BRAZIL AND THE MIDDLE-INCOME TRAP: HUMAN CAPITAL MISSALLOCATION, LEGAL HYPERTROPHY, AND STRUCTURAL BARRIERS TO INNOVATION

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Abstract

Brazil has still been in the middle-income stage of development for more than four decades despite having vast natural resources, a large domestic market, and a relatively diversified economy. This article investigates the structural causes of Brazil's persistent stagnation by examining the misallocation of human capital in higher education and the institutional consequences of a legalistic professional structure. Using comparative analysis with South Korea, China, the United States, and the European Union, the study argues that Brazil's disproportionate production of legal professionals compared to engineers reflects a deeper systemic bias toward distributive rather than productive economic activities. The article combines comparative institutional analysis, educational statistics, and economic theory to show how this imbalance contributes to low innovation capacity, limited technological upgrading, and reduced total factor productivity. The findings suggest that Brazil's educational and institutional architecture reinforces a "litigation economy" rather than an "innovation economy," thereby perpetuating the middle-income trap. Policy recommendations include restructuring incentives in higher education, strengthening STEM formation, and reforming legal and regulatory institutions that discourage productive investment.

Keywords: middle-income trap, human capital allocation, STEM education, legal systems, economic development, Brazil.

1. INTRODUCTION

Brazil stands for one of the most intriguing cases in contemporary development economics. The country has characteristics commonly associated with successful economic transformation: a large domestic market, abundant natural resources, significant industrial capacity, and a diversified economic base. Despite these advantages, Brazil has still been trapped within the middle-income category for more than four decades.

Since the late 1980s, Brazil's per capita income growth has been modest compared with several Asian economies that started from similar or even lower levels of development. During the 1960s and early 1970s, Brazil's GDP per capita was comparable to that of South Korea. However, while South Korea successfully transitioned into a high-income economy characterized by advanced technological industries, Brazil's economic growth slowed considerably after the 1980s and has since shown persistent productivity stagnation.

This phenomenon is commonly referred to as the **middle-income trap**, a concept widely used in development economics to describe countries that experience difficulty transitioning from resource-driven or labor-intensive growth to innovation-driven growth (Gill & Kharas, 2007).

Countries that escape this trap typically undergo a structural transformation in which productivity growth becomes increasingly driven by technological innovation, advanced manufacturing, and knowledge-intensive industries. Achieving such a transition requires strong human capital formation, particularly in science, technology, engineering, and mathematics (STEM).

Brazil's experience, however, reveals a different pattern. Despite expanding access to higher education during the past two decades, the country has produced a professional structure disproportionately concentrated in legal and administrative professions rather than technical fields essential for industrial innovation. This imbalance may have profound implications for long-term economic growth.

Economic theory suggests that the occupational distribution of highly skilled individuals can significantly influence a country's growth trajectory. When talented individuals disproportionately choose professions associated with redistribution, litigation, or bureaucratic administration rather than productive innovation, the economy may experience lower productivity growth.

Murphy, Shleifer, and Vishny (1991) famously described this phenomenon as the **allocation of talent problem**, arguing that societies in which talented individuals pursue careers in engineering and entrepreneurship tend to grow faster than those where talent concentrates in rent-seeking activities such as litigation or financial speculation. Brazil appears to represent a contemporary case of this dynamic.

This article investigates whether the composition of Brazil's human capital may contribute to the country's persistent middle-income status.

1.1. Research question

The central research question guiding this study is:

Why has Brazil remained trapped in the middle-income stage of development despite having structural conditions favorable to economic growth?

The article proposes that part of the explanation lies in the **misallocation of highly skilled human capital**, particularly the disproportionate concentration of graduates in legal professions compared to engineering and technological fields.

This imbalance may affect economic development through several mechanisms:

1. Reduced technological innovation capacity.
2. Increased regulatory and legal complexity.
3. Lower productivity growth.
4. Limited industrial upgrading.

To explore this hypothesis, the study adopts a comparative analytical framework examining Brazil's professional structure compared to countries that successfully transitioned to high-income status.

1.2. Contribution to literature

This study contributes to literature in three ways:

1. It integrates **human capital allocation theory** (Murphy et al., 1991) with the **middle-income trap framework**, which is rarely done explicitly.
2. It introduces the **lawyer-to-engineer ratio** as an analytical proxy for structural allocation of talent.
3. It links legal **hypertrophy to regulatory friction and innovation constraints**, extending institutional economics perspectives (North, 1990; Acemoglu & Robinson, 2012).

1.3. Theoretical foundations

The analytical framework of this study integrates three complementary strands of economic theory:

1. Endogenous growth theory.
2. Human capital allocation theory.
3. Institutional economics.

Endogenous growth theory

Endogenous growth models emphasize the importance of technological innovation as the primary driver of long-term economic growth. Romer (1990) showed that investment in knowledge production generates increasing returns through innovation and technological spillovers.

In these models, engineers, scientists, and researchers play a central role in generating new technologies and improving productivity.

Allocation of talent theory

Murphy et al. (1991) introduced a crucial insight into the relationship between occupational choice and economic growth.

