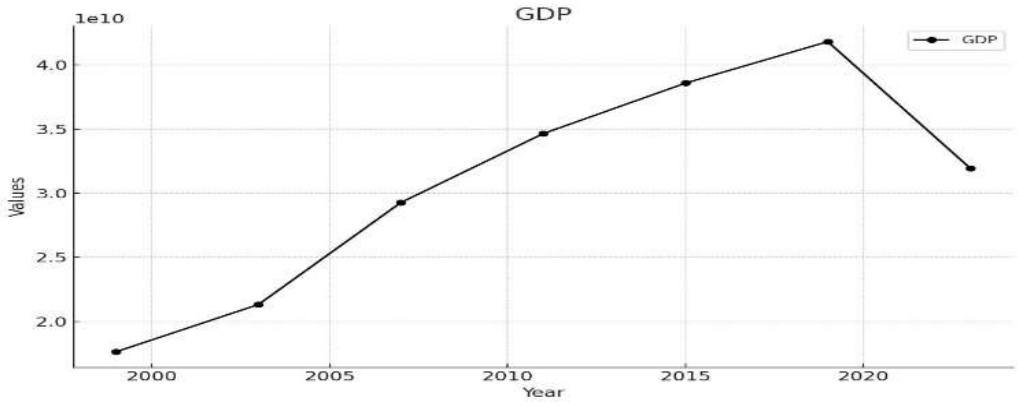

***Figure 4.2:** Time-plot of the GDP in Jordan from 1999 to 2023*

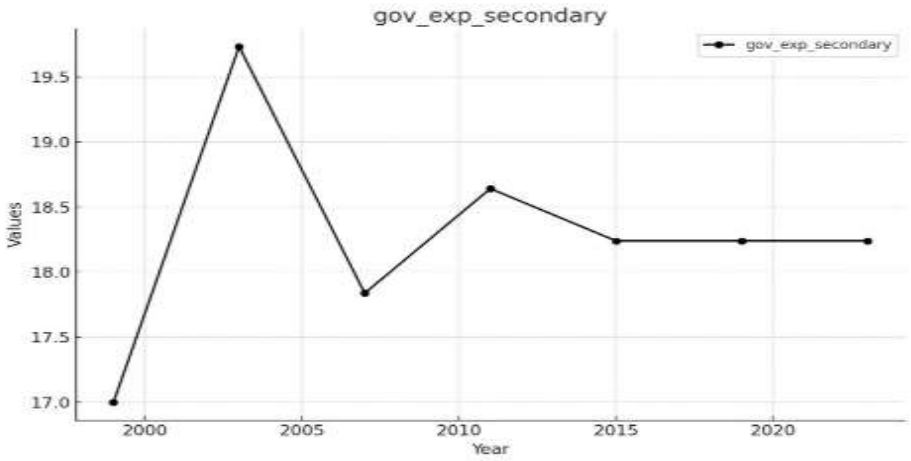

Figure 4.3: *Time-Plot of the Gov_Exp_Secondary in Jordan from 1999 to 2023*

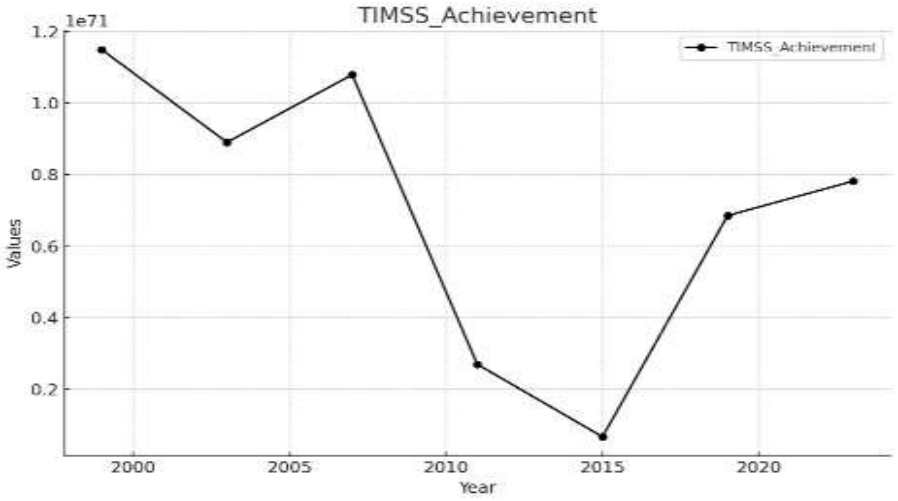

Figure 4.1: *Time-plot of the TIMSS_Achievement in Jordan from 1999 to 2023*

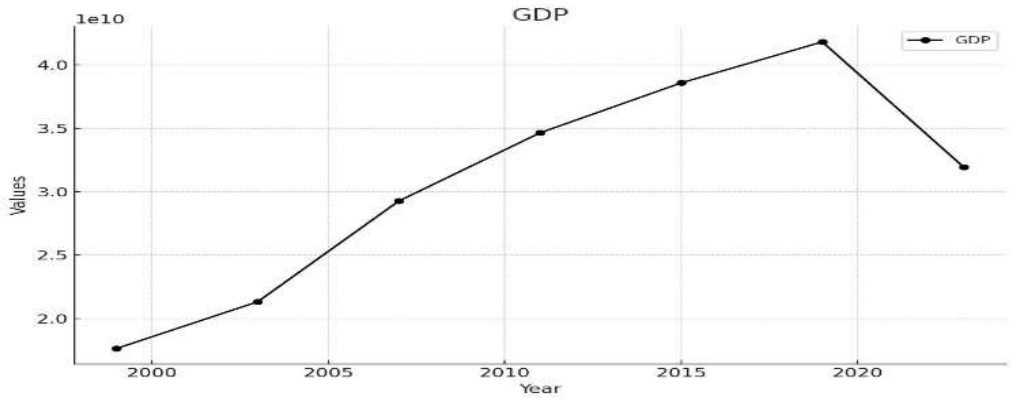

Figure 4.2: *Time-plot of the GDP in Jordan from 1999 to 2023*

