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Impact of Research and Development Expenditures on Economic Growth: Evidence from Industrial Development in Pakistan and A Comparison from Developed Countries

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ABSTRACT

This study examines the impact of research and development (R&D) expenditures on economic growth, with a focus on industrial development in Pakistan and a comparative analysis with developed countries. Despite being the sixth most populous country, Pakistan faces significant challenges in achieving sustained growth. Using a panel least squares regression model, this study analyzes the data of eight countries over a period of 25 years, including Pakistan and seven G7 nations i.e. France, the United States, the United Kingdom, Germany, Japan, Italy, and Canada. The correlation results reveal that R&D expenditures positively and significantly impact GDP across these countries. The GDPs of the G7 countries are significantly higher to Pakistan, highlighting the potential for substantial economic gains through increased R&D investment. The model shows a high R^2 and adjusted R^2, explaining 88.79% of the variation in GDP, with significant predictors including research expenditures and the lagged GDP into R&D expenditure. These findings suggest that for Pakistan, increasing R&D expenditure could lead to notable improvements in GDP and overall economic performance. Recommendations to increase government allocation to R&D, focusing on key industries such as textiles, automobile, electronics, technological advancement and infrastructure, and implementing policies that encourage private sector investment in R&D. Additionally, enhancing academic research and providing a roadmap for policymakers to foster industrial and economic development in Pakistan.

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1. Introduction

Pakistan's contribution to global scientific research is a merely a less than 0.5%. This underinvestment in technology and technological improvement poses a good sized barrier to the country's economic development and social development. Even as science is recognized as a critical motive force of increase inside the modern-day aggressive economy, countrywide efforts have been inadequate. The scientific and Technological studies division became based in 1964 to: (i) coordinate and enforce countrywide technological know-how and era guidelines; (ii) sell studies and apply its consequences; (iii) broaden, produce, and utilize nuclear strength; and (iv) manage medical and technological manpower. It oversaw the country wide technological know-how Council, the Council of clinical and commercial research, the Atomic energy commission, and the distance and top Atmospheric research Committee. On the grounds that 1972, the Ministry of technology and era (most) has served as Pakistan's number one organization for planning, coordinating, and directing clinical and technological projects. It's miles chargeable for launching

packages and projects aligned with the countrywide schedule to foster a strong and sustainable technology and generation studies base, important for Pakistan's socio-monetary development, in accordance with the Federal government policies of business 1973. The division is led with the aid of a Secretary and accommodates 176 personnel with an additional 17 dedicated to development projects. Its operations are divided among management & Finance Wings and 5 technical wings: (i) policy & Coordination, (ii) planning & improvement, (iii) era, (iv) global Liaison, and (v) Electronics Wing. Key areas of awareness include Human-useful resource improvement, era switch from Research and Development institutions and Universities to enterprise, and advancements in food & Agriculture, business evaluation, fitness, Electronics, Ocean resources, New substances, Biotechnology, Textiles, and prescription drugs. Industrial innovation is a crucial driver of economic growth and competitiveness, especially in today's rapidly evolving global market. The significance of research and development (Research and Development) expenditure in promoting business innovation is paramount, as it provides the foundation for technological advancements, increased productivity, and the creation of new products and processes. This study examines the impact of Research and Development expenditure on industrial innovation in Pakistan over a 25-year period. Additionally, it compares these findings with industrial development trends in more developed economies to derive actionable insights and recommendations for enhancing Pakistan's innovation landscape.

Khan and Rehman (2013)'s study plays an important role in economic growth of a country through technological advancement and spillover effects. In Pakistan, Research and Development expenditure is primarily funded by the government through investments in higher education, with universities being the primary centers for research. Higher education funding significantly contributes to Research and Development efforts. Additionally, there are a few specialized Research and Development organizations in Pakistan. Research expenditure and quality have improved notably since the establishment of the Higher Education Commission (HEC) in 2001. Before the HEC's formation, annual publications in Pakistan were only 271 (ISI, 2010). This number nearly doubled by 1984-85, reaching 512 publications. The 2000s marked a significant decade for research in Pakistan, with substantial increases in the number of publications, research organizations, and research expenditures. Publications rose from 1305 in 2000-01 to 7661 in 2008-09. Pakistan's business zone, appreciably its fabric enterprise, has historically been a sizable contributor to the country wide economy. but, inspite of its potential, the world has struggled with numerous demanding situations, consisting of outdated era, confined Research and Development investments, and a lack of innovation. These issues have impeded the arena's capacity to compete the world over, particularly towards countries like China and Bangladesh, that have made significant advancements in business innovation. Research and Development expenditure is a pivotal element in addressing these challenges. Investments in Research and Development lead to the development of latest technologies, tactics, and merchandise, which in turn force industrial boom and performance. The relationship among Research and Development and industrial innovation has been considerably studied in developed nations, revealing a clean advantageous impact on financial performance and competitiveness. However, there is a paucity of complete studies analyzing this courting in the context of Pakistan's business quarter.