Their model suggests that talented individuals choose careers based on relative financial rewards and social prestige. If legal or bureaucratic professions offer greater incentives than engineering or entrepreneurship, talent may shift toward these activities even though they contribute less to economic productivity. Such an allocation of talent can reduce innovation and slow economic growth.

Institutional economics

Institutional economists emphasize the role of political and legal institutions in shaping economic outcomes.

Acemoglu and Robinson (2012) argue that inclusive institutions that encourage innovation and entrepreneurship are essential for sustained economic growth. However, excessive legal complexity or regulatory barriers may discourage productive investment and technological experimentation.

These theoretical perspectives collectively provide the foundation for the hypothesis explored in this article.

1.4. Methodology

This study adopts a **comparative macro-institutional approach** combining descriptive statistics, cross-country comparisons, and institutional analysis.

The research focuses on four major economies standing for different development trajectories: Brazil, South Korea, China, and the United States. These countries were selected because they illustrate contrasting models of economic development.

Selection Criterion	Justification
Development trajectory contrast	Brazil (stagnation) vs Korea/China (catch-up success)
Economic scale relevance	Large or globally influential economies
Availability of comparable data	OECD, World Bank, UNESCO datasets

South Korea and China represent examples of successful industrial upgrading driven by strong technical education systems. The United States is an innovation-driven economy combining legal institutions with strong entrepreneurial ecosystems. Brazil serves as the primary case study being a middle-income economy with significant industrial potential but persistent productivity stagnation.

1.4.1. Data sources

The empirical indicators used in this study were drawn from several international databases:

- OECD Education at a Glance.
- World Bank World Development Indicators.
- World Economic Forum reports.
- UNESCO Institute for Statistics.
- Brazilian Higher Education Census (INEP).

These datasets provide reliable cross-country comparisons of human capital composition, innovation capacity, and economic performance.

1.4.2. Key indicators

The analysis focuses on three key indicators that capture the relationship between human capital and economic development.

Indicator	Theoretical relevance
Engineers per million	Proxy for technological capability
R&D (% GDP)	Innovation investment intensity
Lawyer-to-engineer ratio	Allocation of talent (Murphy et al., 1991)

1. Engineers per million inhabitants

This indicator measures the density of technical professionals within the workforce and reflects the capacity for technological innovation.

2. Investment in research and development (R&D)

R&D investment as a percentage of GDP is a critical indicator of innovation intensity.

3. Lawyer-to-engineer ratio

This indicator captures the relative allocation of highly educated professionals between redistributive and productive activities.

Together, these indicators provide a useful framework for comparing national innovation capacity.

1.5. Econometric framework

To analyze the relationship between human capital composition and economic development, the study employs a simplified econometric framework based on endogenous growth models.

The basic functional form is expressed as:

GDP growth = alpha + beta1 Engineering Density + beta2 R&D Investment + beta3 Institutional Quality + epsilon

The formula is a **multiple linear regression** model used to estimate how much each specific factor contributes to economic growth. Where:

- **GDP is the Dependent Variable:** The variable that explains the rate of change in the Gross Domestic Product.
- **Alpha is the Intercept:** The "baseline" growth that is the expected GDP growth if all other variables were zero and so captures factors not explicitly included in the model.
- **Betha are Coefficients:** These are the **impact indicators**. They show how much the GDP changes for every 1 unit increase in the corresponding variable
  - Engineering Density is engineers per million inhabitants.
  - R&D Investment is national research expenditure.
  - Institutional Quality captures regulatory efficiency and governance.
- **Epsilon is the Error Term:** The "random noise" that is everything else that affects the GDP but is not captured by the variables in the formula (e.g., global crises, weather, or pandemics).

Earlier studies suggest that higher engineering density and R&D investment are positively correlated with productivity growth (Hausmann et al., 2014). In contrast, excessive legal complexity may generate negative effects through increased transaction costs.

1.6. Comparative international evidence

To illustrate these relationships, Tables 1,2 and 3 compares Brazil with South Korea, China, and the United States across several human capital and innovation indicators.

Table 1: Engineers per Million Inhabitants

Country	Engineers per Million
Brazil	950
South Korea	7,200
China	5,300
United States	4,300

Sources: UNESCO, OECD, World Bank.

The difference between Brazil and advanced technological economies is striking. South Korea produces nearly **seven times more engineers per capita than Brazil**, reflecting its deliberate policy emphasis on technical education since the 1960s. China also shows a significantly higher density of engineers due to its large-scale STEM education system. The United States, although less centralized in its educational planning, benefits from strong engineering universities and immigration of highly skilled technical workers.

Table 2: Investment in Research and Development (% of GDP)

Country	R&D investment
Brazil	1.2%
South Korea	4.8%
China	2.4%
United States	3.5%

Sources: OECD, World Bank.

R&D investment levels provide another important indicator of innovation capacity. South Korea's investment in research exceeds 4.5 percent of GDP, one of the highest levels in the world. China has also dramatically increased its R&D spending over the past two decades. Brazil, by contrast, invests approximately 1 percent of GDP in research and development, significantly limiting its technological upgrading.

