

PAPER

Engineering Education, Innovation, and Economic Growth: A Case Study

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ABSTRACT

The role of engineering education is pivotal in driving regional economic expansion, especially in the context of wider development strategies. The research investigates the connection between engineering-oriented tertiary education and technological advancements, utilizing panel data from Shanghai (2014–2023). Shanghai, as China's economic center, serves as the focal point of this study. The study investigates the role of regional innovation in bridging the gap between education and economic expansion, serving as a crucial link. The study underscores the intricate interplay among education, innovation, and economic growth, underscoring the significance of strategic investments and partnerships between industry and universities. Research indicates that merging educational elements with innovative approaches promotes industrial advancement and enduring economic development, potentially extending its impact beyond Shanghai to influence worldwide regional economies.

KEYWORDS

China-Africa relationship, high-quality engineering education, technological innovation, economic development, industry-academia collaboration

1 INTRODUCTION

Shanghai's advanced tech industrialization, innovation-centric policies, and strong academia-industry ties make it a key model for studying engineering education's impact on economic growth. The shift in economic growth from relying on resources to fostering innovation is significantly influencing Chinese industrial enhancement and economic evolution [1]. Within these elements, the significance of engineering education in nurturing an innovative environment that connects academic and industrial realms has grown [2]. Enhancing local market demand and merging technological progress with sector-specific requirements bolsters the economic competitiveness of the region [3]. Endogenous growth theory posits that companies reallocating their earnings towards technological R&D and knowledge creation hasten the evolution of production techniques, thereby boosting sustained

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economic viability [4]. The rise of top-tier engineering education has produced a skilled workforce capable of driving technological and industrial advancements, increasing productivity [5]. Investment in higher education not only boosts social capital but also optimizes resource allocation, fostering innovation and sustained economic growth [6]. Shanghai exemplifies how advanced engineering education, combined with local innovation, contributes to economic growth. Studies like those by Xu et al. [7] highlight how such education supports technological and industrial enhancement, with the regional innovation index indicating the potential for further economic growth. Despite challenges in African economies, the Shanghai model offers insights into using engineering education to enhance economic diversity and drive modernization [8]. This study explores the relationship between elite engineering education, innovation, and economic growth in Shanghai from 2014 to 2023, emphasizing engineering education's role in transforming industries and advancing technology. The study advocates aligning educational strategies with economic objectives to foster innovation, enhance industrial competitiveness, and ensure long-term economic growth in both China and Africa.

2 MATERIALS AND METHODS

2.1 Examination of literature and hypotheses

Engineering education's link to economic expansion is intricate and non-linear, hinging on elements such as knowledge dissemination, the spread of technology, and the reshaping of industries [9]. Allocating funds to superior engineering education bolsters human capital frameworks, thus hastening the pace of innovation-led industrial change and promoting enduring economic expansion [10]. Professionals in engineering, armed with technical know-how and research skills, play a role in advancing technology and boosting productivity, enhancing industrial frameworks, and fostering economic variety [11]. Such procedures also lead to the transfer of knowledge, enhancing the effectiveness of physical assets and the economic productivity of the region.

The study underscores the vital importance of superior engineering education in fostering regional economic development. Education in engineering serves a dual purpose: it not only nurtures expert technical staff directly but also propels industrial advancement via the dissemination of knowledge and the spread of technology [12]. The advanced engineering education framework in Shanghai fosters economic development via partnerships between universities and industries, along with technological innovation and business incubation. The results suggest that boosting funding in engineering education elevates human capital quality, boosts labor efficiency, cultivates industries fueled by innovation, and ultimately aids in economic expansion. Our proposed hypothesis is as follows: Hypothesis 1: The Positive Effect of Engineering Education on Economic Expansion.

