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ICT DIFFUSION AND STOCK MARKET DEVELOPMENT: ANALYZING THE MODERATING ROLE OF TECHNOLOGICAL INNOVATIONS AND GLOBALIZATION IN ASEAN AND SAARC ECONOMIES

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Abstract
This study analyzed how ICT diffusion, with the moderating role of technological innovations and globalization, has made contribution in the stock market development of SAARC and ASEAN countries. The comparative analysis of both regions brings into light how the regional differences in the name of ICT diffusion, technological innovation, and level of globalization, have played significant role in the stock market development. The findings reveal that ICT significantly enhances stock market growth in both regions. However, the effects of individual ICT components vary, with broadband and telephone subscriptions playing a more consistent role, while mobile subscriptions exhibit a negative impact in SAARC. Technological innovations, measured through resident and non-resident patent applications, positively influence stock market development and further strengthen the ICT-stock market growth relationship. Globalization also supports stock market expansion, though its interaction with ICT differs across regions. These results highlight the need for integrated policies that promote digital infrastructure, foster innovation, and enhance financial market efficiency.

KeyWords: Information and Communication Technology, Technological Innovations, Globalization and Stock Market Development.

1. INTRODUCTION:

The information and communication technology has played major role in the financial development of modern economies. Fourth Industrial Revolution has proven to uphold the hegemony of globalization, technological innovations and ICT diffusion that has made indispensable contribution in the wake of latest developments in financial sector. The speed and level of accessibility of information has been greatly enhanced by the introduction of ICT in stock markets. These recent developments in financial markets have reduced the informational asymmetry and now investors are in a better position to make informed decisions by exploiting the opportunity to assess and analyze latest business announcements, economic and financial data (Bilal, et al. 2025). While electronic and computerized order matching system has a significant impact on the speed at which transactions take place in stock market eventually increase market efficiency. In contrast to traditional open floor trading, newly emerged electronically automated trading enabled investor to transact at speed, improved liquidity and facilitate in price discovery. Another feature of ICT is introduction of algorithmic trading in stock markets, now computers execute transactions based on certain rules and pre-defined algorithms. The speed of execution is hallmark of these algorithms, improving market liquidity and efficiency of stock market without significant human intervention. The most important feature is online trading of stock market which helps in market liquidity providing flexibility to investor by remotely interacting with market. Now real time market data, research reports, trading tools are accessible to remote investor without being on trading floor. It encourages the greater participation of investors in trading (Yuferova, D. 2024).
Technological advancement by the ICT in the stock market enabled the regulatory authorities to manage market risk with the use of improved risk management tools and surveillance methods. Introduction of modern technology has improved monitoring and control of market activities by the regulatory bodies, resultantly enhance and maintain market integrity and confidence of participants. Most importantly ICT facilitate in modernizing the global stock market with the introduction of modern ICT tools and methods such as machine learning, artificial intelligence (AI) and data analysis software and tools. The market trends can be predicted more acutely by these ICT soft wares and

tools than ever before. In addition to the numerous added benefits of ICT the most important challenges it poses is cyber security along with market failure caused by technological disruption such as dotcom bubble in the past concerns the regulators and participants. These issues require greater monitoring and control from the regulatory bodies, other than this the role of ICT has greatly improved market efficiency (Li, Z et al. 2025).

Since the start of 20th century technological innovation reported as an unpredictable component of company's market value of stock (Perez, 2003), these innovations became cause of market price speculation (Fisher, 1930). The region of ASEAN done much better in terms of economic and technological development than SAARC (Kiani et al. 2023). Maranville (1992) asserts that innovations mean offering market demand-based solution in the form of efficient products and services with the use of technology. He further argues that innovation could be source of quality improvement in product and services already offered and to reduce the cost of production. In another study by Serrat (2017) argued that innovation could be split into three categories such as innovation related to products, services and organization. Technological innovation is important for social and sustainable development, especially economic development (Omri, 2020).

In this era the moderating role of globalization in stock market development cannot be ignored as it boosted exponentially the economic and financial ties between various nations globally. Globalization has not only increased cross border trade of goods and services rather it played crucial role in technology transfer, flow of capital and information internationally. Globalization has reduced liquidity constraints and promoted foreign portfolio investments and foreign direct investment that has enhanced market depth significantly. It has also integrated global financial markets and improves the performance of stock markets by reducing informational gap and technology transfer. Due to modern market infrastructure and well-organized trading arrangements, investors across the globe can now avail broad range of investment opportunities that allows them to diversify their portfolio and adopt better risk management strategies. The main objective of this study is to analyze how ICT diffusion, with the moderating role of technological innovations and globalization, has made contribution in the stock market development of SAARC and ASEAN countries. The comparative analysis of both regions will bring into light how the regional differences in the name of ICT diffusion, technological innovation, and level of globalization, have played significant role in the stock market development.