2. Literature Review

Pakistan, as a developing financial system faces huge demanding situations in attaining sustained monetary increase. Economists and policymakers in Pakistan are diligently operating to pick out the key elements driving economic increase. According to Hussain, Maitlo, Raza-ul-Mustafa, and Mujahid (2022), foreign direct investment, home funding, and change openness are crucial determinants of financial boom in Pakistan. However, the country has yet to leverage its population for ideal financial gain. Price range deficits and overseas debt also play crucial roles in shaping the monetary panorama. Iqbal and Zahid (1998) emphasized the significance of number one education and bodily capital as foundational elements for Pakistan's monetary growth. Schooling is diagnosed as a crucial device for development, and prioritizing it in public regulations is vital for achieving lengthy-term financial stability (Khattak, 2012; Taqi, Ali, Parveen, Babar, & Khan, 2021). Additionally, fitness, total aspect productiveness, and the labor pressure are diagnosed as long-time period drivers of the economic system, with extended investment in higher schooling yielding considerable benefits (Khattak, 2012).

Inside the current generation, studies and improvement (Research and Development) has emerged as a critical issue of financial boom, as highlighted via New increase Theories. Research

and Development fosters innovation, improving both the first-class and quantity of manufacturing. Modern corporations enjoy transient monopoly blessings until subsequent improvements emerge (Aghion & Howitt, 1992). Engelbrecht (1997) highlighted the multifaceted role of human capital and Research and Development in fostering home innovation and facilitating international expertise spillovers, which in flip power monetary increase. Blackburn (2000) incorporated Research and Development with human capital accumulation in an endogenous increase model, drawing on the ideas of (Grossman & Helpman, 1989; Lucas, 1988; Mansha, Yang, Ul Mustafa, & Nasim, 2022; Romer, 1990; Uzawa, 1965). These research together suggest for the buildup of abilities and know-how to spur economic boom, suggesting that human capital development now not handiest quickens boom however additionally incentivizes research and innovation, thereby enhancing production pleasant. Severe pupils, such as Jones (2002); Lee (2006); Rehman, Abro, Mustafa, Ullah, and Khattak (2021) have underscored the critical function of Research and Development and training in riding financial increase. Despite the stated importance of Research and Development, this region has no longer received adequate interest from policymakers in Pakistan. This paper examines the impact of Research and Development on Pakistan's economic system over the duration from 1971 to 2008, highlighting its significance for economic development.

Pakistan has verified surprising financial increase over the last little a long time. The agriculture, enterprise, and services sectors had been most important contributors to GDP growth. However, the agricultural quarter's contribution has been declining even as the economic sector's share has been growing. In 1950, agriculture contributed 53.2% to GDP, which reduced to 30.6% via 1980 and further to 23.3% in 2005 (country financial institution of Pakistan, 2005). Conversely, the industrial region's percentage rose from 9.6% to 22.6% in the course of the equal period. The Pakistani economic system grew at a price of 2% for the duration of the 2008-9 financial year (economic Survey of Pakistan, 2008-9). First of all, after its independence, Pakistan's growth charge changed into three.14% in its first decade, hampered by means of agricultural and commercial underdevelopment, low exports, and nascent alternate family members. While boom turned into consistent from 1961 to 1970, it fell to 4.6% in the Nineteen Seventies, a decade marked by the disintegration of Pakistan into separate states, Pakistan and Bangladesh. The period from 1991 to 2000 saw a extra solid growth rate of 6.15%, with Pakistan experiencing each democratic governance and army rule. From 2001 to 2008, the boom charge averaged 4.68%.

