The CAPM Revisited Using Structural Equation Model: Mediating Role of GDP-Growth in Pakistan Stock Exchange

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Abstract

In emerging equity markets, the Capital Asset Pricing Model (CAPM) continues to produce significant results. The CAPM is investigated in this study using time-series OLS regression and the Structural Equation Model (SEM), with GDP-Growth acting as a moderator. Using monthly data from January 2002 to December 2020 and a comprehensive sample of 522 financial and non-financial firms listed on PSX, the study's findings reveal a statistically significant nexus between market excess returns and portfolio excess returns. Based on four portfolios constructed as small, big, value, and growth stock portfolios, the results show a positive and statistically significant relationship between market excess returns and GDP-growth, as well as a negative relationship between market excess returns and GDP-growth. Furthermore, the CAPM is still used to explain average stock portfolio returns in PSX.

Keywords: CAPM, SEM, GDP-growth, Pakistan Stock Exchange

Introduction

Active investors and equity portfolio managers around the world are acutely conscious of the significance of asset valuation and asset allocation decisions in a volatile equity market. To generate excess returns, they use various valuation techniques to make rational decisions about asset selection and allocation for a diversified portfolio. In order to make rational decisions about their equity market investments, they use appropriate asset pricing models to forecast the potential returns from financial securities to be invested. The Capital Asset Pricing Model (CAPM) was the first theoretical and empirical model to recognise the risk-return nexus and postulate significant results in multiple scenarios, and it has been studied all over the world from various macroeconomic perspectives (Ali, He, & Jiang, 2018; Petkova, 2006; Vassalou, 2003; Farooq, 2018). Several empirical tests in developed and emerging equity markets showed that CAPM produced valid results on their own but were influenced by a variety of macroeconomic variables. As a result, using emerging market data from the Pakistan Stock Exchange (PSX), this study investigates the role of GDP in mediating CAPM from a novel perspective.

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Literature Review

Investors and portfolio managers are motivated to evaluate and determine asset prices and expected returns, so they employ modern forecasting techniques to outperform the market and earn excess returns. This concept is highlighted as the intrinsic value of an asset by (Graham, Dodd, & Cottle, 1934), indicating that asset analysis and valuation has historically supported the background. Later, (Markowitz, 1952) laid the groundwork for modern portfolio theory, which shifted the trend of asset evaluation into mean-variance portfolio selection. The risk factor has been divided into two categories: systematic risk and unsystematic risk (Kim, Kim, & Lee, 2013). Since more than 50 years, the CAPM has been independently developed by (Lintner, 1965; Mossin, 1966; Sharpe, 1964); researchers and practitioners have been in pursuit of a perfect model and diversified portfolios to forecast potential stock returns, but have yet to reach a conclusion. In 1990, Markowitz and Sharpe were both awarded the Nobel Prize for their model, which produced simple and efficient results. Furthermore, since the 1970s, a plethora of empirically investigated studies with a variety of factors and equivalent asset pricing models have been conducted to determine the expected portfolio stock returns, which is supported by asset pricing theory. Furthermore, the majority of studies discovered that the Sharp-Lintner-Mossin SLM-CAPM produces influential results in estimating risk-adjusted securities expected returns. As a result, this study revisits the conventional CAPM with the novelty of GDP-growth as a mediating variable in Pakistan's emerging equity market.

Numerous research studies, such as (Douglas, 1967), have empirically investigated and argued that the CAPM linear relationship is too flat, which is associated with measurement error in beta (Miller and Scholes, 1972). To reduce measurement errors, (Black et al., 1972; Fama and MacBeth, 1973) linked this nexus with portfolio, supporting the argument that this association is near linear while slope is still under estimated (Fama and French, 1992) also revealed a too-flat and statistically insignificant relationship between risk and returns. Furthermore, there are two versions of CAPM based on beta analysis: static OLS, where the beta coefficient is assumed to be constant over time, and time varying beta coefficient.

Kassimatis (2008) discovered that HML and UMD react as if they are disappearing based on time-varying beta. Using Australian equity market data, on the other hand, reduces SMB returns. Furthermore, the

results revealed that the momentum effect performs poorly in the market. The study also argued that because the business cycle (macroeconomic situation) varies from country to country, so does the return-generating process. As a result, estimating beta as a constant may result in erroneous regression results.