2. REVIEW OF LITERATURE:

2.1 Information and Communication Technology: Mendy & Diomande (2019), Pradhan (2014), Bhunia (2011), Levine (1991), asserted that ICT plays an important role in the stock market development of an economy and reduce liquidity constraints substantially. ICT allows trading without the active engagement of broker and it also reduced the burden of intermediation fees and investors can trade and monitor investment activities online in a hassle-free manner (Amalendu, 2011). ICT supported platforms provide fast and reliable information, and investor can reduce the transaction cost by making wise investment decisions. The lowering of transaction cost and reduction in inefficiencies of share trading as an outcome of stock market automation is evident from the literature, introduction of ICT positive effect on the operation and activities of stock exchanges by minimizing the cost associated with a manual system (Amalendu, (2011); Binuyo and Aregbeshola, (2014)). Clemons and Weber (1990) argued that ICT has substantially reduced the market inefficiencies and cost of trading in London stock exchange. Computerization of stock market has significantly increased the trading activities and removes liquidity constraints. The role of ICT is imperative for the availability and disbursement of credit to businesses and households (Binuyo & Aregbeshola 2014). It ensures transparency and rapid transfer of information among investors that allow financial institutions to manage risk efficiently (Asongu & Nwachukwu, 2017). Porteba and summers (1988) argued that short-term market liquidity and volatility are caused by computer-assisted trading strategies. In contrast, Fama and French (1988), argues that the adoption of ICT has enhanced stock market efficiency due to swift translation of available market information in stock prices. They have further argued that ICT provides a reliable and effective platform for exchange of information. In addition, ICT has also helped in the availability of improved products and instruments to its users. A similar study by Pradhan, (2014) supported the claim that ICT has contributed to the efficiency of the stock market while Mahonney (1997) reported that technological innovations result in radical changes in the settlement, clearance, and execution of transactions.

2.2 Technological innovations: Classic endogenous growth theory proposed by Schumpeter explains how economic growth is attained through the process of innovation known as "creative destruction". It further argues that there exists a strong relation between technological advancement and economic growth Romer (1994) and Lucas (1978). Since the development of groundbreaking theories by Schumpeter, Romer, Lucas, Grossman and Helpman etc. numerous empirical findings indicate strong association between technological innovation and economic development. Silva et al. (2017) reported that in international business the companies with technological innovation have positive impact on economic growth. In another study conducted by Acikgoz and Mert (2014) on Hong Kong, Taiwan, Singapore, and Republic of Korea established that technological development is essential to rapid economic growth. Stock market

development is an indicator of economic growth so we can deduct from the above-mentioned discussion that technological innovations play significant role in the development of stock markets of countries. In the presence of better ICT infrastructure, a higher level of technological innovations may contribute to the efficient transmission and utilization of latest information that might contribute positively in stock market development.

2.3 Globalization: Globalization is another important aspect that can be viewed as one of the major factors that assists in the dissemination of information and technology globally. The impact of globalization is primarily investigated on economic growth and the literature of globalization on stock market is limited. There is significant empirical findings on globalization and its impact on economic growth, although the findings are contentious. One strand of literature approves the positive effect of globalization on economic growth, such as Gurgul and Lach (2014) investigated the impact of globalization on economic growth of central and eastern European countries and reported positive impact of social and economic dimension but insignificant impact of political dimension of globalization.

Globalization playing an important role in helping economies to take advantage through trade of goods, services and exchange of culture and public policies Bilgili et al. (2020). Most of previous studies in literature identified economic globalization as being one of economic growth driver in less developed countries, most of studies in literature are limited to FDI and trade measurement Santiago et al. (2020). Heimberger (2022) studied globalization-growth effect from reported 5542 estimates extracted from 516 primary studies with the use of Meta-analysis and Meta-regression. The results indicate growth enhances in tandem with globalization. Kumeka et al. (2024) investigated the effect of globalization on economic growth of 45 African countries for the period of 1996- 2018, results indicate significantly positive impact of globalization on economic growth.

Table 1: Literature Summary

Author(s)	Sample	Duration	Methodology	Dependent Variable	Independent Variables	Major Findings
Lgwilo and Sibindi (2022)	11 African Countries	2008-2017	GMM	Stock market total value traded Stock market Capitalization Stock Market Turnover Ratio Number of Listed Companies	The number of Internet, mobile cellular, telephone, users per 100 inhabitant, Financial Freedom Index Real GDP	ICT adoption has stimulated the stock market growth in African countries. An increase in telephone lines/mobile/broadband users has increased the stock market traded volume and stock market turnover ratio.
Mousavi Jahromi, et. al. (2023)	Tehran's data of 41 companies	2014-2019	Analytical-applicative approach	The variables examined in this research include the dependent of the companys efficiency information technology in five areas:hardwared)Hardware-Invi,(, software (software-Invij), network and communication facilities		The findings of the research indicate that information technology and its components have a positive effect on improving the efficiency of companies admitted to the Tehran Stock Exchange

				(Network-Invij), database (Database-Invij) and investment in skilled human resources (Humanresources), company size and risk.		
Cheng, et.al. (2021)	72 Countries	2000-2015	Dynamic GMM	real GDP per capita growth	gross capital formation to GDP	First, regardless of the national income level, the empirical results show that financial development is always unfavorable for economic growth, but this negative effect is greater in high-income countries. Second, ICT diffusion can improve economic growth in high-income countries, but the effect is ambiguous in middle & low-income countries. In middle & low-income countries, only mobile growth can raise economic growth, whereas increasing Internet or secure Internet servers cannot. Finally, the interaction effects between ICT and financial development are positive in both income-level countries, implying the interaction effects of ICT and finance can reduce the negative effects of financial development, but the 2022effects are only significant for high-income countries.
Ashraf & Joarder (2009)	Bangladesh	2004-2007 Monthly	OLS & ANOVA	Shares traded	ICT	Internet access has increased the trade volume in the stock market.
Pradhan et al., (2018)	Cross Country	1988-2012	Panel VECM Granger Causality	ICT Penitration Stock Market Development		This study assessed the causal nexus between ICT penetration, stock market development, and economic development and found long-run and