Table 3: Lawyer-to-Engineer Ratio

Country	Lawyer-to-engineer ratio
Brazil	1.35 : 1
United States	1.2 : 1
South Korea	1 : 8
China	1 : 16

Sources: OECD, national professional association.

The contrast between Brazil and the Asian economies is particularly notable. In China and South Korea, engineering professionals significantly outnumber lawyers, reflecting a development strategy oriented toward technological production. In Brazil, the opposite pattern is seen: lawyers outnumber engineers, showing a professional structure oriented toward legal administration and dispute resolution rather than technological creation.

1.7. Institutional implications

These differences in professional composition have important institutional implications. Countries with high densities of engineers tend to show stronger innovation ecosystems, including:

- Advanced manufacturing industries.
- Higher patent generation.
- Stronger technological entrepreneurship.

Conversely, countries with excessive concentrations of legal professionals may experience institutional environments characterized by regulatory complexity and litigation. Brazil currently faces one of the highest litigation rates in the world, with tens of millions of ongoing legal cases in the judicial system.

While legal institutions are essential for democratic governance, excessive reliance on litigation can increase transaction costs and discourage entrepreneurial experimentation. This phenomenon contributes to what Brazilian economists often describe as **"Custo Brasil"**, the complex network of regulatory and institutional barriers that increase the cost of doing business in the country.

1.7. Hypothesis

Based on the theoretical and empirical evidence presented above, this article proposes the following hypothesis:

Brazil's persistent middle-income status is partly the result of a structural misallocation of human capital toward legal and administrative professions rather than engineering and technological fields.

This imbalance reduces innovation capacity and contributes to regulatory complexity, thereby slowing productivity growth.

2. COMPARATIVE DEVELOPMENT PATHS

2.1. Persistence of Brazil's middle-income status

The persistence of Brazil's middle-income status can only be fully understood within a comparative framework that examines how other countries have successfully transitioned from middle-income to high-income economic structures. In particular, the experiences of South Korea and China illustrate how deliberate policy choices about education, industrial policy, and technological development can reshape a nation's economic trajectory. At the same time, the United States is a distinct model in which innovation ecosystems, venture capital, and research universities serve as engines of technological leadership.

This section compares Brazil with these economies across several dimensions central to technological development: the formation of engineers and technical professionals, the structure of STEM education pipelines, national industrial policies, and the organization of innovation ecosystems.

The analysis reveals that the divergence between Brazil and these economies is not accidental but reflects differences in institutional priorities and policy choices over several decades. Countries that successfully escaped the middle-income trap systematically invested in technical education, research and development, and industrial capabilities. Brazil, by contrast, expanded higher education primarily through low-cost social science and legal programs, resulting in a professional structure less aligned with technological development. Understanding these differences is essential for finding the structural reforms necessary for Brazil to achieve sustained productivity growth.

2.2. Econometric perspective on human capital and innovation

From an econometric standpoint, the relationship between human capital composition and economic growth can be examined through models linking technological capability to productivity growth. In endogenous growth theory, technological innovation appears from investments in knowledge production, which depend heavily on the availability of scientists and engineers.

Several empirical studies have proved a strong correlation between engineering density and national innovation performance. For example, studies using OECD data show that countries with higher proportions of STEM graduates tend to show higher levels of patent activity, technological exports, and total factor productivity growth (Aghion & Howitt, 2009).

To illustrate these relationships, consider a simplified econometric model in which productivity growth is influenced by engineering density and research investment:

TFP growth = alpha + beta1 Engineers per capita + beta2 R&D investment + beta3 Human Capital Quality + epsilon

In this model:

- **TFP (Total Factor Productivity) growth.**
- **Engineers per capita** measures the availability of technical professionals capable of generating innovation.
- **R&D investment** captures the national commitment to knowledge production.
- **Human Capital Quality** is educational quality and training effectiveness.

Empirical research suggests that the coefficients associated with engineering density and R&D investment are both positive and statistically significant in explaining long-term productivity growth (Romer, 1990; Hausmann et al., 2014).

Countries that combine high engineering density with strong research investment typically prove stronger technological capabilities. When these indicators are examined across Brazil, South Korea, China, and the United States, striking differences appear.

2.3. Engineering formation systems

The formation of engineers is one of the most critical elements in the development of technological capabilities. Engineers play central roles in industrial design, infrastructure development, manufacturing processes, and technological innovation.

Countries that have achieved rapid industrialization have typically implemented educational systems specifically designed to produce large numbers of technically trained professionals (Table 1).

Brazil

Brazil produces approximately ninety thousand engineering graduates annually. While this number may appear substantial in absolute terms, it is relatively small given the size of the country's population and economy.

More importantly, Brazilian engineering programs suffer from extremely high dropout rates. Estimates suggest that between forty-five and fifty-five percent of students who begin engineering degrees do not complete them. Several factors contribute to this phenomenon. One major issue is the weakness of mathematical preparation among secondary school students. Engineering programs require strong foundations in calculus, physics, and advanced mathematics, yet many Brazilian high school graduates lack sufficient preparation in these areas.

