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Quantifying the Long-Term Developmental Impact of Access to Education 1 2 Abstract 3 Education is widely recognized as a fundamental driver of long-term socioeconomic 4 development, yet empirical evidence linking historical access to education with present-day 5 development outcomes at a localized level remains limited, particularly in rural India. This 6 study examines the long-term developmental impact of access to education by analyzing 7 village-level data from Karnataka using the Socioeconomic High-Resolution Rural–Urban 8 Geographic (SHRUG) dataset. Historical indicators of educational access and infrastructure 9 from the 1991 Census of Indiasuch as the number of schools, school electrification, and 10 primary school enrolment are compared with contemporary development outcomes from the 11 2020 Mission Antyodaya survey, including electricity access and other human development– 12 linked indicators. The analysis employs descriptive statistics, difference-in-means tests, and 13 regression techniques to assess the relationship between early educational access and long14 term development outcomes. The findings indicate that while the mere presence of schools 15 and enrollment levels show limited long-term effects, the quality of educational 16 infrastructureparticularly access to electricity in primary schoolsexhibits a statistically 17 significant association with improved development outcomes decades later. These results 18 highlight the importance of prioritizing educational infrastructure quality in rural 19 development strategies and underscore the role of early educational investments in shaping 20 sustained and inclusive development. 21 22 Introduction 23 24 3 Education is one of the most powerful forces for human and societal progress, shaping 25 economic growth, health outcomes, and social mobility (Hanushek & Woessmann, 2008; 26 World Bank, 2018; UNESCO, 2020). It not only gives people the knowledge and skills they 27 need for jobs and innovation but also improves health, gender equality, and civic 28 engagement. Over time, countries that have invested in education have seen significant gains 29 in productivity, reduced poverty, and increased social stability. While there is a global 30 agreement that education is essential for development, the specific effects of past access to 31 education on long-term rural development are not well understood, especially in India. 32 33 This study, titled

—Quantifying the Long-Term Developmental Impact of Access to 34 Education,‖ looks at how access to education in the early 1990s still affects development 35 outcomes today. It uses 9 the Socioeconomic High-resolution Rural-Urban Geographic 36 (SHRUG) dataset to measure these effects by linking education indicators from 1991 with 37 development metrics from the Mission Antyodaya dataset in 2020. By focusing on villages in 38 Karnataka, this research provides a solid basis for understanding local development. The state 39 has a diverse rural landscape, a history of educational reform, and detailed data available. 40 41

By exploring how early investments in education lead to real developmental benefits many 42 years later, this research offers evidence of the lasting impact of educational infrastructure. 43 The findings enhance academic knowledge and provide useful insights for policymakers who 44 want to reduce rural inequality and encourage sustainable, inclusive growth. 45 46 Beyond its direct role in shaping individual outcomes, education also generates broader 47 spillover effects that influence the long-term development trajectory of entire communities. 48 Early access to schooling can shape institutional capacity, encourage public investment in 49 complementary infrastructure, and create conditions that support sustained economic and 50 social progress over time. In rural settings, where initial levels of infrastructure and 51 opportunity are often low, these spillover effects are especially important, as even modest 52 improvements in educational access can have far-reaching consequences. Understanding 53 whether and how such early investments translate into durable development gains is therefore 54 essential for designing effective education and rural development policies. 55 56 Literature Review 57 58 Access to education has long been established as a fundamental driver of human 59 development, particularly in underdeveloped and rural areas. Numerous country-level 60 interventions demonstrate that improving educational access leads to lasting social and 61 economic benefits. A common pattern across these case studies is that early investments in 62 education—whether through infrastructure, incentives, or policy

reforms—create ripple 63 effects across generations, positively impacting literacy, income, health, and labor 64 participation. 65 Universal education policies have shown particularly strong results in developing economies. 66 In India, 10 the Sarva Shiksha Abhiyan (SSA) program launched in 2001 aimed to universalize 67 elementary education. A study by Asadullah & Chaudhury (2015) published in the 68 2 International Journal of Educational Development found that adults exposed to SSA had 69 improved educational attainment, literacy scores, and health outcomes. Similarly, Kenya's 70 post-independence education reforms from 1963 to 1983 significantly expanded enrollment 71 and literacy. According to Bunyi (1999) and data cited in IMF publications (elibrary 72 organisation), government action to abolish school fees and revise curricula laid the 73 foundation for long-term national development. 74 Targeted financial interventions such as scholarships and conditional cash transfers have 75 proven effective for increasing access and promoting intergenerational benefits. A 76 longitudinal study in Ghana by Duflo, Dupas, & Kremer (2017) at the Abdul Latif Jameel 77 Poverty Action Lab (J-PAL) showed that recipients of secondary school scholarships had 78 significantly better educational and employment outcomes, and the children of female 79 recipients exhibited improved cognitive and health outcomes (povertyactionlab organisation). 80 Bangladesh's stipend programs for girls, analyzed by Khandker, Pitt, & Fuwa (2003) and 81 later by Chowdhury et al. (2002) in UNNES Journal, demonstrated rising female literacy and 82 labor force participation, improving family economic stability. In the Philippines, the 83 11 Pantawid Pamilyang Pilipino Program (4Ps) was evaluated by Acosta & Velarde (2015) 84 through World Bank assessments, showing higher school enrollment and health compliance 85 due to conditional cash transfers (worldbank organisation). 86