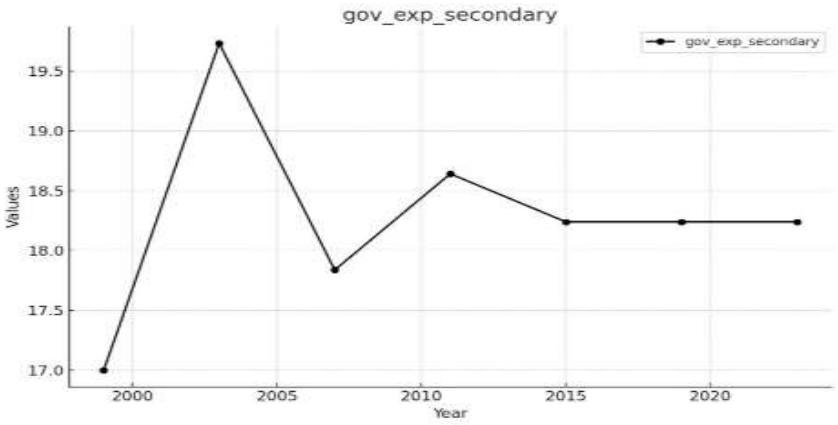

Figure 4.3: *Time-Plot of the Gov_Exp_Secondary in Jordan from 1999 to 2023*

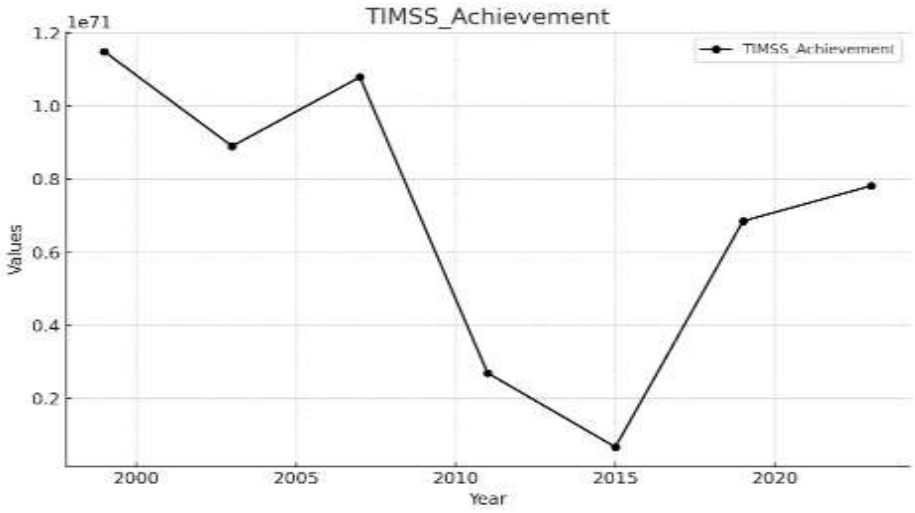

Figure 4.1: *Time-plot of the TIMSS_Achievement in Jordan from 1999 to 2023*

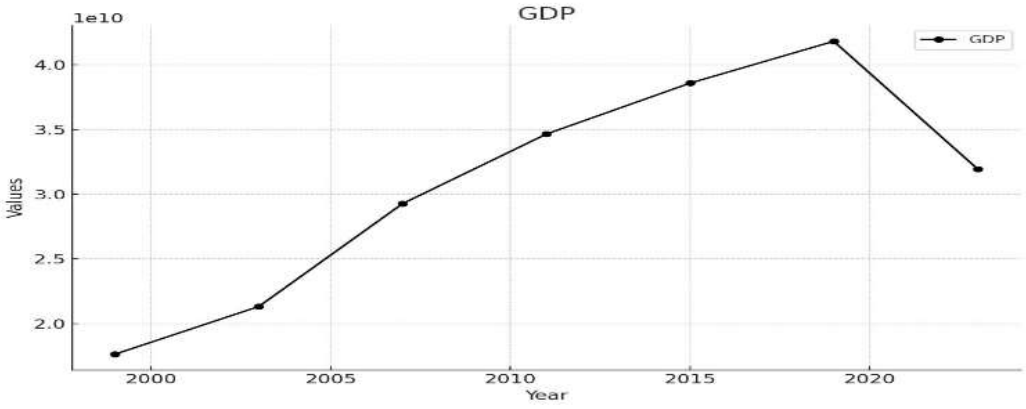

Figure 4.2: *Time-plot of the GDP in Jordan from 1999 to 2023*

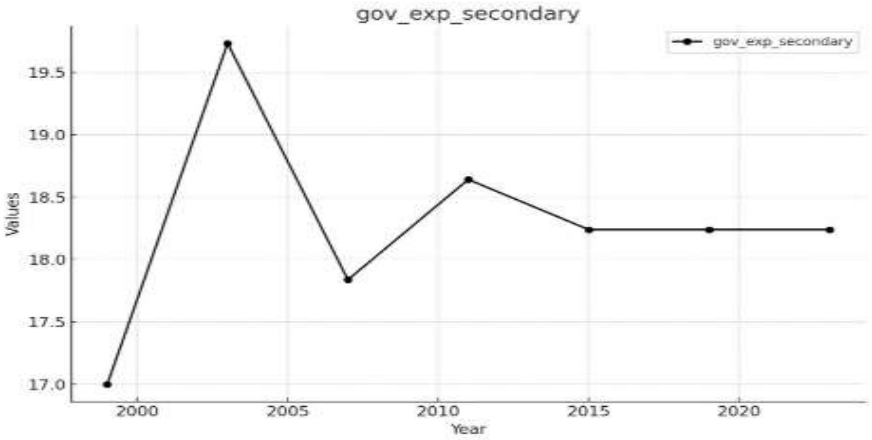

Figure 4.3: *Time-Plot of the Gov_Exp_Secondary in Jordan from 1999 to 2023*

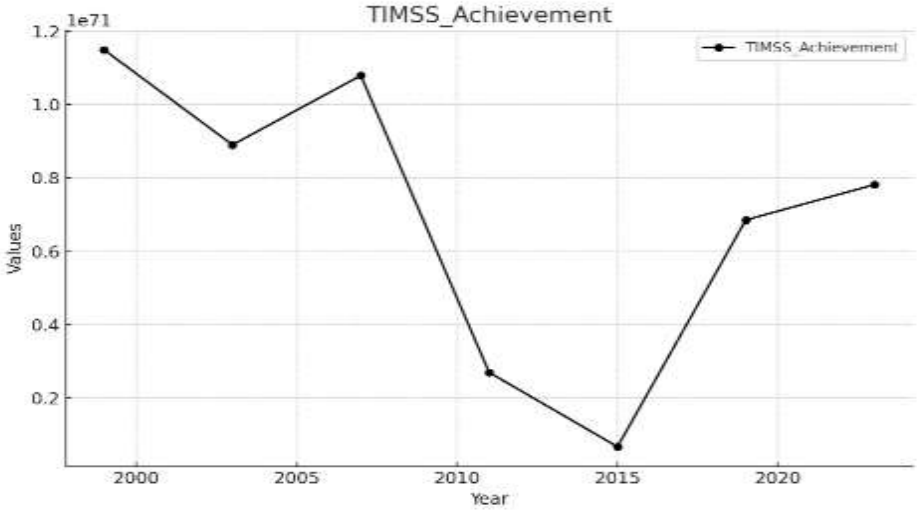