				Per capita Economic Growth		causal relationships among the selected variables in emerging and growth-leading economies.
Bhunia & Ghosal (2011)	India	2001-2011	OLS, Modified Gompertz ICT diffusion equation	Market capitalization, stock market value traded, stock market volume traded, turnover, number of securities listed, public sector bond and private sector debt	Number of stockbrokers, number of stockbrokers with functional websites, total number of internet users, total number of mobile and telephone mainline users.	ICT has significantly improved number of investors, stockbrokers in India. Indian Capital market has shown positive development with respect to ICT penetration.
Afshan et.al. (2021)	10 Asian countries: China, India, Japan, Malaysia, Pakistan, Philippines, Russia, South Korea, Thailand, and Turkey.	2000 M01 to 2016 M12	Quantile-on-quantile cointegration and causality approach	total value of stocks traded as % of gross domestic product	Internet usage as % of population	The results confirmed the positive linkages between stock market efficiency and internet use in the 8 Asian countries while this result is averted in the two Asian countries (i.e., China and Russia) in a given time period.
Tripathi & Inani, (2020)	SAARC Bangladesh, India, Sri Lanka, and Pakistan	1990 – 2014	Pooled OLS mode fixed effect model	GDPPCi	Teledensity (number of fixed and mobile phones per 10,000 people) as the proxy of ICT Gross fixed capital formation Total labor force	Our findings reveal a positive and statistically significant effect of ICT on economic growth The impact of ICT on economic growth is highest for India followed by Sri Lanka, Bangladesh, and Pakistan respectively.
Chien et. al. (2020)	81 Countries	1990-2011	GMM and PSTR*			Development in internet and telephone access has

						improved financial development in general. While increase in mobile connections has positively influenced financial development just in African countries. Empirical evidence supports the non-linear effect of ICT penetration on financial development.
Cooray, & Wickremasing. (2007).	India, Sri Lanka, Pakistan and Bangladesh	January 1996 to January 2005	Augmented Dickey Fuller (ADF-1979, 1981), the Phillips-Perron (PP-1988), the Dicky-Fuller Generalized Least Square (DF-GLS-1996) and Elliot-Rothenberg-Stock (ERS - 1996) test	stock return stock price indice		Weak form efficiency is supported by the classical unit root tests. However, it is not strongly supported for Bangladesh under the DFGLS and ERS tests. Cointegration and Granger causality tests are used to examine semi-strong form efficiency. Semi-strong form efficiency is not supported as these tests indicate a high degree of interdependence among the South Asian stock markets. The above results have implications for domestic as well as foreign investors in South Asian stock markets.
Ngassam, & Gani, (2003).	high-income and emerging market economies	1990-99	least squares dummy variable model	stock market development	personal computers and internet hosts	Controlling for income and technological differences, results lead us to conclude that emerging market economies have already seized an opportunity to leap frog the high-income countries that is, by going straight from underdeveloped networks to fully digitized networks, bypassing the traditional analog technology. A

Lgwilo and Sibindi (2021)	African Countries	2008-2017	Panel ARDL	stock market development index	ICT adoption index (ICTDEX), and the financial freedom index (FFI)	Bi-directional causality/ complementarity exist between ICT and stock market development.
Lee, et.al. (2019)	71 countries	2002 to 2014	Panel unit root tests, panel variance ratio tests, and panel multiple regressions.	Panel Variance Ratio	ICT diffusion	The results of panel unit root tests and panel variance ratio tests show that stock markets in countries with high ICT diffusion are efficient while stock markets in countries with low or medium ICT diffusion are not all efficient. The results of panel regressions further show that the effect of ICT diffusion in reducing market noises was more significant than its effect in magnifying the noises
Gardner et.al., (2017)	81 countries	1998-2014	Fixed Effect Regression	stock market capitalization	Three specifications for ICT are considered: the number of mobile cell subscriptions per 100 people, the number of internet users per 100 people, and the number of fixed broadband subscriptions per 100 people economic freedom FDI/GDP Population	ICT expansions are positively correlated with stock market capitalization

3. DATA AND METHODOLOGY

This study used panel data from 1984 to 2021 for SAARC and ASEAN countries. As this is a longitudinal study with small cross-sectional units and a large time period so this study first checked for cross-sectional dependency, stationarity and cointegration before proceeding to causality tests and formal estimations to get long-run estimates. Detailed description of independent variables, dependent variable and moderators are described in table 2. Principle component analysis is a method to transform a group of correlated variables into a set of linearly uncorrelated components also known as principle components that are obtained using an orthogonal transformation. PCA is objectively used to capture the maximum variation in the data in first component and so on in a descending order. The number of components are often equal to or less than the original number of variables, so the total number of component we choose depends on the level of information that you one to retain. PCA transformation is a way to reduce the dimension and extract the unique uncorrelated features in the data. PCA identifies a new set of variables that are not correlated and captures 48 maximum variation in the original data set. This study used PCA to formulate an index for ICT penetration in SAARC and ASEAN regions Fama(1970). In recent times several indices have been proposed, one of well-known index is KOF globalization index. Initially Dreher (2006) developed KOF globalization index and later it was modified by Dreher et al.(2008a) and Dreher et al.(2008b). KOF index is based on three underlying dimensions of social, economic and political globalization Gygli et al.(2019). The descriptive statistics has been explained in table 3.