Engineering education, through partnerships with industries and investment in R&D, significantly enhances regional innovation. Training elite engineers expands intellectual capacity and drives industrial and technological progress [13]. Innovations such as increased patent outputs and research advancements are linked to economic growth, with technological improvements enhancing production efficiency and reducing costs, thereby stimulating market demand [14]. Shanghai's model demonstrates how robust innovation systems attract investments and support the growth of advanced technology sectors, underscoring innovation's critical role

in economic development, especially in tech-dependent industries. Our suggested theory is as follows: Hypothesis 2: The Positive Effect of Innovation on Economic Expansion.

Technological advancements enhance workforce efficiency, reduce manufacturing costs, and create new market demands, fueling industrial competition and regional economic growth [15]. This study identifies trade openness—measured by the imports and exports to GDP ratio—as crucial for economic expansion. Open trade policies facilitate technology transfer, enhance local competitiveness, and promote knowledge sharing. In Shanghai, extensive globalization through trade liberalization significantly drives economic growth by intensifying industrial competition, attracting foreign investments, and catalyzing industrial transformation. Our suggested theory is as follows: Hypothesis 3: The Positive Effect of Trade Openness on Economic Expansion.

The study shows that R&D investments by governments and corporations, as a percentage of GDP, significantly stimulate economic growth. Shanghai's model shows a strong link between R&D funding and economic expansion. Such investments enhance corporate innovation, technology commercialization, and regional competitiveness through partnerships between engineering schools and research entities. This supports the theory that R&D investment drives both immediate technological progress and long-term industrial and economic development [16]. Our suggested theory is as follows: Hypothesis 4: The Link between Superior Engineering Education and Regional Economic Expansion Is Facilitated by Regional Innovation.

The Shanghai case demonstrates that the transition from traditional manufacturing to high-tech and knowledge-intensive industries, through investment in advanced fields such as IT, renewable energy, and AI, promotes sustained regional economic growth [17]. Our suggested theory is as follows: Hypothesis 5: The Industrial Framework Beneficially Affects Economic Expansion.

This study focuses on the economic impact of modernizing industrial frameworks in Shanghai, highlighting the transition towards high-tech industries through advances in engineering education and technology, which have evolved traditional manufacturing into more sophisticated methods. Emphasizing sectors such as IT, renewable energy, and AI is crucial for maintaining growth and underscores the necessity of updating industrial infrastructures to boost economic development. The research demonstrates that from 2014 to 2023, engineering education has significantly enhanced regional economic growth by improving workforce quality and fostering innovation. It also highlights the need for strategic investments in engineering education and strong partnerships between academia and industry to drive regional innovation and growth, providing valuable lessons for regions such as Africa [18].

2.2 Data collection and research methods

- **Model setup:** The study examines the relationship between advanced engineering education, local innovation, and economic growth in Shanghai from 2014 to 2023, using a mediation effect model. It assesses the direct and indirect effects of engineering education on economic expansion via technological progress. Key variables include 'Growth_it' for economic expansion, measured by Green Total Factor Productivity (GTFP); 'edu_it' for engineering education, sourced from university research grants and technology transfer income; and 'Digit,' representing digital transformation through GDP's digital share and IT funding. 'Inn_it' tracks regional innovation through patent counts and tech company metrics.

Control variables such as trade openness, government R&D, and industrial upgrades are included, with ‘ ϵ_{it} ’ capturing unexplained factors. The model is specified as follows model (1):

$$growth_{it} = \alpha_0 + \beta_1 edu_{it} + \beta_2 digit_{it} + \beta_3 innov_{it} + \gamma control_{it} + \epsilon_{it} \quad (1)$$

- The origins of data and the choice of variables: Table 1 categorizes variables impacting economic growth, measured by GTFP. It includes variables such as university research funding, regional patent grants, trade openness, R&D investment, and industrial sophistication, which are all pivotal in assessing the growth and sustainability of regional economies.