Vassalou (2003) investigated the GDP-growth link with FF-3FM and discovered that the presence of GDP-growth news can influence the outcomes of asset pricing factors such as size and value. Similarly, Liew and Vassalou (2000) contended that both size and value factors can predict future economic growth. Similarly, whether GDP growth has an impact on stock returns directly or indirectly needs to be investigated. Furthermore, Boamah (2015) investigated the Fama-French factors' ability to forecast future South African economic growth (GDP). According to the findings, FF-3FM factors significantly predict future GDP growth. Similarly, with the exception of the HML factor, the FF-3FM factors accurately predict Pakistan's future GDP growth (Ali, He, & Jiang, 2018). Furthermore, Vassalou (2003) and Petkova (2006) discovered that in the presence of macroeconomic risk, the FF-3FM factors have a moderated explanatory power; however, more research is needed to examine the mediating role of GDP growth using the CAPM model, which produced statistically significant effects in all of the above-mentioned literature. Furthermore, the CAPM is the most empirically tested and criticised model in equity markets around the world, but it still contributes significant results and performs efficiently. This study revisits the CAPM with the objective of mediating GDP growth in Pakistan's emerging equity market.

The investment decision-making process is based on expected returns and risk (Ben Rejeb & Boughrara, 2014), which is at the heart of the capital asset pricing model (CAPM) supported by modern financial theory (Abdeldayem & Darwish, 2018). The researchers proposed a variety of contributory risk-factors in the domain of asset pricing models to determine the direct determinants of stock returns, such as (Fama and French, 1992; 1993; Carhart, 1997), but there has been very little work done in finance regarding mediating contribution to stock returns in emerging equity markets. As a result, this study is an attempt to investigate the relationship between market risk-factor and average portfolio stock returns in PSX using GDP-growth as a mediating factor.

Furthermore, macroeconomic variables play a significant role in determining stock returns in developed and emerging markets around the world. However, among macroeconomic variables, GDP-growth played a

significant role in forecasting stock returns and estimating future asset values. As a result, the stock market is an inseparable part of the economy (Setiawan, 2020). Similarly, prior literature empirically demonstrated a closed nexus between stock returns and GDP-growth, such as (Khan, Tantisantiwong, Fifield, and Power, 2015), which investigates the relationship between macroeconomic variables and stock returns using South Asian markets. In addition to the (Fama & French, 2004) highlighted hypothesis that market betas explain expected returns, this study augmented GDP-growth as a mediating variable to investigate the PSX market.

The rest of this work is organised as follows: Part 3 explains data and methodology, Part 4 explains analysis and discussion, and Part 5 explains Conclusion.

Theoretical Framework

Due to methodological flaws, the empirical findings show divergence, distinguishing their studies from other prior literature. As a result, this study distinguishes the methodology by investigating the mediating role of GDP-growth with CAPM using various equal-weighted portfolios as dependent variables such as size (small-sRi and big-bRi) and B|M ratio (high-vRi and low-gRi) and excess market returns as independent variable (RmRf) to perform mediation analysis in Pakistan's emerging market using Structural Equation Modeling (SEM), also known as path analysis.

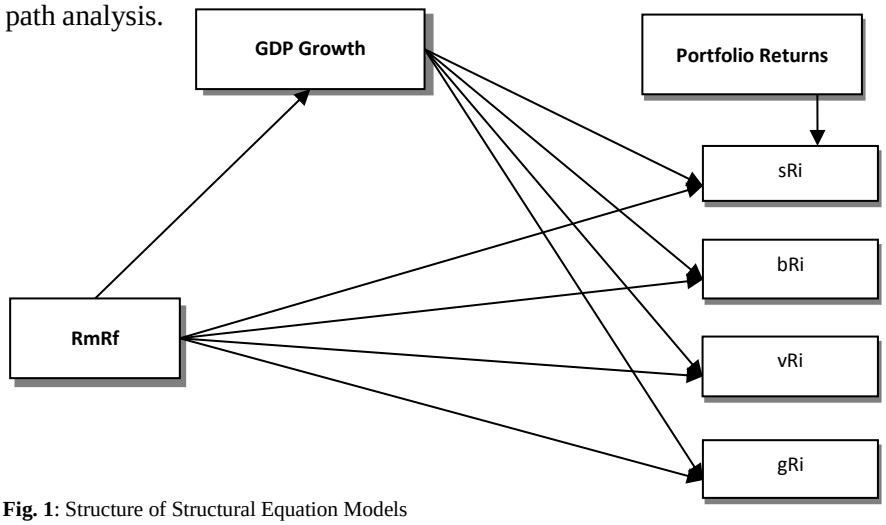

Fig. 1: Structure of Structural Equation Models

The direct and indirect (mediating) nexus between excess market returns and excess equally-weighted stock portfolios is depicted in Figure 1.