Table 2: Variable Description

Variables	**Indicators**	**References**	**Data Sources**
	Dependent Variable		
Stock Market Development	Stocks Traded, Total Value (% of GDP)	Lgwilo and Sibindi (2022); Ashraf & Joarder (2009); Pradhan et al., (2018); Bhunia & Ghosal (2011); Afshan et.al. (2021); Lee, et.al. (2019)	World Development Indicators
	Independent Variables		
Information and Communication Technology (ICT)	Access to Internet Mobile Subscription Broadband Subscription Telephone Subscription	Lgwilo and Sibindi (2022) Ming-Hsuan et.al. (2018) Cheng, et.al. (2021) Ashraf & Joarder (2009) Pradhan et al., (2018) Bhunia & Ghosal (2011) Tripathi & Inani, (2020) Chien et. al. (2020) Lee, et.al. (2019) Gardner et.al., (2017)	World Development Indicators
	Moderators		
Technological Innovations	Total Patent Registered by Residents Total Research and Development Expenditures Intellectual Property rights receipts	Kotlebova, et. al. (2020) Nguyen, et.al (2020) Chwdhury and Maung (2012)	World Development Indicators
Globalization	KOF Globalization Index: Economic, Social and Political Dimension of Globalization	Balcilar et. al. (2019) Zaher, H. F., & Buics, L. (2022).	KOF Swiss Economic Institute

Table 3: Descriptive Statistics SAARC

SAARC						
	Mean	Median	Max	Min	SD	Obs.
Stocks Traded as a percentage of GDP	22.02	4.87	109.49	0.20	29.79	92
Fixed Telephone Subscriptions per 100 People	4.21	2.40	17.31	0.16	4.79	92
Mobile Cellular Subscriptions per 100 People	55.88	61.42	143.08	0.20	41.47	92
Fixed Broadband Subscriptions per 100 People	1.58	0.81	10.99	0.00	2.38	92
ICT Index	0.00	-0.23	4.66	-1.64	1.44	92
KOF Globalisation Index	53.65	53.58	62.65	37.44	5.95	92
Patents Total	9795	655	66126	284	17924	92
Patents Non Residents	6957	444	36311	188	12317	92
Patents Residents	2838	182	29815	22	6037	92
GDPP Growth	3.71	4.56	8.18	-7.93	2.96	92
Gross Fixed Capital Formation	24.66	26.23	35.81	12.83	6.76	92
Trade (Percentage of GDP)	41.18	39.92	88.64	21.46	14.44	92
Urbanization	2.41	2.53	4.56	0.48	1.05	92

Table 4: Descriptive Statistics ASEAN

ASEAN						
	Mean	Median	Max	Min	SD	Obs.
Stocks Traded as a percentage of GDP	37.456	25.662	210.725	1.000	36.083	138
Fixed Telephone Subscriptions per 100 People	14.228	10.222	48.007	2.435	12.324	138
Mobile Cellular Subscriptions per 100 People	99.450	114.443	181.767	0.998	51.187	138
Fixed Broadband Subscriptions per 100 People	7.443	4.034	37.360	0.001	8.516	138
ICT Index	0.000	-0.244	3.683	-2.099	1.420	138
KOF Globalisation Index	68.159	65.000	84.000	42.000	10.045	138
Patents Total	6048	5784	14653	854	2958	138
Patents Non Residents	5316	5021	12945	644	2586	138
Patents Residents	732	626	3093	34.00	510.31	138
GDPP Growth	3.483	4.014	14.362	-10.978	3.102	138
Gross Fixed Capital Formation	25.471	25.030	35.160	18.182	4.443	138
Trade (Percentage of GDP)	151.937	127.331	437.327	32.972	104.478	138
Urbanization	57.026	47.836	100	24.374	23.042	138

3.1 Cross-Sectional Dependence Test

All the selected countries are integrated economically, socially, and geographically so there is a higher probability for the existence of cross-sectional dependence, so this study choose Breusch-Pagan LM and Pesaran (2004) test to eliminate inefficiencies and bias in our estimates. Breusch-Pagan (1980) developed a Langrage multiplier test to check whether the correlation in error term is zero in cross sections under analysis. The LM test statistics is defined below where $\hat{\rho}_{ij}^2$ is the square of pairwise residual's Pearson correlation coefficient.

$$LM = T\left[\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^2\right]$$

LM statistic is distributed as χ^2 with N(N-1)/2 degree of freedom and ρ_{ij} is the estimate of pair-wise correlation between residuals. Under the null hypothesis of no cross sectional dependency LM statistics is asymptotically distributed as chi-squared with a degree of freedom i.e. N(N-1)/2 when T approaches infinity and fixed N. However, Pesaran (2004) cross dependence test statistic is specified below where the CD test statistic is normally distributed with zero mean and constant variance. CD test proposed a flexible model structure that allows heterogeneous dynamic models and non-stationary models. For a sufficiently large value of N and T, the statistics proposed by CD test is expected to follow a standard normal variate where the null hypothesis is zero cross-sectional dependence. CD test is defined as

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{s=1}^{p}\sum_{i=1}^{N-s}\hat{\rho}_{i,i+s}\right)$$

The results for cross-sectional dependence show that all the series are cross sectionally dependent except for stock market development measured in terms of total stocks traded in SAARC. Each model has also been tested for the cross sectional dependence and results indicate that all the regression equations are cross sectionally dependent in SAARC and ASEAN region.