Figure 4.1: *Time-plot of the TIMSS_Achievement in Jordan from 1999 to 2023*

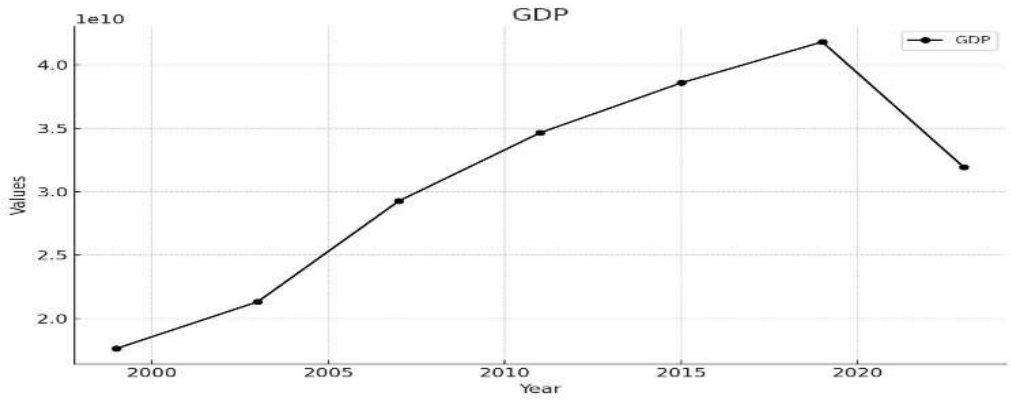

Figure 4.2: *Time-plot of the GDP in Jordan from 1999 to 2023*

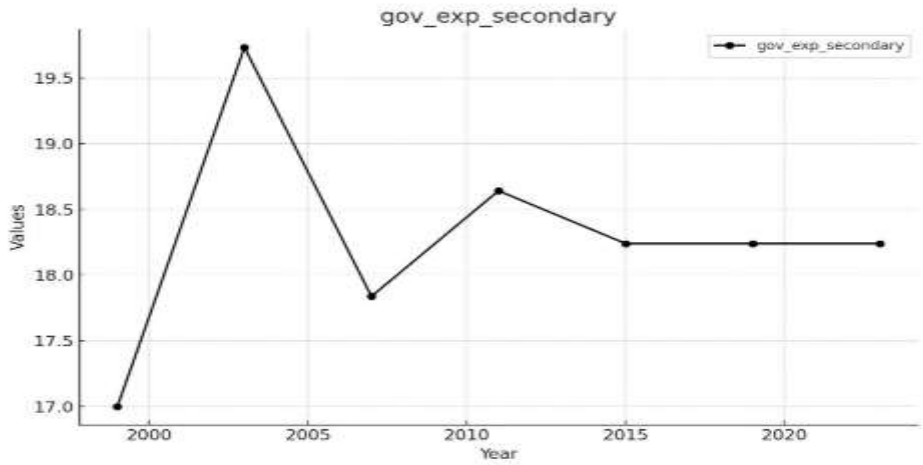

Figure 4.3: *Time-Plot of the Gov_Exp_Secondary in Jordan from 1999 to 2023*

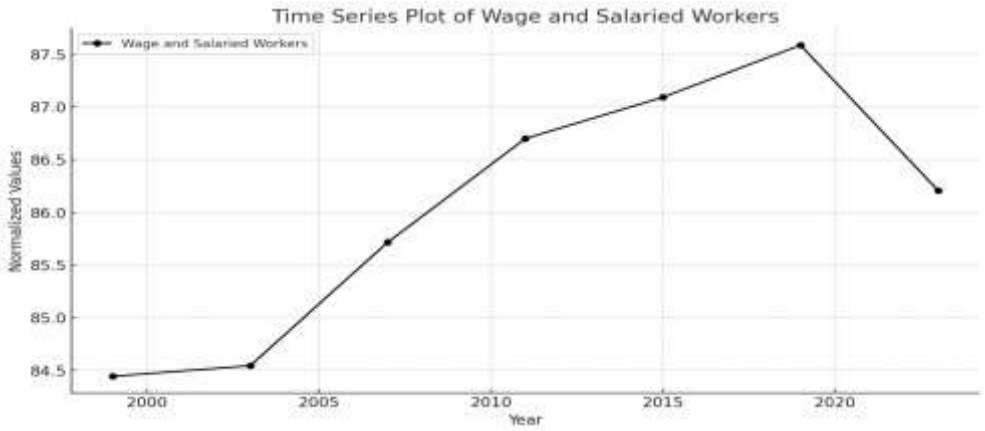

Figure 4.4: *Time-plot of the wage_and_salaried_workers in Jordan from 1999 to 2023*