Another factor is the economic incentive structure. Engineering degrees typically require five years of study and demanding coursework, while legal and administrative professions often offer more stable career prospects in the public sector. As a result, many talented students choose legal education rather than engineering. This dynamic contributes to a shortage of highly skilled engineers in the Brazilian economy despite the presence of large industrial sectors.

South Korea

South Korea presents a strikingly different model of technical education. Since the 1960s, the Korean government has pursued deliberate policies to expand engineering education and align university training with industrial needs.

Engineering programs in Korea are closely integrated with national industrial strategies. Universities collaborate with major corporations such as Samsung, Hyundai, and LG to develop specialized training programs in areas such as semiconductor engineering, robotics, and advanced materials. Approximately twenty-five percent of Korean university graduates come from engineering fields, creating a dense technical workforce capable of supporting advanced manufacturing industries.

China

China has implemented one of the largest technical education expansions in history. The country now produces more engineers annually than any other nation.

Chinese universities emphasize engineering, computer science, and applied sciences as strategic priorities for national development. Engineering graduates play central roles in infrastructure construction, manufacturing, telecommunications, and emerging technologies such as artificial intelligence. In addition to expanding university programs, China has invested heavily in vocational technical education, creating multiple pathways for students to enter engineering-related professions.

United States

The United States runs a more decentralized system but keeps strong engineering education through research universities and technological institutes. Institutions such as MIT, Stanford, and Caltech have played critical roles in generating technological innovation and training highly skilled engineers. The U.S. system is also characterized by strong connections between universities and private industry, particularly in high-technology sectors such as semiconductors, biotechnology, and software.

Another distinctive feature of the American system is the role of immigration. A significant portion of the engineering workforce consists of international students who stay in the country after completing advanced degrees.

2.4. STEM education pipelines

The formation of engineers depends not only on university education but also on the broader pipeline of STEM preparation beginning in primary and secondary education. Countries that produce large numbers of engineers typically invest heavily in mathematics and science education at early stages.

South Korea

South Korea's education system emphasizes rigorous training in mathematics and science from early schooling. Korean students consistently perform among the highest in international assessments such as the Programme for International Student Assessment (PISA). This strong mathematical foundation allows students to enter demanding engineering programs with adequate preparation.

China

China also prioritizes STEM education within its national curriculum. The country's education system places strong emphasis on mathematics, physics, and engineering fundamentals. Elite universities such as Tsinghua University and Shanghai Jiao Tong University have become major centers for engineering education and technological research.

United States

In the United States, STEM education is supported through a combination of federal research funding, university research programs, and private sector innovation initiatives. Programs such as the National Science Foundation provide funding for scientific research and engineering education.

Brazil

Brazil's STEM pipeline faces several structural challenges. International assessments consistently show that Brazilian students perform below the OECD average in mathematics and science. These deficiencies in early education create difficulties for students entering engineering programs, contributing to high dropout rates. The weakness of STEM preparation therefore is a significant bottleneck in Brazil's technical education system.

2.5. Industrial policy and technological development

Engineering education alone does not guarantee technological development. Successful industrial transformation also requires coordinated industrial policies that align education, research, and industrial investment.

South Korea: developmental state model

South Korea's industrial success is often attributed to its developmental state model. Beginning in the 1960s, the Korean government implemented policies designed to promote industrialization and technological upgrading. Key elements of this strategy included:

- Targeted support for strategic industries.
- Close coordination between government and major corporations.
- Large investments in technical education.
- Export-oriented industrial policies.

This strategy enabled Korea to develop globally competitive industries in electronics, shipbuilding, and automotive manufacturing.

China: state-driven technological upgrading

China has adopted a similar but even more expansive approach. The Chinese government has implemented large-scale industrial policies designed to accelerate technological upgrading. Initiatives such as the **Made in China 2025** strategy aim to develop domestic capabilities in advanced manufacturing, robotics, artificial intelligence, and semiconductor technologies. These policies are supported by massive investments in research infrastructure and engineering education.

United States: innovation ecosystem model

The United States relies less on centralized industrial planning but keeps a powerful innovation ecosystem driven by universities, venture capital, and entrepreneurial culture. Silicon Valley is the most prominent example of this model. Universities such as Stanford and Berkeley serve as centers of research and innovation, while venture capital provides financing for technological startups. Federal research funding also plays an important role in supporting scientific research.

Brazil: fragmented industrial policy

Brazil has historically implemented various industrial policies, particularly during the import substitution industrialization period between the 1950s and 1980s. However, many of these policies were disrupted by economic crises and political instability. In recent decades, Brazil's industrial policy has lacked long-term strategic coherence. Investment in technological development has still been relatively modest, and coordination between universities, research institutions, and industry has been limited.

2.6. Innovation ecosystems

Innovation ecosystems consist of networks of institutions, firms, and research organizations that support technological development. Countries with strong innovation ecosystems typically show close collaboration between universities, industry, and government.

South Korea

South Korea has developed innovation clusters centered around major technology firms. Government research institutes collaborate with universities and corporations to develop new technologies.

China

China's innovation ecosystem has expanded rapidly in recent years. Technology hubs such as Shenzhen and Beijing host large numbers of technology startups and research institutions.

