

Impact of R&D Investment on Economic Growth and Industry Competitiveness in Indonesia

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ABSTRACT

This study examines the impact of research and development (R&D) investment on economic growth and industrial competitiveness in Indonesia, focusing on 55 industrial sectors. Using a quantitative approach, data were collected through a structured Likert scale survey and analyzed with SPSS version 26. The results demonstrate a significant positive relationship between R&D investment and both economic growth and industrial competitiveness. Regression analysis reveals that R&D investment accounts for 58% of the variance in economic growth and 62% of the variance in industrial competitiveness. These findings highlight the pivotal role of R&D in fostering innovation, enhancing productivity, and achieving global competitiveness. Policymakers and industry stakeholders are encouraged to prioritize R&D funding to drive sustainable economic development in Indonesia.

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1. INTRODUCTION

Investment in research and development (R&D) is essential for driving economic growth and improving industrial competitiveness, particularly for developing countries like Indonesia. R&D fosters innovation, enabling industries to develop advanced technologies, optimize production processes, and create new market opportunities, thereby facilitating the transition from a resource-based to an innovation-driven economy essential for sustainable development and global competitiveness. For instance, countries like the United States, Japan, and China, with significant R&D investment, lead in innovation and economic performance [1]. In Romania, the R&D sector contributes to

regional economic development by fostering the growth of startups that introduce disruptive technologies and new market opportunities [2]. Additionally, R&D investment positively impacts employment growth by creating roles in research, engineering, and administration, supported by technological advancements and government incentives [3]. In Uzbekistan, investments in scientific research for digital transformation and automation have enhanced industrial competitiveness by improving production processes and reducing costs [4]. The relationship between R&D spending and economic growth is also evident in Romania, where regions with higher R&D investment experience more sustainable and long-term economic growth,

underlining the role of R&D in addressing regional disparities and promoting socio-economic development [5].

Indonesia's economic transformation has been characterized by increased industrial diversification and integration into global value chains (GVCs), with a notable rise in value-added exports, particularly in the mining and manufacturing sectors, and a focus on regional partnerships in Asia [6]. The country plays a significant role in exporting intermediate goods and incorporates higher shares of domestic value-added in its exports compared to other ASEAN countries [6]. However, technological development is hindered by a mismatch between local resources and technological needs, limiting competitiveness in the context of Industrial Revolution 4.0 [7]. The manufacturing sector struggles with unsatisfactory performance due to challenges in enhancing human and technological competencies, highlighting the need for innovation and human capital development [8]. While Indonesia's shift towards a service-centered economy has driven productivity growth through within-sector gains and labor movement to higher-productivity sectors, the service sector's relatively low productivity compared to the industrial subsector poses challenges for dynamic economic growth [6], [9]. Additionally, slower industrial growth since the Asian Financial Crisis is attributed to historical, policy, and organizational factors, fueling debates on deindustrialization and the need for a capability-focused industrial policy to address technological inferiority and enhance innovation in the manufacturing sector [8], [10].

Previous studies have highlighted the positive impact of R&D investment on economic performance and competitiveness in developed economies. Research and development (R&D) investment is widely recognized as a critical driver of economic performance and competitiveness, with its positive impact influencing employment, firm performance, and national economic indicators across developed and developing economies. R&D significantly contributes to

employment growth by creating roles in research, engineering, and administrative areas, supported by technological advancements and government incentives that drive innovation, productivity, and market creation [3]. In Chinese manufacturing enterprises, increased R&D personnel and investment costs have been shown to significantly boost operating income, highlighting the importance of enhancing R&D capabilities and strategically allocating resources to improve competitiveness and economic benefits [11]. On a macroeconomic level, R&D and innovation are pivotal for long-term sustainable economic growth, with evidence suggesting that economies with higher past growth rates benefit more from R&D intensity [12]. However, the relationship between R&D investments and firm performance is non-linear, as demonstrated by the Sigmoid (S) curve model, which shows varying impacts at low, medium, and high levels of R&D intensity, a trend particularly evident in Anglo-Saxon and developing countries [13], [14].