Table 4.4*: Results of the Pairwise Correlation*

Variables	TIMSS_Achievement	GDP	Gov_Exp_Secondary	Wage_and_Salaried_Workers
TIMSS_Achievement	1			
GDP	-0.7031	1		
Gov_Exp_Secondary	-0.3005	0.1003	1	
Wage_and_Salaried_workers	-0.7094	0.9935	0.0237	1

Table 5.4: *Results of the Factor Loadings*

Variable	MR1	MR2	MR3	Communalities (h^2)	Uniqueness (u^2)
TIMSS_Achievement	-0.46	-0.19	0.87	1.00	0.005
Gov_Exp_Secondary	0.01	0.99	-0.13	1.00	0.005
GDP	0.95	0.06	-0.30	1.00	0.0039
Wage_and_Salaried_workers	0.94	-0.03	-0.33	1.00	0.0038

Table 6.4: *Results of Factor Statistics*

Description	MR1	MR2	MR3
SS Loadings	2.00	1.02	0.96
Proportion of Variance	0.50	0.25	0.24
Cumulative Variance	0.50	0.76	1.00

Table 7.4: *Results of Fit and Adequacy Measures*

Measure	Value
Mean Item Complexity	1.3
Tucker Lewis Index of Factoring Reliability	2.217
RMSR (Root Mean Square of the Residuals)	0
Chi-Square of the Model	23.21
DF of the Model	-3
Objective Function Value	0.06