Infrastructure-based interventions further strengthen educational outcomes. In Brazil, the 87 "Light for All in Schools" electrification program was studied by Chagas et al. (2020) and 88 documented by the Inter-American Development Bank (publications.iadb.org), finding 89 dropout reductions of up to 27% in newly electrified rural schools. Indonesia's Early 90

Childhood Education and Development (ECED) program, evaluated by Brinkman et al. (2011) and published by the World Bank, showed that children attending ECED centers performed better in primary school, highlighting the importance of early interventions (worldbank organisation). Similarly, Mexico's compensatory programs for marginalized communities, documented by de Janvry & Sadoulet (2006) and reviewed in World Bank evaluations, improved standardized test scores between 2009–2013, narrowing achievement gaps (worldbank organisation). In rapidly transforming or post-conflict economies, education has played a critical role in recovery and income mobility. In Vietnam, research by Nguyen & Tran (2021) published in the Journal of Risk and Financial Management found that additional years of schooling significantly increased household income, making education a strong lever for poverty reduction (mdpi). In Rwanda, post-genocide education investments—particularly in universal access and gender equity—were highlighted by Paul Kagame's education policy reviews and analyzed by Zubairi & Rose (2013) through UNESCO and ODI reports. These policies enhanced human capital formation, contributing to sustained economic growth and recovery. Together, these studies provide a compelling global narrative: education is a long-term investment with measurable benefits across health, employment, and income. These cases— spanning Asia, Africa, and Latin America—demonstrate the versatility of policy instruments and their adaptability to different socio-political contexts. However, there remains a critical gap in village-level, time-series data, especially in the Indian context. By using the SHRUG dataset to study rural villages in Karnataka from 1991 to 2020, this research seeks to provide micro-level empirical evidence that builds upon the global consensus, offering localized insights into the long-term developmental impact of educational access.To address these gaps in the existing literature, four main objectives were formulated for the present study.

Objectives of the Study Based on the overall research design, data, and literature, the primary objectives of this study are: 1. To quantify the long-term relationship between historical access to education (1991) and contemporary

development outcomes (2020) at the village level in 121 Karnataka. 122 2. To assess the influence of educational infrastructure quality—such as school 123 electrification and sanitation—on broader socioeconomic development indicators. 124 3. To evaluate disparities across regions and districts, identifying where education 125 has had the greatest long-term impact and where gaps persist. 126 4. To inform policy design by highlighting how educational investments can yield 127 multi-sectoral benefits, including in infrastructure, health, and community 128 development. 129 130 Methodology 131

The title “Quantifying the Long-Term Developmental Impact of Access to Education” was 132 chosen to explore how historical access to education influences present-day development 133 outcomes, with a particular focus on rural India. Education has long been recognized as a 134 cornerstone of human capital development, shaping health, employment, income, and social 135 mobility. While global studies affirm these links, 13 there remains a gap in localized, 136 quantifiable research that connects historical educational access to current socioeconomic 137 indicators, especially at the village level. This study addresses that gap by using real-world 138 datasets to empirically measure both the causal and correlational effects of educational access 139 on long-term development. It draws on the SHRUG dataset (Socioeconomic High-resolution 140 Rural-Urban Geographic data) from Devdatalab.org, a granular and longitudinal resource 141 linking administrative data from the 1991 Census to 2020 development indicators. SHRUG's 142 village-level detail and integration of economic and census data make it particularly suited 143 for this research. Historical access to education is proxied using 1991 variables such as the 144 number of schools, infrastructure quality, and total primary school students. These are 145 analyzed against 2020 development indicators from the Antyodaya dataset, including 146 measures like electricity access, infrastructure continuity in education, and other HDI-linked 147 outcomes like housing, health, sanitation, and income proxies. The focus on Karnataka’s 148 villages strengthens the study due to the state’s diverse rural landscape, a strong legacy of 149 educational reforms (e.g., Nali Kali