Studies has a vital function in riding the financial boom through technological advancements and spillover outcomes. Nadiri (1993) highlighted that Research and Development expenditure in high-tech sectors is especially efficient. In Pakistan, Research and Development funding is mainly government-pushed, with sizeable investments in better training. Universities are imperative to analyze activities, and spending on higher schooling significantly impacts Research and Development. The status quo of the better schooling commission (HEC) in 2001 has significantly improved studies great and expenditure. Previous to the HEC's formation, Pakistan's annual e-book count become handiest 271 (ISI, 2010), which nearly doubled by way of 1984-85 to 512. The 2000s marked a research boom in Pakistan, with guides growing from 1,305 in 2000-01 to 7,661 in 2008-09. Research and Development expenditure is indicative of a country's dedication to science, era, and overall monetary development. Wealthier international locations make investments closely in Research and Development, with worldwide expenditures growing from $410 billion in 1999-2000 to $755 billion, 80% of which turned into through OECD nations (UNESCO, 2004). In Pakistan, because of records boundaries, better education expenditure is used as a proxy for Research and Development investment, justified by way of the high correlation among higher training spending and clinical guides. Notwithstanding its significance, the Research and Development area in Pakistan has been historically overlooked, with most effective 0.16% of GDP spent on Research and Development in 1997. This percentage noticed minor fluctuations earlier than growing to 0.44% in 2005. Spotting the vital function of Research and Development, the government extended Research and Development expenditure to 0.68% of GDP by 2007, in large part due to the efforts of the HEC. Because the fourth-biggest cotton producer globally, Pakistan's textile company money owed for one-fourth of the USA’s industrial output and employs about 40% of the economic labor strain. however contributing 60% of the country's overall exports, fabric exports had been declining since 2013-14. This have a look at investigates the impact of innovation on productiveness and overall performance within the fabric enterprise in Faisalabad and Lahore, Pakistan, which together account for 47% of the industry and 8% of Punjab's textile groups. the use of Stochastic Frontier evaluation on

information from 193 randomly sampled cloth firms, the look at highlights the exquisite characteristic of corporation ownership in decreasing inefficiency. agencies with fewer liabilities are greater inclined to take risks, put into effect new thoughts, and embody innovation. furthermore, hiring professional hard work enhances operational performance.

The findings reveal a strong correlation among efficiency and numerous kinds of innovation, with studies and improvement expenditure additionally improving productivity and overall performance. instructing personnel similarly improves business enterprise productivity, suggesting that authorities assist for worker schooling and elevated funding for studies and development might be beneficial. Clothing business plays an important role in environmental and economic life (ul Mustafa, Abro, & Awan, 2021). It is therefore important to focus on how inputs are utilized and focus on innovation, technology and efficiency. In today's time drive, innovation promotes financial success and increases business efficiency by increasing the efficiency of production. Companies must innovate to remain globally competitive because innovation will help reduce production costs and increase operational complexity, thus making them competitive (Boso, Story, & Cadogan, 2013). The use of technology and innovation gives the country an incentive to improve textile quality (Kafouros, Wang, Piperopoulos, & Zhang, 2015) However, many organizations find that ensuring equity in support and development is ineffective and difficult to implement. In order for businesses to survive in the global environment, they need energy production, which requires large investments. International players such as China and Bangladesh are competing. In addition, the backwardness of Pakistani textile companies' machinery and equipment and lack of innovation lead to low production and high production costs, making it difficult to compete in international trade.

The economy has a positive impact on profits, shows the importance of time and sustainable development in the economy, and strong management plays an important role in gaining competitive advantage (Anning-Dorson, 2018). Investing in innovation is essential to create products and underpin economic health by creating wealth and making businesses more competitive in the global marketplace. This innovation strategy increases the effectiveness of innovation, and in addition, foreign sales also increase the effectiveness of innovation (Mairesse, Mohnen, Kremp, & KREMP, 2005). Development is often referred to as the introduction of innovation. These ideas greatly influence the deformation results and help improve efficiency. Some students believe that the benefit of change is more important than innovation in terms of productivity. Therefore, research and development costs help reduce production costs, and product innovation reduces substitutability thru developing spending on professional hard paintings. green advancing era complements the anticipated final results scale , studies and development funding will boom company productiveness, with firm size additionally gambling a feature in productiveness boom (Huergo & Jaumandreu, 2004). Technological innovation. Improved input-output ratio, resource utilization and average productivity. Addressing the limitations of value and creating value together lead to a positive impact on performance. Investing in innovation is important to make hard work worthwhile, lay the foundation for healthy living through financial savings, and enable organizations to have a say in the global economy. Thanks to export, the quality of the new product also increases (Mairesse et al., 2005). These ideas greatly influence progress results and increase the effectiveness of hard work. Some researchers argue that the benefits of change have a more significant impact on productivity than new entry.