Table 5: Cross-Sectional Dependence Test

	Stocks Traded	KOF	Patents	Broad Band	Telephone	Mobile
Breusch-Pagan LM	9.842	102.178***	49.419***	114.627***	23.522***	130.999***
	[0.1314]	[0.0000]	[0.0000]	[0.0000]	[0.0006]	[0.0000]
SAARC	No	Yes	Yes	Yes	Yes	Yes
Breusch-Pagan LM	12.534***	10.035***	2.006**	10.693***	2.308**	11.444***
	[0.0000]	[0.0000]	[0.0448]	[0.0000]	[0.0210]	[0.0000]
ASEAN	Yes	Yes	Yes	Yes	Yes	Yes
Note: ***and ** denotes 1% and 5% level of significance respectively						

Table 6: Cross-Sectional Dependence Tests for Models

Models	Breusch Pagan LM	P-Value	
SAARC			
Stock Traded = f [ICT, GDPP, INV, TO, C]	26.956***	0.000	Yes
Stock Traded = f [ICT, KOF, KOF*ICT, GDPP, INV, TO, C]	18.218***	0.006	Yes
Stock Traded = f [ICT, PAT, PAT*ICT, GDPP, INV, TO, C]	26.372***	0.000	Yes
ASEAN			
Stock Traded = f [ICT, GDPP, INV, TO, C]	37.553 ***	0.000	Yes
Stock Traded = f [ICT, KOF, KOF*ICT, GDPP, INV, TO, C]	38.682***	0.001	Yes
Stock Traded = f [ICT, PAT, PAT*ICT, GDPP, INV, TO, C]	46.954***	0.000	Yes

*****and ** denotes 1% and 5% level of significance respectively**

3.2 Panel Unit Root Test

A plethora of research highlighted panel data models may face an issue of cross-sectional dependence in the error term. It may be due to unobserved mechanisms and shocks eventually becoming part of spatial dependence, error term, and idiosyncratic pairwise dependence (Pesaran 2004). Another point to consider is that the interaction of economies and integration may rise to cross-sectional dependence De Hoyos & Sarafidis (2006). The first unit root test is used commonly in most of the early studies Maddala and Wu (1999); Levin et al. (2002); Im et al. (2003). However second generation unit test considers the cross section dependence in panel data as compared to the first

generation unit root test by Smith et al. (2004); Moon and Perron (2004); Pesaran (2007) and Bai and Ng(2004). Third-generation unit tests have been employed by the researchers in recent studies which helps tackle structural breaks of data. Their unit root test has certain pitfalls related to statistical power and size as highlighted by Hossain (2011). Most importantly first unit root test faces an issue of incorrect rejection of the null hypothesis in presence of cross-sectional dependence Banerjee et al. (2001). Choi (2006) and Pesaran (2007) resolved this issue by introducing a second-generation unit root test and corrected the issue of false null hypothesis rejection. However, the homogeneity assumption is still untrue across the cross-sectional dependence as stated by Urbain and Westerlund (2006). The presence of unit root may lead to the spurious regression estimates; hence, this study will apply not only IPS and PP tests but also second generational tests, such as CIPS test of Pesaran (2007) to deal with cross-sectional dependence in the panel. The second generational panel unit root test equation is specified as under:

$$\triangle Y_{it} = \beta_{\circ} + \beta_i Y_{it-1} + \theta_i T + \sum_{j=1}^{n} \gamma_{ij} \Delta Y_{i.t-j} + \varepsilon_{it}$$

Where Y_{it} is the variable to be analyzed, ε_{it} is the random term, $\triangle$ is the first difference operator, $\beta_{\circ}$ is the intercept of the equation, and T is the time trend. A cross-section augmented IPS (CIPS) panel unit root test is recommended to cope with the problem of cross-sectional dependence (Pesaran, 2007). CIPS statistic is given below whereas CADF is a cross-sectional adjusted augmented Dickey-Fuller test statistic.

$$CIPS = \frac{1}{N} \sum_{i=1}^{N} CADF_i$$

The results for panel unit root test for each series shows that all the series are stationary at first difference in ASEAN except GDP per capita growth. While in case of SAARC globalization, stock market development and GDP per capita growth are stationary at level while all other series are stationary at first difference.

Table 7: Panel Unit Root Tests

Variables	**ASEAN**	**SAARC**
KOF Globalisation Index	I(1)	I(0)
Patent Applications	I(1)	I(1)
Stocks Traded as a percentage of GDP	I(1)	I(0)
Mobile Cellular Subscriptions per 100 People	I(1)	I(1)
Fixed Broadband Subscriptions per 100 People	I(1)	I(1)
Fixed Telephone Subscriptions per 100 People	I(1)	I(1)
GDPP Growth	I(0)	I(0)
Gross Fixed Capital Formation	I(1)	I(1)
Trade (Percentage of GDP)	I(1)	I(1)

3.3 Panel Cointegration Test and Panel ARDL: The study aims to examine relationships among variables by employing panel co integration tests developed by Kao. This test is valuable for assessing long-term associations and co-movements among the variables, considering both cross-sectional and time-series dimensions. The use of panel co-integration techniques enhances the robustness of the analysis and contributes to a nuanced understanding of stable, long-term connections within the dataset. Kao panel cointegration test assumes homogeneous panel cointegration with a single cointegration vector across all cross sectional units. Kao test confirms the presence of cointegration within panel as shown in table 8. To understand the short-run and long-run relationship panels ARDL has been applied.