United States

The U.S. innovation ecosystem is still the most dynamic in the world. Venture capital markets, research universities, and technology firms interact within a highly entrepreneurial environment.

Brazil

Brazil has several promising innovation clusters, particularly around universities such as UNICAMP and UFMG. However, the scale and intensity of innovation activity remain significantly lower than in the countries examined above.

2.7. Comparative summary

The comparative analysis presented in this section highlights several structural differences between Brazil and the economies that successfully achieved technological upgrading. First, Brazil produces far fewer engineers relative to its population compared with South Korea, China, and the United States (Table 1). Second, Brazil invests significantly less in research and development (Table 2). Third, the country's innovation ecosystem is still fragmented and less integrated with industrial policy. These factors collectively limit Brazil's ability to generate technological innovation and increase productivity.

3. INSTITUTION, LEGAL SYSTEMS, AND INNOVATION ECOSYSTEMS

3.1. Economic development is also shaped by the institutional environment

Economic development is shaped not only by the availability of human capital and technological knowledge but also by the institutional environment within which economic actors run. Institutions decide the incentives that guide entrepreneurial behavior, investment decisions, and technological innovation. Consequently, institutional structures play a decisive role in explaining why some countries succeed in achieving sustained economic growth while others stay trapped at intermediate levels of development.

In the context of the middle-income trap, institutional quality is particularly important because the transition from factor-driven growth to innovation-driven growth requires environments that support experimentation, technological risk-taking, and entrepreneurial investment. Such environments typically involve legal systems capable of protecting property rights, regulatory frameworks that ease business formation and technological development, and financial systems that provide capital to innovative firms.

However, legal institutions can also produce unintended economic consequences when regulatory frameworks become excessively complex or when litigation becomes a dominant mechanism for resolving economic disputes. In such environments, economic actors may devote significant resources to legal compliance and dispute resolution rather than productive investment and innovation.

This section examines how institutional structures influence innovation ecosystems by comparing Brazil with economies that have achieved technological leadership, particularly the United States and major Asian innovation systems. The analysis focuses on four key dimensions: legal system structure, regulatory friction, venture capital ecosystems, and patent production.

The central argument advanced in this section is that Brazil's institutional configuration, characterized by high levels of regulatory complexity and litigation, contributes to an environment in which entrepreneurial innovation faces significant barriers. While legal institutions are essential for ensuring stability and protecting property rights, excessive legal complexity can increase transaction costs and discourage technological experimentation. Understanding these institutional dynamics is therefore essential for explaining Brazil's persistent productivity stagnation.

3.2. Institutional economics and technological development

Institutional economics provides a theoretical framework for understanding the relationship between governance structures and economic performance. According to North (1990), institutions are the formal and informal rules that shape economic behavior. These rules influence transaction costs, incentives for investment, and the allocation of resources within an economy. In innovation-driven economies, institutional frameworks typically support several key functions:

1. Protection of intellectual property rights.
2. Efficient dispute resolution mechanisms.
3. Regulatory frameworks that enable experimentation.
4. Financial systems that distribute capital to innovative ventures.

When institutions do not perform these functions effectively, innovation activity may decline. For example, excessive regulatory barriers may discourage entrepreneurs from launching new ventures, while weak intellectual property protection may reduce incentives for research and development.

However, institutional efficiency does not necessarily depend on the quantity of legal rules but rather on their clarity and predictability. Countries with large volumes of legislation and complex bureaucratic procedures may experience higher transaction costs even if the formal legal framework is intended to promote economic stability. In this sense, institutional complexity can create what economists describe as **regulatory friction -** the accumulation of legal and administrative procedures that slow economic activity. Brazil provides an instructive case study of this phenomenon.

3.3. Legal system structures: Brazil versus innovation economies

The Brazilian legal system is among the most complex in the world. The country runs under a civil law tradition derived from Portuguese and European legal frameworks, but over time the accumulation of statutes, regulations, and administrative procedures has produced a highly intricate regulatory environment.

Brazilian businesses must follow an extensive array of legal requirements related to taxation, labor regulation, environmental licensing, and administrative procedures. While many of these regulations serve legitimate policy aims, their cumulative complexity can create substantial administrative burdens for firms.

Estimates suggest that Brazilian companies devote thousands of hours annually to tax compliance alone. According to data from the World Bank's Doing Business reports, Brazilian firms historically spent far more time on tax compliance than firms in most developed economies.

In contrast, innovation-driven economies such as the United States tend to rely on more streamlined regulatory frameworks that emphasize flexibility and entrepreneurial experimentation. Although the United States also has complex regulatory institutions, its legal environment generally allows faster business formation and technological commercialization.

A key difference lies in the structure of dispute resolution systems. The U.S. legal system places strong emphasis on contractual enforcement and intellectual property protection but allows significant flexibility for new business models to appear before comprehensive regulation is developed. In Brazil, by contrast, regulatory frameworks often try to predict and regulate economic activity in advance, leading to extensive procedural requirements. This difference has important implications for technological innovation.