Therefore, while R&D expenditures help reduce production costs, product innovations reduce turnover by increasing costs for certain operations. Green technology innovation increases the expected level of output. Funding for research and development increases efficiency and size supports product growth (Huergo & Jaumandreu, 2004). Research and new technologies increase the input-output ratio, efficient use of resources and productivity. Eliminate resource constraints and increase efficiency together to achieve better financial results. The Crepon, Duguet and Mairesse (CDM) model is important for analyzing the relationship between production and deformation (Crepon et al., 1998). While many studies distinguish between different methods and products, some consider different types of incremental and radical growth. At the very least, companies should focus on developing new products to encourage adoption of new products. This approach can stimulate business, thereby increasing productivity and improving the efficiency and effectiveness of international business. Companies in emerging nations regularly underestimate the function of exports in boom, probably due to constrained opportunities and

challenges in accessing numerous export markets. Market-primarily based sources and capitalization additionally pose big difficulties (Boso, Story, & Cadogan, 2013). Globalization has pressured nations to enhance monetary development via exports. But, nearby companies need to adhere to global standards to compete globally. Exports generate foreign exchange and investment, developing wonderful externalities and earnings-producing employment possibilities (Iqbal & Zahid, 1998). An addition in proportion to new marketplace and overseas income may aid economies succeed in their balance of payments against import and investment objectives, accelerating development. Pakistan ranks 4th globally in cotton manufacturing and has the ability to growth crop output if uncooked materials are available regionally. The textile value chain, encompassing everything from cotton harvesting to the production of finished goods like garments, involves various stages, each contributing value and creating employment opportunities. This sector significantly enhances industrial value-added, representing one-fourth of industrial production and employing approximately 40% of the industrial workforce in Pakistan.

The number one method to assess the impact of innovation on productivity is through the implementation of Research and Development, often called innovation enter, which extensively influences innovation output and sooner or later enhances exertions productivity. Product innovation entails enhancing present services or products or introducing new ones to consumers, while process innovation involves adopting new or stepped forward manufacturing strategies. Additionally, getting access to new markets and organizational changes are also taken into consideration dimensions of innovation (OECD, 2005). Rehman et al. (2021) investigate the relationship between organizational size and innovation in manufacturing firms and points out that operational progress does not necessarily create risks at the micro level. Increasing productivity can increase exports, but the impact of new products on exports may be delayed. Communication and exchange rate changes have an undesirable impact on sales in remote parts of the country. Although new processes often increase the productivity of a firm's workforce, technology has a greater impact on productivity than increased management (Fu li et al., 2018). Gilal et al. (2019) explored the relationship among structural modifications and financial increase in Pakistan the usage of time series records from the sector improvement indicators for the period 1976-2014. The studies applied GDP growth because the established variable and covered inflation (INF), outside debt (EXD), foreign direct funding (FDI), gross constant capital formation (GFCF), gross countrywide fees (GNEX), remittances (REM), domestic credit score to the non-public zone (DCRPS), trade openness, actual exchange price, and economic deepening (FDS) as impartial variables. Using a Kalman clear out-based totally time-various parameter technique for empirical evaluation, the examine observed that GFCF, INF, GNEX, and REM had sizeable influences on financial boom. However, the impact of these macroeconomic determinants on the growth manner numerous over time and turned into no longer steady for Pakistan.

The commercial area in Pakistan plays a pivotal role within the USA’s monetary development, yet it has faced sizable challenges in achieving innovation and sustained increase. Regardless of the significance of studies and improvement (Research and Development) expenditure as a driving force for commercial innovation and development, the connection among Research and Development investments and business growth in Pakistan remains underexplored. This research seeks to research the impact of Research and Development expenditure on commercial innovation in Pakistan during the last 25 years, imparting a comparative analysis with evolved industries. The take a look at makes use of regression evaluation to determine the importance and quantity of the effect of Research and Development expenditure on commercial development. Information this dating is important for formulating effective rules that may decorate business innovation and growth, thereby contributing to financial development.