2. LITERATURE REVIEW

2.1 Theoretical Foundations

The endogenous growth theory emphasizes the pivotal role of knowledge, innovation, and human capital in fostering long-term economic growth, positing that R&D investment enhances the stock of knowledge and serves as a catalyst for technological advancements and productivity improvements. Ziesemer's study highlights that both private and public R&D stocks significantly enhance labor-augmenting technical change in OECD countries, demonstrating strong public-to-private spillovers [15]. Similarly, Kruse-Andersen's research supports semi-endogenous growth models, indicating that while fully endogenous models may not hold, R&D remains crucial for productivity growth, though with diminishing returns as technologies advance [16]. Verba's model further underscores the importance of knowledge and R&D accumulation dynamics,

showing that long-term growth can be sustained through idea-driven innovation without relying on continuous increases in R&D employment [17]. Human capital also plays a critical role, as Bella et al. point out, highlighting conditions under which countries may struggle to accumulate human capital, aligning with Lucas' model that productivity in goods production can sometimes overshadow the benefits of education, thereby influencing growth trajectories [18]. A dynamic panel data analysis for OECD countries reveals that knowledge indicators, including human capital, R&D, trade, and ICTs, positively influence economic growth and convergence, reinforcing the importance of knowledge accumulation for growth performance [19]. Aligning with this framework, Porter's theory of competitive advantage emphasizes that R&D-driven innovation is essential for firms to develop unique products and processes, securing a competitive edge in global markets [15], [17].

2.2 Empirical Evidence on R&D and Economic Growth

Investment in Research and Development (R&D) is widely recognized as a catalyst for economic growth, particularly in developed economies, where empirical studies consistently demonstrate that R&D expenditure enhances GDP growth, labor productivity, and technological innovation. In countries like the USA, Japan, and Germany, R&D investments significantly contribute to economic growth, with research indicating that a 1% increase in R&D expenditure can lead to a 2.83% increase in GDP growth rate [20]. Similarly, in OECD countries, higher R&D spending correlates positively with GDP growth, emphasizing the critical role of R&D in fostering productivity and technological advancements [21]. Advanced econometric models, such as kernel-based regularized least squares, further confirm the non-linear positive impact of R&D on economic growth, particularly in high-income countries [22]. However, in emerging markets, the relationship between R&D and economic growth is more complex, influenced by factors

such as institutional quality and absorptive capacity, with challenges like inadequate infrastructure and limited funding often hindering the full realization of R&D benefits [23], [24]. This disparity in R&D impact between developed and developing countries underscores the need for tailored policy interventions, encouraging policymakers to focus on improving macroeconomic determinants and institutional frameworks to maximize the effectiveness of R&D investments [22], [23].

2.3 Empirical Evidence on R&D and Industrial Competitiveness

Indonesia's industrial competitiveness relies on its capacity for innovation and R&D investment, key drivers of technological advancement that enhance performance and competitiveness. Despite this, Indonesia's R&D spending remains low compared to regional peers, limiting growth potential. R&D is crucial for developing technologies that boost productivity, reduce costs, and improve product quality, supporting long-term growth [25]. Industries with higher R&D engagement show stronger export performance and resilience to external shocks, underscoring its role in competitiveness [26]. Effective innovation strategies enhance market share and profitability [27], while moderate competition fosters innovation, crucial for manufacturing and service sectors [28]. Enhancing R&D infrastructure and policies for innovation and entrepreneurship is critical to strengthening Indonesia's competitiveness [26].

2.4 Gaps in the Literature

While existing literature establishes the importance of R&D investment for economic growth and competitiveness, several gaps remain. First, most studies have focused on developed economies, with limited attention to the unique challenges and opportunities in emerging markets like Indonesia. Second, the sectoral dynamics of R&D impacts have not been fully explored, particularly in industries with varying levels of technological adoption. Third, there is a need for more robust quantitative studies that integrate R&D's effects on both

macroeconomic outcomes and firm-level competitiveness.

2.5 Conceptual Framework and Hypotheses

Building on the theoretical and empirical foundations, this study hypothesizes a positive and significant relationship between R&D investment and two key outcomes: economic growth and industrial competitiveness. The conceptual framework is grounded in the following hypotheses:

H1: R&D investment has a positive impact on economic growth in Indonesia.

H2: R&D investment enhances industrial competitiveness in Indonesia.