Table 1. Variable names and definition

Variable Type	Variable Name	Measurement Definition
Dependent Variable	grow	Measured by Green Total Factor Productivity (GTFP), representing the quality and sustainability of economic growth.
Independent Variable	gra	Measured by university research funding and technology transfer income, reflecting higher education’s capacity in regional development.
Independent Variable	cit	Measured by the number of patents granted to enterprises by region, indicating the innovation output and technological capabilities.
Independent Variable	open	Measured by the logarithm of the ratio of total imports and exports to GDP, representing the degree of integration into global trade.
Independent Variable	rd	The ratio of regional R&D expenditures to GDP, indicating the public support for innovation and technological advancement.
Independent Variable	isa	The ratio of value added in secondary and tertiary industries, reflecting the level of industrial sophistication and modernization.

- Statistical description: In our empirical study, we gathered panel data across 16 Shanghai districts from 2014 to 2023, amassing a total of 160 observations. Linear interpolation was utilized in specific years to guarantee the completeness of the dataset and preserve its statistical precision, owing to missing data. This dataset offers an extensive perspective on the interplay among superior engineering education, local innovation, and economic expansion, aligning with Shanghai’s strategic growth plans. Table 2 displays descriptive statistics for these crucial variables, summarizing their distribution, diversity, and key trends:

Table 2. Descriptive statistics of variables

Variable	Obs	Avg	Std	Min	Max	Med
grow	160	.832	1.145	-1.947	2.789	.97
gra	160	1.949	1.33	.058	6.385	1.638
cit	160	.546	.134	.257	.897	.568
open	160	1.19	1.375	-0.145	4.102	4.635
rd	160	1.332	1.345	.345	1.675	1.865
isa	160	.984	1.245	.643	2.345	1.285

- Analyzing the direct impact of Engineering education on economic growth: This study investigates the direct effects of superior engineering education on regional economic expansion, addressing issues such as heteroskedasticity and cross-sectional correlation in Shanghai's panel data from 2014 to 2023. Using Driscoll-Kraay standard errors and a Hausman test that confirmed the suitability of a fixed-effects model, the study illustrates how engineering education investment (EDU_it) significantly boosts economic growth by enhancing human capital, disseminating knowledge, and improving industrial efficiency. The focus is on the substantial impact of engineering education devoid of intermediary innovation elements, laying a foundation for further analysis into how education fosters technological advancements and partnerships crucial for economic strategies in regions such as Shanghai and potentially African nations [19].

2.3 Mediation effects of regional innovative development

According to model (1), Table 3 demonstrates the regression coefficients of the mediating effect.

Table 3. Results of mediation effect test

Variables	Grow	Cit	Digit	Grow_2	t_values	Cit_t	Digit_t	Grow_2_t
gra	.252	.098	.12	.151	-7.55	-7.02	-6.78	-7.69
digit	-	-	-	.09	-	-	-	-6.25
cit	-	1.036	-	1.036	-	-9.03	-	-8.03
open	.118	.086	.07	.035	-2.27	-2.89	-3.21	-1.43
Constant	3.5726	5.1124	4.3261	28.1317	-0.0181	-0.0545	-0.0427	-1.2124
City_effect	YES	YES	YES	YES	-	-	-	-
Year_effect	YES	YES	YES	YES	-	-	-	-
R2	.998	.965	.958	.978	-	-	-	-
N	160	160	160	160	-	-	-	-

According to Table 3, regional economic growth (GROW_it) is driven by significant variables including engineering education (EDU_it), innovation (INNOV_it), trade openness (OPEN_it), R&D investment (RD_it), and industrial upgrades (ISA_it), which collectively enhance economic growth directly. This analysis confirms the substantial role of advanced engineering education in boosting regional economies, supported by findings similar to those of Sterlacchini. Innovation and technology development through targeted educational and economic strategies are vital for fostering sustainable growth in diverse regions, including Africa [20]. The study emphasizes the importance of aligning educational strategies with technological and economic objectives to maximize the benefits of engineering education. This alignment is crucial in regions such as Shanghai, where it has led to significant economic and industrial advancements. By integrating engineering education with market needs, regions can stimulate economic diversity, enhance competitiveness, and drive long-term growth [21].