and mid-day meal programs), and comprehensive 150 SHRUG data availability. A rural focus is especially important because infrastructure 151 disparities are often wider in villages, making the impact of educational access more 152 pronounced than in urban areas where baseline conditions are generally better. Moreover, 153 targeting rural contexts aligns with India's broader development priorities, including those 154 outlined [1] in the National Education Policy 2020. 155 156 Analysis 157 158 Table 1: Descriptive Statistics 159 Indicator 1991 (Education Access) 2020 (Development Outcomes) School Availability Many villages lacked a primary school, especially in rural and underdeveloped districts. Access to education was uneven, with certain talukas having better infrastructure due to early state-led education drives. Villages that had a school in 1991 report only 12% of households without electricity in 2020, compared to 18% in those without schools. School Electrification Only a limited proportion of schools had electricity in 1991. This reflected broader gaps in rural infrastructure and administrative capacity. Villages that had electrified schools in 1991 now show markedly better electrification and

infrastructure outcomes. Sanitation in Schools Sanitation facilities were scarce or non-existent in most rural schools during 1991. By 2020, 64% of villages with schools in 1991 had toilets in schools, compared to 47% of villages without schools. 160 Source: Compiled by the author using SHRUG (Census of India, 1991) and Mission 161 Antyodaya data (2020). 162 163 The descriptive statistics establish a strong foundation for understanding how early access to 164 education correlates with improved long-term outcomes. Villages that had schools and basic 165 educational infrastructure in 1991 experienced higher rates of electrification and sanitation by 166 2020. This pattern suggests that the benefits of education access extend beyond literacy and 167 enrollment — they trigger a cycle of development. Schools act as nodes of infrastructure 168 investment, attracting other improvements such as roads, electricity, and water. The presence 169 of schools in 1991 likely made villages more visible to government schemes, encouraging 170 subsequent rounds of development assistance. 171 172 Table 2:

Difference-in-Means Tests 173 Outcome (2020) Villages with School in 1991 Villages without School in 1991 Difference Significance Electricity Deprivation 12% 18% -6 pp $p < 0.01$ School Toilet Availability 64% 47% +17 pp $p < 0.01$ Electrified School 72% 58% +14 pp $p < 0.01$ 174 Source: Compiled by the author using SHRUG (Census of India, 1991) and Mission 175 Antyodaya data (2020). 176 177 The difference-in-means results confirm that these gaps are statistically significant and not 178 random. Villages with schools in 1991 displayed consistently better infrastructure outcomes 179

nearly three decades later. The 6 percentage point drop in electricity deprivation suggests that 180 educational access in the early 1990s had lasting effects on village electrification and 181 economic modernization. Similarly, the 17 percentage point increase in school sanitation 182 facilities demonstrates that educational presence has a cascading influence on social 183 infrastructure and public health priorities. These differences underscore that early investments 184 in education create measurable, long-term development advantages. 185 186 Table 3: Regression Analysis (with Controls) 187 1991 Variable (Independent) 2020 Outcome (Dependent) Effect Size Significance School Electrification Village electricity deprivation -6.1 pp $p < 0.001$ School Availability Village electricity deprivation Small, not significant n.s. Student Enrollment Village infrastructure outcomes Weak or no significant effect n.s. 188 Statistical significance levels are denoted as *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Variables 189 marked as n.s. are not statistically significant. 190 Source: Compiled by the author using SHRUG (Census of India, 1991) and Mission 191 Antyodaya data (2020). 192 193 The regression analysis provides stronger evidence by controlling for other influencing 194 factors such as population size, household count, and district-level characteristics. It reveals 195 that school electrification in 1991 remains a powerful predictor of present-day village 196 development. Villages where schools had electricity in 1991 are 6.1 percentage points less 197 likely to experience electricity deprivation in 2020, even after accounting for other variables. 198 This finding highlights a crucial insight: it is not merely the presence of a school that matters, 199 but the quality

and infrastructure of that school. Electrified schools symbolize better resource 200 allocation, stronger administrative presence, and local capacity for maintenance all of which 201 compound over time to produce better developmental outcomes. On the other hand, raw 202 school numbers and enrollment alone show weaker effects, implying that physical and 203 infrastructural quality of education access is the key driver of long-term development.The 204 table reports village-level regression estimates linking historical educational access to long205 term development outcomes. Coefficients represent percentage-point changes in the 206 dependent variable. Standard errors are reported in parentheses. All regressions control for 207 village population, number of households, and district fixed effects. 208 209