Data and Methodology

This study employs a sample of financial and non-financial enlisted 522 out of 612 companies' data obtained from the Pakistan Stock Exchange (PSX) official website. Based on data availability, the sample spans monthly data from January 2002 to December 2020. Furthermore, this study includes firms with data for two consecutive years. To avoid survivorship bias, this study used a purposive sampling technique to collect data from all enlisted firms. This work employs the 3-month government treasury bills rate as the risk-free rate, which was obtained from the official website of the State Bank of Pakistan. Similarly, the PSX-100 index is used as a proxy for market returns.

There are various factors that are familiarised as additional factors to determine expected stock returns based on associated risk, but CAPM still has a significant potential to explain average portfolio stock returns using diversified methodologies. As a result, in order to present the novelty and investigate the direct and indirect relationship between market excess returns and average excess portfolio returns, the study employs the CAPM-single factor model with a mediating effect of GDP-Growth, as articulated below:

Capital Asset Pricing Model (CAPM)

$$(R_m - R_f) = R_f + \beta_g \text{ (GDP Growth)} + \varepsilon \quad (1)$$

Where, R_f, is Risk-free rates (T-bills rates as proxy). R_m is the expected return from market. β_g is the sensitivity or factor loading of GDP Growth. ε represents error term.

$$Rpt - Rf = Rf + \beta c\ (Rm - Rf) + \beta g\ (\text{GDP Growth}) + \varepsilon \quad (2)$$

Where, R_{pt} is the returns from portfolio. $R_{pt} - R_f$ is excess average portfolio returns. β_c is the path coefficient.

$$Rpt - Rf = Rf + \beta m\ (Rm - Rf) + \varepsilon \quad (3)$$

Where, Ri is expected excess portfolio returns. Rf, is Risk-free rates, the study assumes Treasury-bills rates as proxy. Rm is the market returns. β_m *is the sensitivities or factor loading of market factor.*

Analysis and Discussion

Construction of Portfolios

Based on Size-B|M ratios, four equal-weighted portfolios were constructed in this study. This study, like Fama and French (1993; 2015), ignored negative value firms. To add novelty, the study creates six portfolios as suggested by (Fama and French, 1993; 2015), but in the end, the study consolidates three and two portfolio returns based on firm-specific characteristics as small, big firms' portfolios and high, low firms' portfolios and divides them into three and two respectively to create equally-weighted four portfolios as follows:

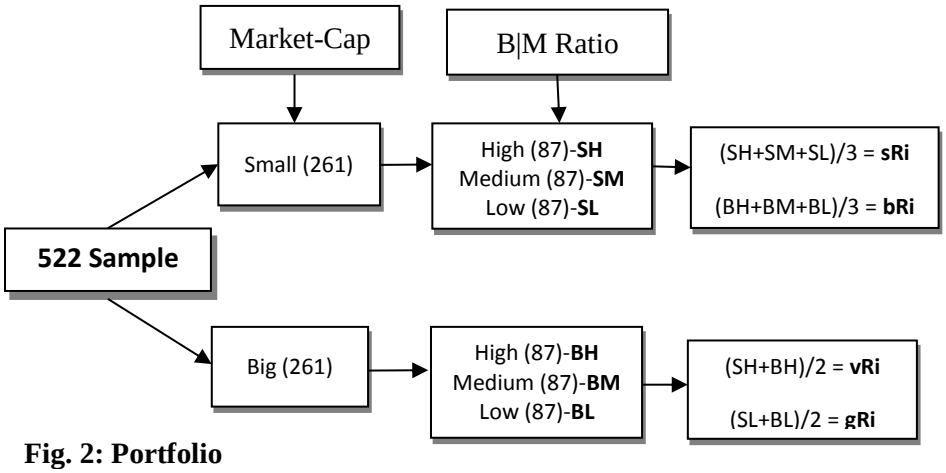

Fig. 2: Portfolio

The explanatory variable-market-factor is built in the manner suggested by (Fama and French, 1993). Excess market portfolio returns are calculated by subtracting risk-free rates from market returns and using the equation of ln(P1/P0) to estimate the nexus with an equally-weighted portfolio in PSX.