3 RESULTS

Table 4. Results of direct effect test

Variables	Grow_1	Grow_2	Grow_3	t_values_1	t_values_2	t_values_3
Gra	.258	.305	.336	-8.02	-11.89	-12.45
Open	.521	.044	-	-4.45	-	-
Rd	.623	.547	-	-3.54	-	-
Isa	.546	.386	-	-2.59	-	-
Constant	-	-	-	-	-	-
City_effect	YES	YES	YES	-	-	-
Year_effect	YES	YES	YES	-	-	-
R2	.991	.992	.985	-	-	-
N	160	160	160	-	-	-

Table 4 shows that engineering education development (EDU_it) significantly boosts regional economic growth, with a strong positive correlation highlighting its crucial role in regional development. This substantial impact underscores the importance of high-quality engineering education for sustainable economic development, supported by empirical evidence [22]. Furthermore, regional growth is positively influenced by innovation (INNOV_it) through new practices and outputs, trade openness (OPEN_it) indicating the region's trade engagement, direct contributions from R&D investment (RD_it), and industrial modernization efforts (ISA_it).

Engineering education enhances regional economic growth by improving human capital and fostering technological innovation, thus boosting industrial efficiency and productivity. By developing skilled professionals and facilitating knowledge transfer, engineering education accelerates industrial modernization and increases graduates' earning potential, which in turn stimulates domestic demand and long-term economic growth. External economic factors such as trade openness and government R&D investment also show significant positive effects, demonstrating their importance in regional growth. This model is evident in Shanghai and offers valuable insights for integrating modern educational strategies with socio-economic structures in regions such as Africa to drive substantial economic transformations [23].

4 DISCUSSION

Regional innovation, powered by engineering education, is crucial for economic expansion and sectoral technological progress. Higher education institutions, crucial in skill provision and research application, enhance regional innovation capacity, thus driving tangible industrial development. Collaborations among universities, industry, and government spur innovation and competitiveness, aligning engineering education with market demands [24]. The Shanghai model exemplifies this by integrating engineering education with innovation strategies to bolster economic growth, crucial also for African regions adapting education to local needs for sustainable development [25]. Partnerships between Chinese and African institutions aid technology transfer and economic enhancement. Policymakers should develop educational institutions that align with industry needs, fostering innovation and

enhancing research capabilities to support sustainable economic growth. Integrating traditional cultural values with modern educational systems ensures holistic development. Policy support is essential for creating industry-aligned curricula, fostering university-industry collaborations, and increasing research funding to drive innovation and economic diversity [26].

5 CONCLUSION

Modernizing industry is crucial for economic modernization, leveraging advanced technologies to enhance efficiency and sustainability. The Belt and Road Initiative boosts Sino-African economic ties, fostering technological exchanges that improve competitiveness and deepen interconnections, enhancing mutual economic benefits [27]. Investments in high-tech industries are vital, supporting sectors rich in knowledge such as digital technology and innovation clusters, essential for balanced economic growth [28]. These strategies enhance Shanghai's role as a development leader and can similarly benefit African nations through tailored educational and technological strategies [29]. To address disparities, especially in regions such as Shanghai, education and innovation policies must promote inclusive development [30]. These policies should align educational reforms with industry needs to support sustained economic growth and diversification [31]. For African nations, adapting these strategies encourages continuous economic and industrial advancement, leveraging educational and technological collaborations for broader economic impacts [32].