These hypotheses will be tested using data from 55 industrial sectors in Indonesia, with a focus on understanding the extent and nature of the relationship.

3. METHODS

3.1 Research Design

This study adopts a quantitative research design to examine the relationship between R&D investment and its impacts on economic growth and industrial competitiveness. A structured survey approach was employed, utilizing a Likert scale (1–5) to capture respondents' perceptions on the variables of interest. The analysis is based on cross-sectional data collected from 55 industrial sectors, providing a comprehensive snapshot of the current dynamics of R&D investment in Indonesia.

3.2 Population and Sample

The target population for this study includes industries operating in Indonesia, with a focus on those engaged in innovation-driven activities. The sampling frame was drawn from diverse industrial sectors to ensure representation across varying levels of R&D intensity, and a purposive sampling method was used to select 55 firms and organizations actively involved in R&D activities based on their availability of R&D investment data and their contribution to the national economic and industrial landscape. The sample size of 55 was considered sufficient based on statistical power and

practical constraints, ensuring robust and meaningful insights. Data were collected through a structured questionnaire designed to measure the key variables and distributed electronically to respondents in managerial or strategic positions within the selected firms. To ensure data reliability, a pilot test was conducted with 10 respondents prior to full-scale data collection, and necessary adjustments were made based on the feedback received.

3.3 Data Analysis Techniques

The collected data were analyzed using SPSS version 26, a statistical software widely utilized for quantitative data analysis. The analysis involved several techniques: descriptive statistics were employed to summarize the demographic and organizational characteristics of the sample, including industry type, firm size, and R&D intensity; reliability and validity testing was conducted using Cronbach's Alpha to ensure the internal consistency of survey items; Pearson correlation coefficients were calculated to examine the relationships between R&D investment, economic growth, and industrial competitiveness; and multiple regression models were developed to quantify the impact of R&D investment on the dependent variables—economic growth and industrial competitiveness. The regression equations were formulated as follows: Model 1 ($Y_1 = \beta_0 + \beta_1 X + \epsilon$) represented economic growth (Y_1), where X is R&D investment and ϵ is the error term, and Model 2 ($Y_2 = \beta_0 + \beta_1 X + \epsilon$) represented industrial competitiveness (Y_2), with the same explanatory variables. Hypothesis testing was performed using T-tests and F-tests to evaluate the significance of the regression coefficients at a 95% confidence level ($p < 0.05$).

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The descriptive statistics summarize the demographic and industrial characteristics of the sample. The 55 firms surveyed represent diverse industries,

including manufacturing (40%), technology (25%), agriculture (15%), and services (20%). The average R&D investment as a percentage of revenue was 4.2%, with variations across

sectors. Manufacturing and technology industries reported higher R&D spending compared to agriculture and services.

Table 1 highlights the key descriptive statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
R&D Investment (%)	4.26	1.56	2.0	5.0
Economic Growth (score)	3.83	0.84	2.5	4.8
Industrial Competitiveness (score)	3.95	0.72	2.8	4.7

The average R&D investment as a percentage of revenue is 4.26%, indicating a moderate commitment to innovation among the surveyed industries, with a standard deviation of 1.5% reflecting significant variation in investment levels. The range of 2.0% to 5.0% highlights that even the highest investors fall short of the global leaders, where R&D spending often exceeds 10%, pointing to a critical gap in Indonesia's innovation ecosystem that may hinder sustained competitiveness and growth. Economic growth, measured on a Likert scale of 1 to 5, averages 3.83, suggesting moderate-to-high levels of growth, though a standard deviation of 0.8 and a range of 2.5 to 4.8 reveal disparities across industries; these disparities may stem from structural challenges or differences in the effectiveness of R&D strategies. Industrial competitiveness averages 3.95 on the same scale, with a lower standard deviation of 0.7 and a range of 2.8 to 4.7, indicating a more consistent perception of competitiveness across industries. However, industries at the lower end of the competitiveness scale may face challenges such as insufficient R&D investment or operational inefficiencies, which hinder their ability to differentiate in the market.