Table 8.4*: Results of the CFA*

Parameter	Estimate	Post. SD	95% PI Lower	95% PI Upper	Rhat	Prior Distribution	Comments
Latent Variables							
GDP	1.000	-	-	-	-	-	Fixed parameter (no variability)
Wage_nd_slrd_wrk	3.397	0.367	2.765	4.311	1.003	normal(0,10)	Strong and precise effect
Gov_Exp_Scndry	1.000	-	-	-	-	-	Fixed parameter (no variability)
Latent_variable	-0.294	5.508	13.192	11.290	1.012	normal(0,10)	High variability
Regressions							
Gv_exp_secondary	0.230	1.503	-2.615	3.471	1.007	normal(0,10)	Uncertain effect size
Variances							
GDP	0.003	0.007	0.000	0.019	1.000	gamma(1,0.5)[sd]	Low variance, stable estimate
wg_nd_slrd_wrk	0.039	0.092	0.000	0.196	1.005	gamma(1,0.5)[sd]	Relatively stable
gov_exp_scndry	1.143	1.332	0.132	4.548	1.002	gamma(1,0.5)[sd]	High variability
Latent_variable	0.156	0.276	0.000	0.683	1.001	gamma(1,0.5)[sd]	Moderate variability
TIMSS_Achievmn	0.286	1.058	0.000	1.870	1.019	gamma(1,0.5)[sd]	High variability

Table 9.4: *Results of the Bayesian SEM Estimation*

Category	Parameter	Estimate	Post. SD	95% PI Lower	95% PI Upper	Std.lv	Std.all	Rhat	Prior
Latent Variables									
	GDP	1.000	-	-	-	0.484	0.993	1.001	-

Category	Parameter	Estimate	Post. SD	95% PI Lower	95% PI Upper	Std.lv	Std.all	Rhat	Prior
	wg_nd_slrd_wrk	3.351	0.330	2.746	4.010	1.622	0.993	1.001	normal(0,10)
	gov_exp_scndry	1.000	-	-	-	1.131	1.000	-	-
	TIMSS_Achivmnt	1.000	-	-	-	1.326	1.000	-	-
Covariances									
	Latent_variable ~~ Endogens_vrbl1	-0.008	0.244	-0.501	0.476	-0.014	-0.014	1.001	lkj_corr(1)
	Latent_variable ~~ Rspns_Endgns_v	-0.277	0.347	-1.056	0.158	-0.431	-0.431	1.001	lkj_corr(1)
	Endogens_vrbl1 ~~ Rspns_Endgns_v	-0.241	0.632	-1.615	0.979	-0.161	-0.161	1.001	lkj_corr(1)
Variances									
	GDP	0.004	0.010	0.000	0.019	0.004	0.015	1.002	gamma(1,0.5)[sd]
	wg_nd_slrd_wrk	0.035	0.083	0.000	0.183	0.035	0.013	1.001	gamma(1,0.5)[sd]
	gov_exp_scndry	0.000	-	-	-	0.000	0.000	-	-
	TIMSS_Achivmnt	0.000	-	-	-	0.000	0.000	-	-
	Latent_variabl	0.234	0.319	0.054	0.803	1.000	1.000	1.001	gamma(1,0.5)[sd]
	Endogens_vrbl1	1.279	1.288	0.313	4.415	1.000	1.000	1.000	gamma(1,0.5)[sd]
	Rspns_Endgns_v	1.758	1.383	0.493	5.411	1.000	1.000	1.000	gamma(1,0.5)[sd]

6. Conclusions

The study on mathematics education in Jordan, analyzing TIMSS data from 1999 to 2023, reveals a complex relationship between economic growth and student performance. While economic indicators like GDP and wage-and-salaried workers are linked to increased government spending on education, this financial investment does not directly improve student achievement in mathematics. Fluctuations in TIMSS scores over the years suggest that external factors, including policy changes and socioeconomic disparities, significantly affect outcomes. The findings point to inefficiencies in resource allocation and highlight the need for targeted interventions beyond just increasing financial inputs.

For educational policy, the study recommends prioritizing improvements in teacher quality, curriculum development, and addressing socioeconomic disparities that contribute to unequal access to quality education. Future research should explore non-economic factors, such as teaching methods and regional disparities, to better understand the drivers of student performance. Long-term strategies focusing on these areas, rather than short-term financial solutions, are essential to improving mathematics education in Jordan.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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