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7 REFERENCES

- [1] J. Y. Lin, "New structural economics: A framework for rethinking development," *The World Bank Research Observer*, vol. 26, no. 2, pp. 193–221, 2011. <https://doi.org/10.1093/wbro/lkr007>
- [2] X. Wang, S. Liu, O. Sykes, and C. Wang, "Characteristic development model: A transformation for the sustainable development of small towns in China," *Sustainability*, vol. 11, no. 13, p. 3753, 2019. <https://doi.org/10.3390/su11133753>
- [3] B. Xi and P. Zhai, "Economic growth, industrial structure upgrading and environmental pollution: Evidence from China," *Kybernetes*, vol. 52, no. 2, pp. 518–553, 2023. <https://doi.org/10.1108/K-02-2022-0279>
- [4] E. Helpman, "Endogenous macroeconomic growth theory," *European Economic Review*, vol. 36, nos. 2–3, pp. 237–267, 1992. [https://doi.org/10.1016/0014-2921\(92\)90083-9](https://doi.org/10.1016/0014-2921(92)90083-9)
- [5] G. Oded, "Inequality, human capital formation, and the process of development," *In Handbook of the Economics of Education*, vol. 4, pp. 441–493, 2011. <https://doi.org/10.1016/B978-0-444-53444-6.00005-5>

- [6] J. Zhou, A. Raza, and H. Sui, "Infrastructure investment and economic growth quality: Empirical analysis of China's regional development," *Applied Economics*, vol. 53, no. 23, pp. 2615–2630, 2021. <https://doi.org/10.1080/00036846.2020.1863325>
- [7] H. Xu, W. L. Hsu, T. H. Meen, and J. H. Zhu, "Can higher education, economic growth and innovation ability improve each other?" *Sustainability*, vol. 12, no. 6, p. 2515, 2020. <https://doi.org/10.3390/su12062515>
- [8] M. Ditsela *et al.*, "African feminism and the recognition of cohabitation under customary law," *Africa Development/Afrique et Développement*, vol. 49, no. 1, 2024. <https://doi.org/10.57054/ad.v49i1.5616>
- [9] T. T. Zhu, H. R. Peng, and Y. J. Zhang, "The influence of higher education development on economic growth: Evidence from central China," *Higher Education Policy*, vol. 31, pp. 139–157, 2018. <https://doi.org/10.1057/s41307-017-0047-7>
- [10] A. A. Teixeira and A. S. Queirós, "Economic growth, human capital and structural change: A dynamic panel data analysis," *Research Policy*, vol. 45, no. 8, pp. 1636–1648, 2016. <https://doi.org/10.1016/j.respol.2016.04.006>
- [11] S. Horwitz and P. J. Boettke, "The limits of economic expertise: Prophets, engineers, and the state in the history of development economics," *History of Political Economy*, vol. 37, no. Suppl_1, pp. 10–39, 2005. https://doi.org/10.1215/00182702-37-Suppl_1-10
- [12] J. Drucker, "Reconsidering the regional economic development impacts of higher education institutions in the United States," *Regional Studies*, vol. 50, no. 7, pp. 1185–1202, 2015. <https://doi.org/10.1080/00343404.2014.986083>
- [13] M. Abdulwahed, "Technology Innovation and Engineering' Education and Entrepreneurship (TIEE) in engineering schools: Novel model for elevating national knowledge based economy and socio-economic sustainable development," *Sustainability*, vol. 9, no. 2, p. 171, 2017. <https://doi.org/10.3390/su9020171>
- [14] X. Zhou, M. Song, and L. Cui, "Driving force for China's economic development under Industry 4.0 and circular economy: Technological innovation or structural change?" *Journal of Cleaner Production*, vol. 271, p. 122680, 2020. <https://doi.org/10.1016/j.jclepro.2020.122680>
- [15] N. Cantore, M. Cali, and D. W. te Velde, "Does energy efficiency improve technological change and economic growth in developing countries?" *Energy Policy*, vol. 92, pp. 279–285, 2016. <https://doi.org/10.1016/j.enpol.2016.01.040>
- [16] E. B. Bayarcelik and F. Taşel, "Research and development: Source of economic growth," *Procedia-Social and Behavioral Sciences*, vol. 58, pp. 744–753, 2012. <https://doi.org/10.1016/j.sbspro.2012.09.1052>
- [17] H. You, "Quantifying megacity growth in response to economic transition: A case of Shanghai, China," *Habitat International*, vol. 53, pp. 115–122, 2016. <https://doi.org/10.1016/j.habitatint.2015.11.001>
- [18] B. Jianfeng *et al.*, "The progress of CDIO engineering education reform in several China universities: A review," *Procedia-Social and Behavioral Sciences*, vol. 93, pp. 381–385, 2013. <https://doi.org/10.1016/j.sbspro.2013.09.207>
- [19] N. Agarwal, W. Chen, W. Li, and C. Mohan, "Research on the impact of colleges' English education on regional economic development: A case study of Shanghai and Jiangsu province," *International Journal of Financial Engineering*, vol. 11, no. 4, p. 2442006, 2024. <https://doi.org/10.1142/S2424786324420064>
- [20] J. Drucker, "Reconsidering the regional economic development impacts of higher education institutions in the United States," *Regional Studies*, vol. 50, no. 7, pp. 1185–1202, 2015. <https://doi.org/10.1080/00343404.2014.986083>