3.4. Regulatory friction and economic dynamism

Regulatory friction refers to the cumulative effect of legal and administrative procedures that increase the cost and complexity of economic activity. While some degree of regulation is necessary to ensure safety, environmental protection, and market stability, excessive regulatory complexity can discourage entrepreneurial initiative.

Innovation-driven economies typically try to balance regulation with flexibility. For example, technological sectors such as software, biotechnology, and digital platforms often evolve rapidly, requiring regulatory frameworks that adapt to new developments. In environments characterized by regulatory friction, entrepreneurs may face significant delays in obtaining licenses, approvals, or permits needed to implement new technologies. These delays can increase costs and reduce the attractiveness of innovation investment.

Brazil's regulatory system illustrates these challenges. Infrastructure projects, for instance, often require lengthy environmental licensing processes involving multiple government agencies and legal reviews. While environmental protection is essential, the duration and complexity of these procedures can delay projects for many years. Similarly, startups looking to introduce new products or services may meet regulatory uncertainty about taxation, labor classification, or sector-specific rules. The cumulative effect of these institutional constraints can reduce the rate of entrepreneurial experimentation.

Innovation ecosystems require environments in which new ideas can be tested quickly, and unsuccessful experiments can be replaced by new initiatives. Excessive legal complexity can slow this process and reduce the overall dynamism of the economy.

3.5. Venture capital ecosystems

One of the defining characteristics of innovation-driven economies is the presence of robust venture capital ecosystems. Venture capital provides financing for startups and emerging technology companies that often lack access to traditional bank credit. These investments are inherently risky, as many startups fail. However, successful ventures can generate significant economic value and technological breakthroughs.

The United States has developed the most advanced venture capital ecosystem in the world. Silicon Valley is the most prominent example, where venture capital firms, technology entrepreneurs, research universities, and large corporations interact within a highly dynamic innovation environment. Several institutional features support this ecosystem. First, strong intellectual property protection encourages entrepreneurs to develop new technologies by ensuring that they can capture the economic value of their innovations. Second, financial markets provide mechanisms for venture capital investors to exit their investments through public offerings or acquisitions. Third, regulatory frameworks allow relatively rapid formation of new businesses.

China has also developed a rapidly expanding venture capital sector, particularly in technology hubs such as Shenzhen and Beijing. Chinese venture capital investments have grown dramatically over the past decade, supporting the expansion of technology companies in sectors such as artificial intelligence, e-commerce, and telecommunications.

Brazil has begun to develop a venture capital ecosystem in recent years, particularly in cities such as São Paulo. Brazilian startups have achieved notable successes in fintech and digital services. However, the scale of venture capital investment in Brazil is still significantly smaller than in the United States or China. Institutional factors such as regulatory complexity, taxation rules, and limited exit opportunities continue to constrain the growth of the Brazilian venture capital market. Expanding venture capital ecosystems is essential for strengthening innovation capacity.

3.6. Patent production and technological leadership

Patent production provides an important indicator of technological innovation. Countries with strong research systems and industrial innovation typically generate large numbers of patent applications, reflecting the development of new technologies.

The United States has historically been a global leader in patent production, supported by a strong intellectual property system and extensive research infrastructure. Major American technology firms such as IBM, Intel, and Microsoft consistently rank among the top global patent holders.

China has rapidly increased its patent production in recent years as a result of massive investments in research and development. Chinese universities and research institutes now generate large numbers of patent applications across multiple technological sectors.

South Korea also shows high patent intensity relative to its population size, reflecting its advanced technological industries.

Brazil, by contrast, produces relatively few patents compared with these economies. Although the country has strong research universities and scientific institutions, the translation of research into commercial innovation stays limited. Several factors contribute to this gap. One important factor is the relatively low level of R&D investment discussed in earlier sections of this article. Another factor is the limited integration between universities and industrial firms.

Patent systems also play an important role. Efficient patent examination processes encourage innovation by allowing inventors to secure intellectual property protection quickly. Delays in patent examinations can discourage researchers from pursuing commercialization of new technologies. Improving patent systems and strengthening connections between research institutions and industry can therefore play an important role in enhancing innovation capacity.

3.7. Innovation ecosystems and university-industry collaboration

Innovation ecosystems depend heavily on collaboration between universities, industry, and government institutions. Universities play a crucial role in generating new knowledge, while private firms translate research into commercial products.

In the United States, the Bayh-Dole Act of 1980 significantly strengthened university technology transfer by allowing universities to keep intellectual property rights for federally funded research. This policy contributed to the growth of university-based startups and strengthened collaboration between academia and industry.

South Korea and China have also invested heavily in university-industry collaboration through government-supported research institutes and industrial clusters.

Brazil has several successful examples of such collaboration. The University of Campinas (UNICAMP), for instance, has developed strong partnerships with technology companies and keeps one of the most active technology transfer offices in Latin America. Nevertheless, these examples are still relatively limited in scale compared with innovation ecosystems in the United States and Asia. Expanding university-industry collaboration is an important opportunity for strengthening Brazil's innovation capacity.

3.8. Institutional reforms and technological development

The institutional challenges discussed in this section suggest that technological development requires not only investment in education and research but also reforms aimed at reducing regulatory barriers and strengthening innovation ecosystems. Institutional reforms may include:

- Simplifying regulatory procedures for new businesses.
- Strengthening intellectual property systems.
- Expanding venture capital markets.
- Encouraging collaboration between universities and industry.