Table 8: Cointegration Test Results

Models	**Kao Residual Test**	**P-Value**	**Cointegration Exists**
SAARC			
Stock Traded = f [ICT, GDPP, INV, TO, C]	-2.310**	0.01	Yes
Stock Traded = f [ICT, KOF, KOF*ICT, GDPP, INV, TO, C]	-2.363***	0.006	Yes
Stock Traded = f [ICT, PAT, PAT*ICT, GDPP, INV, TO, C]	-2.158**	0.015	Yes

ASEAN			
Stock Traded = f [ICT, GDPP, INV, TO, C]	-1.524 *	0.063	Yes
Stock Traded = f [ICT, KOF, KOF*ICT, GDPP, INV, TO, C]	-2.328***	0.009	Yes
Stock Traded = f [ICT, PAT, PAT*ICT, GDPP, INV, TO, C]	-4.034***	0.000	Yes

*****and ** denotes 1% and 5% level of significance respectively**

3.4: Regression Analysis:

Preliminary diagnostic tests and data analysis reveal the model under observation suffers from cross sectional dependence issue, integration order among selected variables is also not the same, and hence we should proceed with the technique of ARDL/PMG for the parameter estimation. Cointegration test reveals existence of log run relation between selected models. Tables 9 assess the influence of information and communication technology and Globalisation on the development of stock market in SAARC. The broadband subscription exhibit positively to stock market development in ASEAN, on the other hand coefficient size is model specific in the region of SAARC. In addition result indicates positive impact of telephone subscription on market development; it is worth mentioning that these findings are robust across both regions of ASAEAN and SAARC. It is important to mention that increase of mobile subscription has negative impact on market development but the size of coefficient is smaller in comparison to telephone and broadband subscription. In contrast to SAARC the reported estimates for mobile subscription on market development in the region of ASEAN are robust and significantly positive under different model specification. Along with individual components of ICT, we have developed Index of ICT based on these components such as broadband, telephone and mobile subscription through PCA. The ICT INDEX exhibit robust and significantly positive results for regions under study.

Result of globalization in regression as an independent variable shows positive impact on stock market development of both SAARC and ASEAN though as a moderating variable the impact is statistically insignificant but negative in SAARC region. It is evident that globalization play a crucial role in market development of stock market in both regions but there is not statistical significant moderating impact in SAARC region. In case of ASEAN the interaction term is negative and statistically significant.

The findings indicate positive and robust results of telephone subscription on stock market development in SAARC and ASEAN. This could be an evidence of facilitation provided by fixed-line communication in financial transaction, playing a role by keeping investors and businesses informed and also serve as a stable medium of communication. Land lines provide a channel of static and stable communication which is important for investment and trading activities. In comparison to cellular phones telephone service typically well connected with corporate environment and businesses. Robustness and consistency of results in both regions suggest that land lines play an important role in the development of stock market, it also highlight a fact that in certain regions and countries traditional mode of communication still is land lines networks.

The influence of broadband subscription is positive to the stock market development but its impact is model specific in SAARC. Unlike SAARC, in the ASEAN region impact of broadband subscription is positive due to better internet penetration, advanced digital networks and well integrated online trading platforms. ASEAN region has witnessed steady development in the field of digitalization, which results in improved access to financial market and investment platforms; it also helps in reduction of informational asymmetry. However, result from SAARC region indicate less significant broadband impact due to varying level of its penetration, rural urban digital divide and weak regulatory framework. Regional countries lack basic infrastructure of digitalization, limited broadband access to rural sector that eventually effect stock market development.

Table 9: ICT, Globalization and Stock Market Development in SAARC Region

Independent Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Telephone Subscription	0.002			0.002		
	(0.002)***			(0.000)***		
Broadband Subscription	-0.014			0.021		
	(0.000)***			(0.000)***		
Mobile Subscription	-0.001			-0.0007		
	(0.000)***			(0.000)***		

ICT Index		0.0177			0.008	0.088
		(0.000)***			(0.001)***	(0.005)**
Globalisation			0.005	0.003	0.002	0.004
			(0.042)**	(0.001)***	(0.000)***	(0.000)***
ICT Index*Globalisation						-0.001
						(0.137)
ECM	-0.720	-0.560	-0.783	-0.738	-0.738	-1.284
	(0.008)***	(0.026)**	(0.003)***	(0.026)**	(0.005)***	(0.008)***
Short run						
D(Telephone Subscription)	0.0094			0.016533		
	(0.8467)			(0.5897)		
D(Broadband Subscription)	0.069			-0.053724		
	(0.397)			(0.7336)		
D(Mobile Subscription)	-0.0055			-0.001048		
	(0.1309)			(0.8001)		
D(ICT Index)		-0.1055			-0.185551	-1.090891
		(0.4466)			(0.4251)	(0.3538)
D(Globalisation)			-0.0094	0.022489	0.031494	0.024533
			(0.2653)	(0.4103)	(0.0921)*	(0.103)*
Constant	-1.329	0.8849	-7.059	0.51817		-0.405415
	(0.3444)	(0.304)	(0.0318)**	(0.2386)		(0.3615)
						trend
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	80	84	88	84	84	80

*****and ** denotes 1% and 5% level of significance respectively**

Impact of Mobile subscription is significantly positive in ASEAN, in contrast its influence is negative in SAARC region. The level of influence in both regions could be attributed to the difference in integration and use of cellular technology in financial markets by member states from respective regions. The ASEAN region has made significant strides in use of technology for online trading and online financial transactions to facilitate greater stock market participation. In ASEAN retail investor's market participation is improved by the use of mobile based trading platforms and fintech solutions. In contrast use of mobile phone is limited to social communication in SAARC rather than financial market participation. Major impediments to the mobile users in SAARC region to engage in stock market attributed to lack of financial literacy, cyber security and inadequate online payment networks available. The negative impact also highlight the fact that alone mobile penetration does not foster market development rather financial literacy and developed digital system play an important role.