The descriptive statistics and correlation matrix between market risk premium and GDP-Growth are shown in Table 2. As shown in the

table, the mean monthly returns on factor portfolios in four different scenarios differ slightly. The mean monthly returns of market factors are positive (0.007721) and GDP growth is positive (3.9727), with standard deviations of 0.07465 and 2.0373, respectively. Positive returns are also shown by the dependent variables excess average portfolio returns. Market-factor ranges from -0.45966 to 0.23512, and GDP-growth ranges from -0.381 to 7.54686.

Table 1

Descriptive Statistics and Correlation Matrix

Variable	RmRf	GDP Growth	sRi	bRi	vRi	gRi
Mean	0.00772	3.9727	0.00663	0.00990	0.01106	0.00618
Std. Dev.	0.07464	2.03727	0.06219	0.05716	0.06328	0.05968
Min	-0.4596	-0.381	-0.2871	-0.2550	-0.2970	-0.1874
Max	0.2354	7.5468	0.1477	0.1253	0.1534	0.1968
Obs	228	228	228	228	228	228

Variable	RmRf	GDP Growth
RmRf	1	
GDP Growth	0.1777	1

Notes: Table 1 depicts the descriptive statistics of independent, dependent and mediating variables. The average returns of all dependent variables (sRi, bRi, vRi and gRi), independent variable (RmRf) and mediating variable (GDP Growth) show positive values with standard deviation, maximum and minimum values. The correlation between independent and mediating variable show positive but weak relationship.

Figure 3

Graphical presentation of Excess Market Returns and GDP Growth (2002-2020)

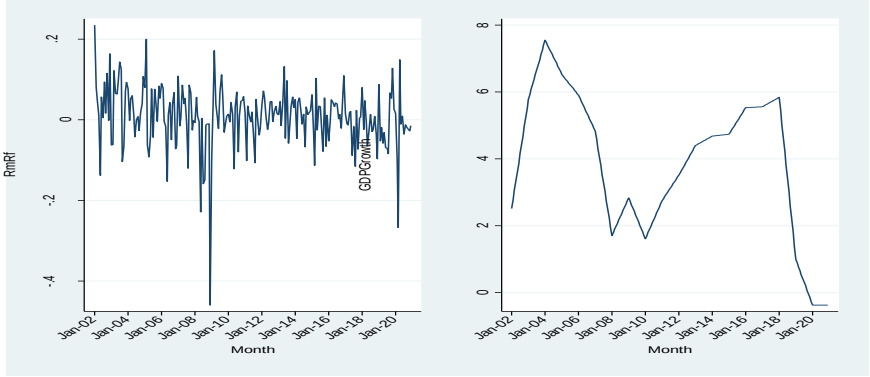

Figure 3 depicts the market risk premium and GDP growth month by month. The market-factor depicts a clearly fluctuating picture of the 2018 financial crises and the impact of the Covid-19 pandemic on the market graph. The GDP growth of Pakistan's economy also shows major fluctuations from 2004 to 2008, then an upward trend from 2010 to 2018, indicating the country's political era, but a drastic decline from 2018 mid to 2020 due to the Covid-19 pandemic.

Empirical Results

OLS Regression Results

This study used four constructed portfolios and market excess returns (CAPM) in PSX to employ robust simple time-series OLS regression techniques. The study also used Structural Equation Models with GDP-Growth as a mediator to investigate the direct and total effects of CAPM in PSX. To address the issue of heteroscedasticity, this study used robust OLS regressions to automatically remove heteroscedasticity from the data.

Table 2

OLS Regression results of CAPM

	(1) **sRi**	(2) **bRi**	(3) **vRi**	(4) **gRi**
RmRf	0.355***	0.292***	0.393***	0.258***
	(7.081)	(6.188)	(7.857)	(5.131)
_cons	0.004	0.008**	0.008**	0.004
	(1.037)	(2.169)	(2.147)	(1.111)
Obs.	228	228	228	228

R-sq	0.182	0.145	0.215	0.104
r2_a	0.178	0.141	0.211	0.100
F	50.143	38.290	61.725	26.328

T-values are in parenthesis

*** *p<0.01*, ** *p<0.05*, * *p<0.1*

Table-2 shows OLS regression results for CAPM using small Market-cap stocks portfolio (model-1), big Market-cap stocks portfolio (model-2), high B|M ratio stocks portfolio also known value-stocks (model-3) and low B|M ratio stocks portfolio also known growth-stocks (model-4). The r2_a represents adjusted R-square and F represents F-statistics.