Such reforms could significantly enhance Brazil's capacity for technological innovation.

4. DISCUSSION

4.1. Understanding Brazil's persistent middle-income stagnation

The comparative and institutional analyses presented in the article provide a framework for understanding Brazil's persistent middle-income stagnation. While Brazil has substantial natural resources, a large domestic market, and an established industrial base, the country has struggled to sustain long-term productivity growth. This stagnation contrasts sharply with the development trajectories of several economies that successfully transitioned from middle-income to high-income status.

The evidence examined in this article suggests that Brazil's difficulties are not solely the result of macroeconomic instability or insufficient investment but also reflect deeper structural issues related to human capital allocation, institutional complexity, and innovation ecosystem development. In particular, the disproportionate concentration of highly educated professionals in legal and administrative fields compared to engineering and technological disciplines may contribute to an institutional environment characterized by regulatory complexity and limited technological dynamism.

This final section synthesizes the key findings of the study, explores their implications for economic policy, discusses limitations of the research, and outlines potential directions for future investigation.

4.2. Synthesis of findings

The analysis conducted throughout this article highlights several structural differences between Brazil and economies that have successfully achieved technological upgrading:

1. Brazil shows a significantly lower density of engineers relative to its population compared with countries such as South Korea, China, and the United States. Engineering density is a critical factor in technological development because engineers play central roles in industrial production, technological design, and innovation processes. Countries that have successfully escaped the middle-income trap have typically invested heavily in technical education and scientific research. South Korea and China give particularly striking examples. Both countries implemented long-term strategies to expand engineering education, strengthen STEM preparation, and align university training with industrial development goals.
2. Brazil invests significantly less in research and development than leading innovation economies. Research investment plays a central role in generating new technologies and enhancing productivity. Countries with high levels of R&D expenditure typically show stronger patent production, more dynamic startup ecosystems, and greater technological competitiveness.
3. Brazil's institutional environment is characterized by relatively high levels of regulatory complexity. While strong legal institutions are essential for protecting property rights and ensuring contractual stability, excessive legal complexity can increase transaction costs and discourage entrepreneurial experimentation.

The interaction of these three factors - human capital allocation, research investment, and institutional structure - appears to play a significant role in shaping Brazil's economic trajectory. **When these factors are considered together, a pattern appears in which Brazil's professional and institutional structure may favor redistributive and administrative activities rather than technological innovation.**

4.3. Econometric interpretation of structural constraints

The econometric framework introduced earlier in this article provides a conceptual tool for interpreting the relationship between human capital composition and economic growth. Empirical studies in the field of endogenous growth theory have consistently shown that technological innovation is a key determinant of long-term economic development. Innovation depends heavily on the presence of highly skilled technical professionals capable of generating new technologies and implementing complex production processes.

Engineering density serves as an important proxy for a country's technological capacity. Economies with high numbers of engineers relative to their populations tend to show stronger manufacturing sectors, higher productivity growth, and greater innovation output.

The econometric model presented earlier can be summarized as follows:

TFP_growth = alpha + beta1 Engineering Density + beta2 R&D Investment + beta3 Institutional Quality + epsilon

Where:

- **TFP-growth:** Total Factor Productivity growth is the part of an economy output growth that measures efficiency, technological advancement, and improved management acting as a residual measure of innovation that allows producing more output with the same or fewer inputs.

- **Alpha is the Intercept:** The "baseline" growth that is the expected TFP growth if all other variables were zero and so captures factors not explicitly included in the model.
- **Betha are Coefficients:** These are the impact indicators. They show how much TFP changes for every 1 unit increase in the corresponding variable
  - **Engineering Density** is engineers per million inhabitants.
  - **R&D** Investment is national research expenditure.
  - **Institutional Quality** captures regulatory efficiency and governance.
- **Epsilon is the Error Term:** The "random noise" that is everything else that affects the TFP but is not captured by the variables in the formula (e.g., global crises, weather, or pandemics).

In this framework, engineering density and R&D investment represent key drivers of technological innovation. Institutional quality influences the efficiency with which these resources are translated into productive economic activity.

Brazil's relatively low engineering density and modest research investment suggest that the country may face structural limitations in its capacity to generate technological innovation. At the same time, regulatory complexity may reduce the efficiency with which available human capital is deployed.

While this study does not perform a full econometric estimation, the comparative evidence presented in earlier sections is consistent with the predictions of endogenous growth models.

Countries that have achieved sustained productivity growth typically combine strong technical education systems with institutional frameworks that encourage innovation and entrepreneurship.

4.4. Policy implications for Brazil

The findings of this study have important implications for economic policy in Brazil. Escaping the middle-income trap will likely require structural reforms that address the interconnected challenges of human capital formation, research investment, and institutional efficiency.

4.4.1. Strengthening STEM education

One of the most important priorities is the expansion and improvement of STEM education. Strengthening mathematics and science education at the primary and secondary levels is essential for preparing students to succeed in engineering and technical programs. Brazilian students consistently perform below the OECD average in international assessments of mathematics and science ability. Improving these outcomes will require investments in teacher training, curriculum development, and educational infrastructure.