Principle component analysis applied to construct the ICT index. It is evident from the robust and significant results that ICT is an important variable effecting stock market growth and development in both regions. Comprehensive ICT index with underlying proxies such as mobile, telephone and broadband significantly impact market growth. The result suggest that well integrated ICT support system can serve a tool to enhance market efficiency, participation of investor and support smooth financial transaction with low cost. In addition, policy maker from ASEAN and SAARC must keep their strong focus on comprehensive ICT index in a holistic approach towards development rather than individual ICT technologies.

Globalisation in an independent direct relation contribute positively to stock market development in ASEAN and SAARC, it reflect advantages of market integration, capital inflow, and liberalization of trade. However, its impact as a moderator variable exhibit inconsistent results across both regions. The negative and insignificant coefficient of moderation in SAARC is an indication that globalization does not moderate role of ICT in SAARC. it is possible that globalization has positive impact on growth in SAARC but might not as effective with ICT in SAARC's financial market, this might be due to lack of integration with international digital market by the SAARC countries. On the other hand the results of ASEAN indicate significantly negative interaction term of ICT and Globalisation. The possible reason could be global integration might leads to domestic competition forcing regulatory challenges, capital outflow and financial volatility.

Overall findings support use of ICT in stock market development but it also dependent on some of other regional dynamics such as investment behavior, financial infrastructure and existing regulatory setup. SAARC require special attention from its policy makers to boost financial literacy, enhance broadband penetration and integrate cellular technology in financial market to benefit full potential. On the other hand ASEAN affected positively by the ICT but it also require careful management of globalization to achieve greater benefits of digital and financial integration.

Table 10: ICT, Globalization and Stock Market Development in ASEAN Region

Independent Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Telephone Subscription	0.0195			0.024286		
	(0.000)***			(0.000)***		
Broadband Subscription	0.0524			0.070061		
	(0.000)***			(0.000)***		
Moblile Subscription	0.0030			0.002895		
	(0.000)***			(0.000)***		
ICT Index		0.1543			0.10115	0.410108
		(0.000)***			(0.000)***	(0.000)***
Globalisation			0.0053	0.010219	0.013642	0.022183
			(0.000)***	(0.000)***	(0.000)***	(0.000)***
ICT Index*Globalisation						-0.005561
						(0.000)***
ECM	-0.884	-0.4845	-0.5761	-0.8454	-0.438446	-1.156568
	(0.0219)**	(0.0715)*	(0.000)***	(0.0322)**	(0.0165)**	(0.000)***
Short run						
D(Telephone Subscription)	0.031			0.002		
	(0.5233)			(0.937)		
D(Broadband Subscription)	-0.0041			-0.00084		
	(0.8561)			(0.959)		
D(Mobile Subscription)	0.0056			0.000626		
	(0.571)			(0.910)		
D(ICT Index)		-0.047			-0.244942	0.768052
		0.6141			(0.1637)	(0.834)
D(Globalisation)			-0.01167	-0.00891	-0.021077	0.056476
			(0.6395)	(0.7131)	(0.1881)	(0.552)

Constant	-0.1032	0.4292				0.211655
	(0.706)	(0.1729)				(0.841)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	126	120	126	126	114	120
Results remain same even if trend has been included						

The table 11 contains results of Information & communication technology and technological innovation on stock market development in SAARC and ASEAN. The result indicates ICT playing significant and positive impact on stock market development in both regions. While the impact of technological innovations influence positively to stock market development. It is worth mentioning that moderating role of technological innovation is positive and significant in SAARC and ASEAN. The significantly positive ICT result highlights importance of ICT to increase market transparency, efficiency and lowering transactional cost. It also indicates that broadband, telephone and mobile network enhance digital infrastructure resultantly increase market efficiency and investor participation. This discussion is particularly relevant in the context of ASEAN, where financial services are digitalized, mobile supported investment platforms along with modern fintech tools are increasingly in use. While in SAARC ICT integration is pronounce in urban areas.

The positive impact of technological innovation also stresses that technological development foster economic growth, bolster investor confidence and enhance firm productivity. Economies with innovation potential attract greater investment in technology led sector. Resident and nonresident patent application is used as a proxy to capture impact of technological innovation. The positive impact of patents suggest protection of intellectual property rights and investment in research and development play an important role in attracting foreign and local investment. Malaysia and Singapore leading R&D investment in ASEAN, technological innovation directly impact stock market growth and development. In SAARC unlike ASEAN innovation is concentrated in economies with strong intellectual property rights such as India.

Model 3 that includes technological innovation as moderating variable in SAARC region is positive and significant. This is evident from the result that improved ICT infrastructure in the presence of technological progress play greater role in stock market development. Most importantly the advent of innovative technologies improves trading platforms with new financial instruments and automation of trading process. ASEAN region is technologically advanced as compared to SAARC, the ICT infrastructure of ASEAN greatly improved over the years and the likely impact of ICT and technological innovation is stronger in ASEAN. Although ICT impact positively the stock market development in SAARC still impediments such as weak regulatory framework, lack of investment on research and development and reluctance to implement innovative technologies restrict the full potential.

Aggregate result highlights the importance of ICT and technological innovation as important drivers for stock market development. The combined effect of these variables on market development is even stronger, these results stress the need for improvement in digital infrastructure and innovation.