2.1. Studies Questions

1. What's the impact of Research and Development expenditure on economic growth evident from industrial innovation in Pakistan over the past 25 years?
2. How has Research and Development investment stimulated business i ncrease in Pakistan?
3. What are the tendencies in Research and Development expenditure and commercial development over the take a look at period?
4. How does the effect of Research and Development expenditure on commercial innovation in Pakistan evaluate to that during advanced industries?
5. What are the important thing variations in Research and Development funding techniques between Pakistan and advanced international locations?

6. How do the consequences of Research and Development expenditure in Pakistan's industrial sector range from those in advanced industries?
7. What are the determinants of powerful Research and Development expenditure in fostering industrial innovation?
8. Which factors contribute to the effectiveness of Research and Development investments in promoting commercial increase?
9. What function do authorities guidelines and institutional frameworks play in improving the effect of Research and Development expenditure?
10. What are the coverage implications of the findings for boosting business innovation in Pakistan?
11. How can policy-makers leverage Research and Development investments to boost commercial innovation?
12. What specific measures may be taken to align Pakistan's Research and Development strategies with those of advanced industries to improve industrial improvement effects?

3. Data And Methodology

3.1. Data

This paper is based on secondary information and time series analysis for the period 1999-2023. The sources of information used in this research are extracted from the World Development Indicators and the State Bank of Pakistan.

3.2. Model Formation

$$GDPt = \beta 0 + \beta 1REXPt + \beta 2\Delta Indlt - 1 + \beta 3D1t + \beta 4D2t + \beta 5D3t + \epsilon t$$

where:

- GDP_t: The dependent variable at time t.
- β_0: Intercept term, representing the expected value of GDP_t when all explanatory variables are zero.
- β_1: Coefficient for $REXP_t$, measuring the impact of research and development expenditure on GDP_t.
- β_2: Coefficient for $\Delta Indl_{t-1}$, measuring the impact of industry value added at lag t−1 on GDP_t.
- β_3, β_4, β_5: Coefficients for the dummy variables $D1_t$, $D2_t$, and $D3_t$, respectively, capturing the impact of categorical factors or structural changes on GDP_t.
- ϵ_t: Error term, capturing the influence of all other factors not included in the mode.

The comparison of Pakistan results with developed countries which are indicated as G7 countries. Equation for the panel least squares model can be summarized as follows:

$$GDPit = \beta 0 + \beta 1REXPit + \beta 2GRLit + \sum j7 = 1\ \beta j + 4Dij + uit$$

where:

- GDP_{it} is the GDP of country i in period t.
- $REXP_{it}$ is the Research and development expense (a specific variable) of country i in period t.
- GRL_{it} is the lagged value of GDP multiplied by REXP,
- D_{ij} are dummy variables for each of the 7 categories (D1 to D7),
- B0,β1,β2,…,β11 are coefficients to be estimated,
- u_{it} is the error term specific to country i and period t.

This equation captures the correlation among GDP and the specified independent/input variables across a panel of 8 countries observed over 25 periods. The model is estimated using panel least squares, which interprets the both cross-sectional and time-series analysis in the provided information.

4. Empirical Results

Table 1: Descriptive Statistics Pakistan

	GDP	REXP	INDL	D1	D2	D3
Mean	23142.45	61.41209	279.9181	0.2	0.24	0.2
Median	23058.7	68.89296	317.5884	0	0	0
Maximum	44180.49	116.4692	1066.301	1	1	1
Minimum	6297.386	7.29867	-693.4717	0	0	0
Std. Dev.	10342.87	27.88757	432.6584	0.408248	0.43589	0.408248
Skewness	0.126288	-0.348541	-0.337988	1.5	1.217562	1.5
Kurtosis	1.987832	2.792905	2.778361	3.25	2.482456	3.25
Jarque-Bera	1.133624	0.550846	0.527153	9.440104	6.455913	9.440104
Probability	0.567331	0.759251	0.768299	0.008915	0.039638	0.008915
Sum	578,561	1,535	6,998	5	6	5
Sum Sq. Dev.	2,570,000,000	18,665	4,492,639	4	4.56	4
Observations	25	25	25	25	25	25

Source: Author's own compilation

Using the provided coefficients from results, we can specify the equation as:

Table 2: Regression Result

Dependent Variable: GDP

Independent Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8053.516	1517.26	5.307935	0
REXP	74.21896	27.77163	2.672474	0.0151
INDL	3.645589	1.446754	2.51984	0.0208
D1	22047.31	1704.391	12.93559	0
D2	6814.815	1915.666	3.557414	0.0021
D3	17327.52	1840.841	9.412825	0
R^2	0.935184	Dependent var of Mean		23142.45
Adjusted R^2	0.918127	S.D. dependent var		10342.87
S.E. of regression	2959.453	Akaike info criterion		19.02896
RSS	166000000	Schwarz criterion		19.32149
Log likelihood	-231.862	Hannan-Quinn criter.		19.1101
F-statistic	54.82741	Stat of Durbin-Watson		1.701873

Source: Author's own compilation

In this regression model, the dependent variable is GDP, and the independent variables include Research and Development expenditure (REXP), industrial growth (INDL), and dummy variables representing different political tenures (D1, D2, D3). Here's a detailed explanation of the results.

5.1. Model Interpretation

Intercept (C): 8053.516, representing the baseline GDP when all other variables are zero. REXP: The coefficient 74.21896 indicates that for every million dollars increase in Research and Development expenditure, GDP increases by $74.21896 million, holding other factors constant. This effect is statistically significant (p=0.0151). INDL: The coefficient 3.645589 indicates that for every million dollars increase in the first difference of industry value added, GDP increases by $3.645589 million, holding other factors constant. This effect is statistically significant (p=0.0208). Overall Model Fit: The R^2 value of 0.935184 indicates that approximately 93.52% of the variation in GDP is explained by the model. The F-statistic is 54.82741 with a p-value of 0.0000, indicating that the overall model is statistically significant. Durbin-Watson statistic: 1.701873 this statistic tests for autocorrelation of the residuals. A value close to 2 suggests no significant autocorrelation, which is desirable. Magnitude of Impact: The coefficient of 74.21896 indicates that for every million-dollar increase in Research and Development expenditure, the GDP of Pakistan increases by approximately $74.22 million, holding other factors constant. This

positive coefficient suggests that Research and Development expenditure has a significant and positive impact on the GDP of Pakistan. Statistical Significance: The t-statistic for Research and Development expenditure is 2.672474, which, with a p-value of 0.0151, indicates that the impact of Research and Development expenditure on GDP is statistically significant at the 5% significance level. This means that there is strong evidence to suggest that Research and Development expenditure positively influences GDP in Pakistan, and this result is not due to random chance. Economic Implication: The significant positive impact of Research and Development expenditure on GDP highlights the importance of investing in research and development for economic growth. It implies that policies aimed at increasing Research and Development spending could lead to higher economic growth and development in Pakistan.

5.2. Political Tenure 2019 to 2023

- D1: Coefficient: 22047.31
- Interpretation: The dummy variable D1 represents the last political tenure from 2019 to 2023. The coefficient of 22047.31 indicates that, on average, during this period, the GDP was $22,047.31 million higher compared to the reference category (the political tenure from 1999 to 2007), holding other factors constant.
- Statistical Significance: The p-value for D1 is 0.0000, indicating that this effect is statistically significant at conventional significance levels (e.g., 1%, 5%, 10%).

5.3. Political Tenure 2013 to 2018

- Coefficient: 17327.52
- Interpretation: The dummy variable D3 represents the second political tenure from 2013 to 2018. The coefficient of 17327.52 indicates that, on average, during this period, the GDP was $17,327.52 million higher compared to the reference category (political tenure from 1999 to 2007), holding other factors constant.
- Statistical Significance: The ppp-value for D3 is 0.0000, indicating that this effect is statistically significant at conventional significance levels (e.g., 1%, 5%, 10%).

5.4. Political Tenure 2008 to 2013

- Coefficient: 6814.815
- Interpretation: The dummy variable D2 represents the first political tenure from 2008 to 2013. The coefficient of 6814.815 indicates that, on average, during this period, the GDP was $6,814.815 million higher compared to the reference category (the political tenure from 1999 to 2007), holding other factors constant.
- Statistical Significance: The p-value for D2 is 0.0021, indicating that this effect is statistically significant at conventional significance levels (e.g., 1%, 5%, 10%).

The regression results indicate that each of the three political tenures (D1, D2, D3) had a positive impact on GDP compared to the reference political tenure (1999 to 2007), which serves as the reference category.