Table 2 summarises the time-series regression of CAPM using monthly data from 2002 to 2020 using equation-based regression (3). The model-2 demonstrates that market-factor has a statistically significant positive relationship with average portfolio stock returns, indicating that CAPM results support the theory in PSX (Azam and Naveed, 2021; Jan, Iqbal, & Aamir, 2021; Khan, Baloch, Arif, & Alvi, 2020). The t-value (7.081) indicates a significant value that is supportive. The F-value (F = 50.143) also confirms the model's significance. Model-2 produces comparable results, with a positive statistically significant coefficient for market-factor with t-value (6.188). Similarly, the model-3 has a statistically significant relationship with excess portfolio stock returns. In conclusion, the results for small-cap stock portfolios are statistically significant. Similarly, big market-cap stock portfolios produce significant results, with model-2 estimates for market-factor coefficients demonstrating a highly statistically significant and positive nexus with excess portfolio stock returns.

Furthermore, both the small market-cap stocks portfolio and the high B|M ratio portfolio (models 1 and 3) have highly significant values (T-values = 7.081 and 7.857). Furthermore, the adjusted R-square values show that CAPM has a stronger predictive influence on the portfolios of small and value firms (17.8 percent and 21.1 percent respectively). Furthermore, for the market-factor in the model, model-4 produces highly positive and statistically significant results. The single-factor (market-factor) demonstrates a significant and positive relationship with average portfolio stock returns. The estimated coefficients and associated t-statistics support CAPM's existence in the market, but it differs from (Jan, Iqbal, and Aamir, 2021; Shaikh, Shaikh, and Shaique, 2017). In

conclusion, the CAPM remains efficient for estimating average portfolio stock returns in PSX.

Structural Equation Model Results

According to Grace and Bollen (2005), SEM is a multi-equation framework that allows researchers to demonstrate a variety of multivariate hypotheses simultaneously in one model. The path analysis identifies the variables' direct and indirect relationships in order to investigate the interdependencies and multiple directions among these variables.

Tables 3

Structural equation model Combine Results

	OIM Coef.	Std. Err.	z	P>|z	[95% Conf.	Interval]
Structural						
GDPGrowth <-						
RmRf	4.848929	1.778712	2.73	0.006	1.362718	8.33514
	3.935262	0.133193	29.55	0.000	3.674207	4.196316
sRi <-						
GDPGrowth	-0.00437	0.001836	-2.38	0.017	-0.00797	-0.00077
RmRf	0.37622	0.050103	7.51	0.000	0.27802	0.474419
	0.021097	0.008113	2.6	0.009	0.005196	0.03700
bRi <-						
GDPGrowth	-0.00426	0.001723	-2.47	0.013	-0.00764	-0.00883
RmRf	0.312159	0.047033	6.64	0.000	0.219959	0.404242
	0.024416	0.007616	3.21	0.001	0.009489	0.029242
vRi <-						
GDPGrowth	-0.00464	0.001827	-2.54	0.011	-0.00822	-0.00106
RmRf	0.415171	0.049863	8.33	0.000	0.317441	0.51290
	0.026302	0.008074	3.26	0.001	0.010477	0.042127
gRi <-						
GDPGrowth	-0.00415	0.001845	-2.25	0.025	-0.00776	-0.00053
RmRf	0.278258	0.050366	5.53	0.000	0.179643	0.377074
_Cons	0.020503	0.008156	2.51	0.012	0.004518	0.036488
var(e.GDPGrowth)|	4.001826	0.374805			3.330703	4.808178
var(e.sRi)|	0.003075	0.000288			0.002559	0.003695
var(e.bRi)|	0.00271	0.000254			0.002255	0.003256
var(e.vRi)|	0.003046	0.000285			0.002535	0.003659
var(e.gRi)|	0.003107	0.000291			0.002586	0.003734

LR test of model vs. saturated: chi2(6) = 1492.64, Prob > chi2 = 0.0000

This study used mediation analysis to assess the role of GDP growth in mediating the relationship between market excess returns and portfolio excess returns (CAPM). Table 3 shows that market excess returns have a statistically significant positive relationship with GDP growth (= 4.848929, t = 2.73, p 0.01). The results remained statistically significant after accounting for GDP growth as a mediating variable, but the relationship between GDP growth and excess portfolio stock returns (sRi) is negative for all four portfolios at the same time. Similarly, the relationship between excess market returns and excess portfolio stock returns is highly statistically significant in PSX for all four portfolios (t-value = 7.51, 6.64, 8.33, and 5.53 for sRi, bRi, vRi, and gRi, respectively, with p 0.001).