Table 11: ICT, Technological Innovations and Stock Market Development in SAARC and ASEAN Region

	SAARC			**ASEAN**		
Independent Variables	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
ICT Index	0.018	0.015	0.069	0.154	0.398	0.077
	(0.001)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.003)***
Patents Applications		0.00002	0.00003		0.000068	0.000067
		(0.000)***	(0.000)***		(0.000)***	(0.000)***
ICT Index*Patent Applications			0.000026			0.000036
			(0.000)***			(0.000)***

ECM	-0.560	-1.050	-1.179		-0.485	-1.203	-0.860
	(0.026)**	(0.046)**	(0.017)**		(0.072)*	(0.014)**	(0.005)***
Short run							
D(ICT Index)	-0.106	-0.025	-1.461		-0.047	-0.480	0.868
	0.447	0.936	0.160		0.614	0.096	0.315
D(Patent Applications)		0.000	0.000			0.000	0.000
		0.977	0.259			0.297	0.287
Constant	0.885	-1.326	-2.749		0.429	1.363	0.629
	0.304	0.504	0.578		0.173	0.126	0.259
Control Variables	Yes	Yes	Yes		Yes	Yes	Yes
Observations	84	76	80		120	114	120
***and ** denotes 1% and 5% level of significance respectively							

In table 12 results for patent application further disintegrated into resident and non-resident components to confirm the result in table 11. These results are in line with initial findings of positive association between technological innovation and stock market development. Resident patents indicate local research and development initiatives, high numbers of local patents indicate robust national innovative infrastructure. This could lead to technology driven investment by the businesses, resultantly attract investor participation and increase in market growth. Countries like Malaysia, Singapore and Thailand known for well-established innovative ecosystem. The domestic innovation system of these countries positively impact stock market development. Similarly in the region of SAARC India pool in greater number f domestic patent application that eventually reflects in growth of technological driven firms.

On the other hand nonresident patent application represent inflow of foreign innovation which is an indication of interest by the foreign investors and company in specific country or region as an attractive destination for technological investment. Greater number of patent applications highlights conducive investment environment, open market and stronger intellectual property rights protection, which resultantly uplift stock market. In the region of ASEAN countries like Singapore greatly benefited by FDI in technology intensive sector, Singapore economy receive great amount of non-resident patent application that plays an important role in market efficiency and development. In SAARC the role of non-resident patent is also positive particularly in economies heavily relying on FDI to technological innovations.

This disintegrated analysis support the result reported in table 11, it confirms role of local and foreign innovation to support market development. On the one side resident patent helps in domestic industry development, while nonresident patent applications reflects external technological spillover effects to strengthen stock market growth and development. The significant and positive impact of technological innovation on ICT is evident from both regions reinforcing that digital infrastructure complemented by technological development.

Focus of Policy makers in both regions must be to create an environment that support domestic innovation and attract foreign investment in technology and innovation. Collaboration between local and international technology leaders, fostering R&D and protection of patent rights will increase stock market development. In SAARC special attention must be given to the elimination of barrier to innovation and technology advancements. A balance between local and foreign innovation and technological development will be important to maintain stock market development.

Table 12: ICT, Technological Innovations (Resident vs Non Resident) and Stock Market Development in SAARC and ASEAN Region

	SAARC				ASEAN		
Independent Variables	**Model 1**	**Model 2**	**Model 3**		**Model 1**	**Model 2**	**Model 3**
ICT Index	0.018		0.106		0.154		0.044
	(0.001)***		(0.000)***		(0.000)***		(0.097)*
Patents Applications Residents		0.001	0.000			0.000	0.000
		(0.099)***	(0.000)***			(0.002)***	(0.002)***
Patents Applications non Residents		-0.001	0.000			0.000	0.000
		(0.000)***	(0.001)***			(0.000)***	(0.015)**
ECM	-0.560	-0.511	-0.791		-0.485	-0.628	-0.782
	(0.026)**	(0.019)**	(0.069)*		(0.072)*	(0.000)***	(0.055)**
Control Variables	Yes	Yes	Yes		Yes	Yes	Yes
Observations	84	76	80		120	120	120

*****and ** denotes 1% and 5% level of significance respectively**

4. CONCLUSION:

The findings of study highlight the important role of ICT diffusion to support stock market development in SAARC and ASEAN. The significantly positive ICT index indicates importance of digital infrastructure to support market efficiency, Investor participation and lowering the transactional cost. However, disintegrated effect of ICT measured through telephone subscription, broadband subscription and mobile subscription have varying impact in both regions. Mobile subscription exhibit negative impact while telephone and broadband subscription present quite robust impact in SAARC region. Globalization play an important role in market development but through interaction with ICT exhibit different result across regions. In SAARC region the moderating impact of globalization is less pronounced while in ASEAN the impact is negative as globalization reduce the impact of ICT on market development, this possibly be attributed to existing regulatory framework and saturation in financial market.

Technological innovation measured through patent application exhibit positive relation with ICT by enhancing the impact of ICT on market development. The results support the assertion that domestic and foreign innovation and technological advancements enhance stock market development. It highlights that when ICT couple with technological innovation, financial market witness greater growth. Findings emphasize the need for the development of policy to promote R&D, improve digital infrastructure and support financial participation. In SAARC, the emphasis must be on innovation lead support system, adoption of fintech to unlock full potential of ICT, while ASEAN must work to establish a balance between globalization and ICT diffusion to sustain stock market development.

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