4.2 Reliability and Validity Testing

The Cronbach's Alpha values for the constructs were all above 0.70, indicating acceptable internal consistency, with R&D Investment at 0.828, Economic Growth at 0.794, and Industrial Competitiveness at 0.857. The validity of these constructs was further confirmed through factor analysis, where all items demonstrated significant loadings onto their respective factors, ensuring that the measurement tools used

were both reliable and valid for assessing the relationships in the study.

4.3 Correlation Analysis

The correlation analysis revealed significant positive relationships between the variables, with R&D Investment showing a strong correlation with Economic Growth ($r=0.687$, $p<0.01$) and Industrial Competitiveness ($r=0.724$, $p<0.01$). These findings indicate that higher levels of R&D investment are strongly associated with improved economic growth and enhanced industrial competitiveness, highlighting the critical role of innovation-driven activities in fostering economic and industrial performance.

4.4 Regression Analysis

The regression analysis tested the hypotheses and quantified the impact of R&D investment on the dependent variables.

Model 1: Impact on Economic Growth

The regression model for economic growth was significant ($F(1,533)=372.2, p<0.01$), with an R^2 value of 0.583, indicating that 58.3% of the variation in economic growth is explained by R&D investment. The coefficient for R&D investment ($\beta=0.684, p<0.01$) was positive and significant, providing strong support for Hypothesis 1 and highlighting the crucial role of R&D investment in driving economic growth.

Model 2: Impact on Industrial Competitiveness

The regression model for industrial competitiveness was significant ($F(1,53)=43.8, p<0.01$), with an R^2 value of 0.62, indicating that 62% of the variation in industrial competitiveness is explained by R&D investment. The coefficient for R&D

investment ($\beta=0.725, p<0.01$) was positive and significant, providing strong support for Hypothesis 2 and emphasizing the importance of R&D investment in enhancing industrial competitiveness.

4.5 Discussion

The findings of this study demonstrate the critical role of R&D investment in driving economic growth and enhancing industrial competitiveness in Indonesia. The positive and significant relationships observed in the regression analysis align with the predictions of endogenous growth theory, which posits that innovation and knowledge accumulation are key drivers of economic performance. The results highlight that firms investing more heavily in R&D experience higher levels of economic growth. This is likely due to the ability of R&D activities to generate technological advancements, improve productivity, and create value-added products. The findings resonate with studies by [2], [14], [29], which found similar positive impacts of R&D on economic growth in developed economies.

The significant impact of R&D investment on industrial competitiveness underscores the importance of innovation in differentiating firms in the global market. Industries that prioritize R&D are better positioned to adapt to market changes, enhance product quality, and achieve competitive advantage. This is consistent with [25], [30], [31] of competitive advantage, which emphasizes the role of innovation in industrial success.

Implications for Indonesia

Despite the positive findings, Indonesia's overall R&D spending remains low compared to regional peers, limiting its potential to fully capitalize on innovation-driven growth. Policymakers should prioritize increasing R&D funding, incentivizing private sector investment, and fostering collaboration between academia,

industry, and government. These measures could address existing gaps and enhance the country's innovation ecosystem.

4.6 Limitations and Future Research

While this study provides valuable insights, several limitations must be acknowledged. First, the sample size is relatively small, limiting the generalizability of the findings. Second, the study relies on cross-sectional data, which restricts the ability to infer causality. Future research could explore longitudinal data and include a larger, more diverse sample. Additionally, sector-specific analyses could provide deeper insights into the varying impacts of R&D investment.

5. CONCLUSION

This study highlights the critical role of R&D investment in driving economic growth and industrial competitiveness in Indonesia, demonstrating that firms with higher R&D investment achieve significant gains in productivity, innovation, and market positioning. The findings align with theoretical models of endogenous growth and empirical evidence from other economies, emphasizing the transformative potential of R&D. However, Indonesia's relatively low R&D spending compared to regional benchmarks poses a challenge to achieving sustained economic development. Policymakers are encouraged to enhance R&D funding, foster public-private partnerships, and create an innovation-friendly ecosystem to strengthen the industrial base and position Indonesia as a competitive global player. Future research could delve into sector-specific dynamics, explore longitudinal impacts, and assess the role of external factors such as government support and technological diffusion for a more comprehensive understanding of R&D's contribution to economic and industrial transformation.

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