- All dummy variables are statistically significant, indicating that the differences in GDP during these political tenures compared to the reference category are not due to random chance.

The regression model indicates that both Research and Development expenditure (REXP) and industrial growth (GRL) have positive and statistically significant impacts on GDP, emphasizing the importance of these factors in economic growth. The negative coefficients of the dummy variables (D1, D2, D3) suggest that certain political tenures were associated with reductions in GDP. These findings highlight the influence of political conditions on economic performance, and the critical role of Research and Development and industrial growth in driving GDP.

Table 3: Descriptive Statistics

	GDP	REXP	GRL	D1	D2	D3	D4	D5	D6	D7
Mean	396000000	11118.63	43571943	0.125628	0.125628	0.125628	0.125628	0.125628	0.125628	0.120603
Median	247000000	5063.634	3666296	0	0	0	0	0	0	0

Maximum	2540000000	91487.88	1710000000	1	1	1	1	1	1	1
Minimum	0	7.29867	-168000000	0	0	0	0	0	0	0
Std. Dev.	493000000	16239.49	175000000	0.333226	0.333226	0.333226	0.333226	0.332266	0.333226	0.326487
Skewness	2.371904	2.735005	7.656079	2.259132	2.259132	2.259132	2.259132	2.259132	2.259132	2.329981
Kurtosis	8.158137	11.01282	67.92341	6.103678	6.103678	6.103678	6.103678	6.103678	6.103678	6.42881
Jarque-Bera	407.2045	780.4639	36893.86	249.1441	249.1441	249.1441	249.1441	249.1441	249.1441	277.5384
Probability	0	0	0	0	0	0	0	0	0	0
Sum	78,800,000,000	2,212,607	8,670,000,000	25	25	25	25	25	25	24
Sum Sq. Dev.	48,100,000,000,000,000,000	52,200,000,000	6,050,000,000,000,000,000	21.8593	21.8593	21.8593	21.8593	21.8593	21.8593	21.10553
Observations	199	199	199	199	199	199	199	199	199	199

Source: Author's own compilation

Table 4: Regression result of Panel Data

Dependent Variable: GDP

Independent Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	20,950,091	34,385,212	0.6093	0.5431
REXP	6,818	1,990	3.4263	0.0008
GRL	0.46	0.09	5.1178	0.0000
D1	171,000,000	49,660,716	3.4377	0.0007
D2	1,070,000,000	99,554,418	10.7971	0.0000
D3	184,000,000	49,673,734	3.6974	0.0003
D4	221,000,000	51,816,873	4.2713	0.0000
D5	329,000,000	56,759,207	5.7972	0.0000
D6	143,000,000	48,839,280	2.9381	0.0037
D7	104,000,000	49,379,560	2.1114	0.0361
R-squared	0.883840	Dependent var $\bar{X}$		396,000,000
Adjusted R-squared	0.878308	Dependent var σ (S.D)		493000000
S.E. of regression	172,000,000.000	Akaike info criterion		41
Sum squared resid	5,590,000,000,000,000,000	Schwarz criterion		41
Log likelihood	-4,051	Hannan-Quinn criter.		40.87894
F-statistic	160	Durbin-Watson stat		1.516554
Prob(F-statistic)	0			

Source: Author's own compilation

The provided regression results analyze the impact of research and development (Research and Development) expenditure on GDP across 8 countries over 25 years, using panel least squares regression. Dummy variables represent different countries, with Pakistan being the reference category.

5.5. Key Variables and Their Impact

1. Intercept (C):
   - Coefficient: 20,950,091

- Interpretation: This is the estimated GDP when all other variables (including Research and Development expenditure, lag values of GDP multiplied by Research and Development expenditure, etc.) are zero for the reference category (Pakistan).

2. Research and Development Expenditure (REXP):
   - Coefficient: 6,818
   - Interpretation: For every additional unit spent on Research and Development, GDP increases by $6,818, holding other factors constant.
   - Statistical Significance: Significant at the 1% level (p=0.0008p = 0.0008p=0.0008).
3. Lag values of GDP×REXP:
   - Coefficient: 0.46
   - Interpretation: The interaction term indicates that a 1-unit increase in the product of lagged GDP and Research and Development expenditure increases GDP by 0.46 units, holding other factors constant.
   - Statistical Significance: Highly significant (p=0.0000).