Table 4

Direct Effects

	Coef.	OIM Std. Err.	z	P>|z	[95% Conf.	Interval]
Structural						
GDPGrowth <-						
RmRf	4.848929	1.778712	2.73	0.006	1.362718	8.33514
sRi <-						
GDPGrowth	-.004372	.0018358	-2.38	0.017	-.0079701	-.0007739
RmRf	.3762195	.0501028	7.51	0.000	.2780198	.4744192
bRi <-						
GDPGrowth	-.0042605	.0017233	-2.47	0.013	-.0076381	-.0008828
RmRf	.3121591	.0470331	6.64	0.000	.2199759	.4043423
vRi <-						
GDPGrowth	-.0046421	.001827	-2.54	0.011	-.008223	-.0010612
RmRf	.4151707	.0498629	8.33	0.000	.3174412	.5129002
gRi <-						

GDPGrowth	-.004146	.0018454	-2.25	0.025	-.007763	-.000529
RmRf	.2783584	.0503659	5.53	0.000	.179643	.3770738

Table 4 shows the direct effects of all dependent, independent, and mediating variables. As with the inclusion of GDP-growth as a mediating variable, the direct relationship between excess market returns and GDP-growth is statistically significant (= 4.848929, t = 2.73, p 0.01). Similarly, the combined direct effect of GDP-growth and excess market returns on small stock portfolio returns (SSPR) is statistically significant, but GDP-growth has an inverse relationship with all excess four portfolio returns. All of the direct effects for all portfolios show statistically significant results, indicating that there is a close and statistically significant relationship between these variables in PSX.

Table 5
Total Effects

	Coef.	OIM Std. Err.	z	P>|z	[95% Conf.	Interval]
Structural						
GDPGrowth <-						
RmRf	4.848929	1.778712	2.73	0.006	1.362718	8.33514
sRi <-						
GDPGrowth	-.004372	.0018358	-2.38	0.017	-.0079701	-.0007739
RmRf	.3550201	.0499152	7.11	0.000	.2571881	.452852
bRi <-						
GDPGrowth	-.0042605	.0017233	-2.47	0.013	-.0076381	-.0008828
RmRf	.2915004	.0469011	6.22	0.000	.1995759	.3834249
vRi <-						
GDPGrowth	-.0046421	.001827	-2.54	0.011	-.008223	-.0010612
RmRf	.3926614	.0497595	7.89	0.000	.2951346	.4901882
gRi <-						

GDPGrowth	-.004146	.0018454	-2.25	0.025	-.007763	-.000529
RmRf	.2582549	.0501102	5.15	0.000	.1600407	.3564692

Table 5 displays the total effects findings for all dependent, independent, and mediating variables. As with the inclusion of GDP-growth as a mediating variable, the total nexus of both excess markets returns and GDP-growth with SSPR is statistically significant but negative between GDP-Growth and SSPR (= -0.004372, t = -2.38 p 0.05). Similarly, all four portfolios, including small, large, value, and growth stock excess portfolios, show statistically significant results even when GDP-growth is added as a mediating variable in PSX, confirming GDP-significant growth's mediating role in the market when adjusted with CAPM. Both alternative hypotheses are accepted because market returns and GDP growth have a statistically significant relationship with portfolio excess returns in the PSX market.

Conclusion

This study investigates the time-series CAPM using OLS regression and the Structural Equation Model (SEM), with GDP-Growth acting as a moderator, based on the direct and indirect relationship between excess market returns and excess average portfolio returns. The findings show a statistically significant positive relationship between excess market returns and excess portfolio returns. By including GDP-growth as a mediating variable, the market's relationship between excess market returns and GDP-growth shows a negative but statistically significant relationship. Our findings provide empirically significant results in both models, indicating that with and without a mediating variable such as GDP-growth, there is a statistically significant relationship and CAPM still exists in Pakistan's emerging market in explaining average excess portfolio returns. It provides support to the hypotheses that there is a statistically significant relationship between market returns and excess portfolio returns in PSX, as well as between GDP growth and excess portfolio returns.

The findings of this study can help policymakers, portfolio managers, and researchers understand the market mechanism. This study used financial and non-financial firms that could be investigated separately using data from 1991 to 2002, which this study limited to. Further research can be carried out by employing multivariate asset pricing

models such as (Fama-French three-five factor models, Carhart (1997) four-factor model, Azam and Ilyas (2011) five-factor model, Azam and Naveed (2021) six-factor model) Covid-19 pandemic, (Iqbal, Azam and Azeem, 2021) and by incorporating various macroeconomic variables such as interest rate, imports, exports, and foreign exchange rate as mediating variables for the study.

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