- [21] L. MacDonald *et al.*, “Aligning learning objectives and approaches in global engineering graduate programs: Review and recommendations by an interdisciplinary working group,” *Development Engineering*, vol. 7, p. 100095, 2022. <https://doi.org/10.1016/j.deveng.2022.100095>
- [22] V. Tandrayen-Ragoobur, B. Seetanah, S. Fauzel, and V. Teeroovengadum, “Digital learning response in the midst of the Covid-19 pandemic,” *Africa Development/Afrique et Développement*, vol. 48, no. 2, pp. 129–158, 2023. <https://doi.org/10.57054/ad.v48i2.5083>
- [23] K. O. Lamidi, “Potentialising a traditional peacebuilding system towards resolving land disputes in African communities,” *Africa Development/Afrique et Développement*, vol. 49, no. 1, pp. 167–192, 2024. <https://doi.org/10.57054/ad.v49i1.5620>
- [24] M. Capriati, “Capabilities, innovation and economic growth in EU regions,” *Journal of Human Development and Capabilities*, vol. 23, no. 3, pp. 373–399, 2021. <https://doi.org/10.1080/19452829.2021.2008886>
- [25] A. Sterlacchini, “R&D, higher education and regional growth: Uneven linkages among European regions,” *Research Policy*, vol. 37, nos. 6–7, pp. 1096–1107, 2008. <https://doi.org/10.1016/j.respol.2008.04.009>
- [26] A. K. Saidou, “Guerre et formation de l’État au Sahel,” *Afrique et Développement*, vol. 48, no. 4, pp. 1–28, 2023. <https://doi.org/10.57054/ad.v48i4.5572>
- [27] G. Zhou and S. Luo, “Higher education input, technological innovation, and economic growth in China,” *Sustainability*, vol. 10, no. 8, p. 2615, 2018. <https://doi.org/10.3390/su10082615>
- [28] F. Fan, H. Lian, and S. Wang, “Can regional collaborative innovation improve innovation efficiency? An empirical study of Chinese cities,” *Growth and Change*, vol. 51, no. 1, pp. 440–463, 2020. <https://doi.org/10.1111/grow.12346>
- [29] E. B. Gebremariam, “Thandika Mkandawire’s model for an african developmental state, and the ethiopian experiment (2001–2018),” *Africa Development/Afrique et Développement*, vol. 49, no. 2, pp. 13–46, 2024. <https://doi.org/10.57054/ad.v49i2.5712>
- [30] S. He and H. Yao, “Business environment, human capital structural upgrading, and economic development quality,” *Frontiers in Environmental Science*, vol. 10, p. 964922, 2022. <https://doi.org/10.3389/fenvs.2022.964922>
- [31] T. Papaioannou, “How inclusive can innovation and development be in the twenty-first century?” *Innovation and Development*, vol. 4, no. 2, pp. 187–202, 2014. <https://doi.org/10.1080/2157930X.2014.921355>
- [32] G. Mohamedbhai, “Engineering education in sub-Saharan Africa: Quest for quality,” *International Journal of African Higher Education*, vol. 2, no. 1, 2015. <https://doi.org/10.6017/ijahe.v2i1.9259>

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