5.6. Dummy Variables Representing Countries

1. France (D1):
   - Coefficient: 171,000,000
   - Interpretation: GDP in France is $171 million higher compared to Pakistan, holding other factors constant.
   - Statistical Significance: Significant (p=0.0007).
2. United States (D2):
   - Coefficient: 1,070,000,000
   - Interpretation: GDP in the United States is $1.07 billion higher compared to Pakistan, holding other factors constant.
   - Statistical Significance: Highly significant (p=0.0000).
3. United Kingdom (D3):
   - Coefficient: 184,000,000
   - Interpretation: GDP in the United Kingdom is $184 million higher compared to Pakistan, holding other factors constant.
   - Statistical Significance: Highly significant (p=0.0003).
4. Germany (D4):
   - Coefficient: 221,000,000
   - Interpretation: GDP in Germany is $221 million higher compared to Pakistan, holding other factors constant.
   - Statistical Significance: Highly significant (p=0.0000).
5. Japan (D5):
   - Coefficient: 329,000,000
   - Interpretation: GDP in Japan is $329 million higher compared to Pakistan, holding other factors constant.
   - Statistical Significance: Highly significant (p=0.0000).
6. Italy (D6):
   - Coefficient: 143,000,000
   - Interpretation: GDP in Italy is $143 million higher compared to Pakistan, holding other factors constant.
   - Statistical Significance: Significant (p=0.0037).
7. Canada (D7):
   - Coefficient: 104,000,000
   - Interpretation: GDP in Canada is $104 million higher compared to Pakistan, holding other factors constant.
   - Statistical Significance: Significant (p=0.0361).

5.7. Model Fit and Diagnostics

- R^2: 0.883840
  - Indicates that the model explains all the variation in GDP, which suggests potential fit.
- Adjusted R^2: 0.878308
  - Adjusts the R^2 value for the number of predictors in the model, indicating a good fit.
- F-statistic: 160
  - Indicates that the overall model is statistically significant (p=0.000000).

6. Conclusions And Policy Recommendations

The regression results indicate that Research and Development expenditure has a positive and significant impact on GDP across the sample of countries. Additionally, the GDPs of France, the United States, the United Kingdom, Germany, Japan, Italy, and Canada are significantly higher compared to Pakistan, with varying magnitudes. These findings highlight the importance of Research and Development investment in boosting economic growth. For policymakers in Pakistan, this suggests that increasing Research and Development expenditure could lead to substantial improvements in the country's GDP. Comparing the dummy variables' coefficients provides insight into the relative economic performance of different countries in the sample. Overall, the panel least squares regression model provides a statistically significant explanation of GDP based on the included variables. The model shows a high R^2 and adjusted R^2, indicating a good fit. Individual coefficients and their statistical significance provide insights into the relationships between GDP and the independent variables (REXP, lagged GDP into REXP, and dummy variables). The regression model shows a strong fit, explaining 88.79% of the variation in GDP. Significant predictors include the constant term, research expenditure (REXP), and the lagged GDP into Research and Development expense.

6.1. Policy Recommendations

Based on the panel data and regression results analyzing Pakistan's Research and Development expenditure in comparison with G7 developed countries, the following recommendations are made to boost industrial growth and economic development:

6.1.1. Government Allocation

The positive coefficient for REXP (6,818) from the regression results indicates that increased research and development expenditure significantly contributes to GDP growth. To stimulate technological innovation and economic advancement, the government should allocate a higher percentage of GDP to research and development activities.

6.1.2. Focus on Key Industries

Specifically, targeting key industries such as textiles and infrastructure development with focused Research and Development investments can catalyze broader economic benefits. Technological advancements in these sectors will not only enhance industrial growth but also contribute to the overall GDP growth of the country.

6.1.3. Learning from Developed Economies

Drawing inspiration from the G7 countries, i.e. France, United States, United Kingdom, Germany, Japan, Italy, and Canada. Pakistan can see the substantial economic benefits that come from prioritizing Research funding. These developed economies demonstrate that consistent investment in research and development leads to sustained economic growth and industrial development.

6.1.4. Policy Implementation

To achieve these goals, the government should implement policies that encourage increased private sector investment in Research and Development, provide tax incentives for research activities, and support public-private partnerships. Establishing innovation hubs and funding grants for research projects can further stimulate the Research and Development landscape. By adopting these strategies, Pakistan can enhance its research and development framework, leading to sustainable industrial growth and a stronger GDP trajectory.

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