At the university level, policies aimed at increasing the number of engineering graduates could include scholarships, research funding, and stronger partnerships between universities and industry. Reducing dropout rates in engineering programs is also critical. This aim may require preparatory programs designed to strengthen students' mathematical foundations before they begin demanding engineering coursework.

4.4.2. Expanding research and development investment

Increasing national investment in research and development is another key policy priority. Brazil's current R&D expenditure stays significantly lower than that of leading innovation economies. Expanding public funding for scientific research could strengthen the country's technological capabilities and support the development of new industries. Private sector research investment should also be encouraged through tax incentives, innovation grants, and collaborative research programs.

4.4.3. Strengthening innovation ecosystems

Innovation ecosystems depend on interactions between universities, firms, and government institutions. Strengthening these connections could enhance Brazil's capacity to translate scientific research into commercial innovation. Technology transfer offices, startup incubators, and university-industry research partnerships can play important roles in this process.

Expanding venture capital markets would also help provide financing for innovative startups. Government policies that support venture capital investment, such as regulatory reforms and public-private investment funds, could contribute to the growth of Brazil's startup ecosystem.

4.4.4. Institutional and regulatory reform

Institutional reform may be necessary to reduce regulatory friction and improve the efficiency of economic governance. Simplifying business formation procedures, streamlining licensing processes, and improving coordination between regulatory agencies could reduce administrative barriers to innovation. Judicial reform may also play an important role. Accelerating dispute resolution and improving the predictability of legal decisions could increase investor confidence and reduce transaction costs. Such reforms would not require weakening legal protections but rather improve the efficiency and clarity of regulatory frameworks.

4.5. Limitations of the study

While this study provides insights into the relationship between human capital allocation and economic development, several limitations should be acknowledged:

1. The analysis relies primarily on comparative indicators rather than comprehensive econometric modeling. Although the comparative evidence suggests strong relationships between engineering density, innovation capacity, and economic growth, more rigorous statistical analysis would be necessary to set up causal relationships.
2. Cultural and historical factors influencing occupational choices were not examined in detail. The prominence of legal professions in Brazil may reflect historical traditions and social preferences that require deeper sociological analysis.
3. Innovation ecosystems are complex systems influenced by many variables, including macroeconomic stability, trade policy, financial systems, and political institutions. While this study focuses on human capital and institutional factors, other variables also contribute to economic development outcomes.

Future research could incorporate added variables and apply econometric techniques to analyze the relationships explored in this article more rigorously.

4.6. Future research agenda

The findings of this study suggest several promising directions for future research. One important area for further investigation involves the econometric relationship between professional composition and national productivity growth. Large international datasets could be used to examine whether countries with higher engineering density consistently show stronger innovation performance.

Another promising avenue involves detailed analysis of educational policy reforms in countries that successfully expanded technical education. Comparative case studies of South Korea, China, and other industrializing economies could provide valuable insights for policymakers.

Future research could also examine the role of regional innovation clusters in Brazil. Certain regions, such as Campinas and Belo Horizonte, have developed relatively strong technology ecosystems. Understanding the institutional factors that support these clusters could inform broader national policy.

Finally, further investigation into the relationship between legal system structure and entrepreneurial activity could offer valuable insights into how regulatory frameworks influence innovation.

5. CONCLUSION

Brazil's persistent middle-income stagnation is one of the most significant challenges in contemporary development economics. Despite having substantial economic potential, the country has struggled to achieve sustained productivity growth and technological upgrading.

This article argued that part of the explanation may lie in the structural allocation of human capital and the institutional environment within which economic activity occurs.

The disproportionate concentration of highly educated professionals in legal and administrative fields compared to engineering and technological disciplines may contribute to an institutional structure that emphasizes regulation and dispute resolution rather than innovation. Comparative evidence from South Korea, China, and the United States proves that countries that successfully escaped the middle-income trap typically invested heavily in technical education, research infrastructure, and innovation ecosystems.

Brazil has the intellectual and institutional resources necessary to pursue a similar path. However, achieving such a transition will likely require coordinated reforms across multiple domains, including education policy, research investment, regulatory frameworks, and innovation ecosystems.

If Brazil can strengthen its technical human capital and create institutional environments that support entrepreneurial experimentation, the country may yet realize its long-recognized economic potential.

6. AI USE DECLATION

The authors declare that artificial intelligence (AI) tools were used in the preparation of this manuscript to support language refinement, structural organization, and editing of the text. Specifically, generative AI was employed to aid in improving clarity, coherence, and academic writing style.

All substantive intellectual contributions - including research design, theoretical framing, data selection, analysis, interpretation of results, and conclusions - are the sole responsibility of the authors. The authors critically reviewed, confirmed, and edited all

AI-assisted outputs to ensure accuracy, originality, and alignment with academic standards.

No AI tool was used to generate empirical data, fabricate results, or replace scholarly judgment. All references were selected, verified, and formatted by the authors following APA 7 guidelines.

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