210 Table 4: Propensity Score Matching (PSM) 211 2020 Outcome Villages with School in 1991 (Matched) Villages without School in 1991 (Matched) ATT (Average Treatment Effect) Electricity Deprivation 13% 17% -4 pp School Toilet Availability 63% 48% +15 pp Electrified School 70% 55% +15 pp 212 Source: Compiled by the author using SHRUG (Census of India, 1991) and Mission 213 Antyodaya data (2020). 214 215 Propensity Score Matching (PSM) helps ensure that the comparisons between school and 216 non-school villages are fair by matching them on similar characteristics such as population, 217 household size, and regional background. Even after matching, villages with schools in 1991 218 continue to show superior outcomes in 2020. The 4 percentage point reduction in electricity 219 deprivation and 15 percentage point higher sanitation coverage confirm that these benefits are 220 not due to pre-existing advantages, but rather the result of historical educational access. This 221 reinforces the idea that the presence of schools generates long-term community spillovers — 222 villages become more attractive for further development investment, administrative focus, 223 and citizen participation in government programs. 224 225 Table 5: Heterogeneity Across Districts 226 District Example 1991 Access to School 2020 Development Impact Belagavi, Tumakuru (less developed) Lower school availability and minimal electrification in 1991. School access linked with 8+

percentage points lower electricity deprivation by 2020. Bengaluru Rural (more developed) Higher school availability and stronger baseline infrastructure. Smaller marginal impact by 2020, with effects under 3 percentage points. Source: Compiled by the author using SHRUG (Census of India, 1991) and Mission 227 Antyodaya data (2020). 228

229 The heterogeneity analysis highlights that the impact of education access is not uniform 230 across Karnataka. In underdeveloped districts like Belagavi and Tumakuru, where 231 infrastructure was weak in 1991, the introduction or improvement of schools led to 232 significant long-term gains in electrification and sanitation. Conversely, in relatively 233 developed districts like Bengaluru Rural, the marginal effect of school presence is smaller 234 because baseline access was already high. This pattern demonstrates that educational 235 investments yield the highest returns in regions starting from a low base, reaffirming the 236 policy importance of prioritizing disadvantaged rural areas. 237 238 Conclusion 239 This study set out to quantify the long-term developmental impact of historical access to 240 education, with a specific focus on rural villages in Karnataka. By linking village-level 241 educational indicators from the 1991 Census to development outcomes observed in the 2020 242 Mission Antyodaya data, the analysis provides robust empirical evidence that early 243 investments in education have persistent and measurable effects on rural development 244 outcomes even three decades later. 245 Consistent with the first objective, the findings demonstrate that villages with access to 246 primary education in 1991 exhibit significantly better development indicators in 2020, 247 including lower electricity deprivation, higher levels of school electrification, and improved 248 sanitation infrastructure. Difference-in-means tests confirm that these gaps are statistically 249 significant, indicating that the observed improvements are unlikely to be driven by random 250 variation. 251 Addressing the second objective, the study finds that the quality of educational 252 infrastructure—particularly school electrification—plays a more decisive role in shaping 253 long-term development outcomes than the mere presence of schools or student enrollment 254 levels. Regression analysis reveals that

villages with electrified schools in 1991 are 255 substantially less likely to experience electricity deprivation in 2020, even after controlling 256 for demographic and regional factors. This underscores the importance of infrastructure 257 quality in amplifying the developmental returns to education. 258 In line with the third objective, the analysis highlights meaningful regional heterogeneity 259 across Karnataka's districts. The developmental impact of early educational access is 260 strongest in historically underdeveloped districts, where baseline infrastructure deficits were 261 more pronounced. This suggests that educational investments have the greatest marginal 262 returns in areas facing structural disadvantages, reinforcing the role of education as an 263 equalizing force in rural development. 264 Finally, by adopting a village-level, longitudinal approach, this study contributes to the 265 broader development literature by demonstrating that education policy should be understood 266 not merely as a social intervention, but as a foundational component of long-term economic 267 and infrastructural development. The results emphasize the need for integrated policy 268 frameworks that prioritize educational infrastructure quality, target underserved rural regions, 269 and recognize the enduring spillover effects of education on broader development outcomes. 270 These insights are directly relevant to current policy priorities under the National Education 271

Policy 2020 and provide evidence-based guidance for designing interventions aimed at 272 promoting inclusive and sustainable rural development. 273 274 275 276 The findings of this study highlight the importance of viewing education as a foundational 277 component of long-term development rather than as an isolated social intervention. Evidence 278 from village-level analysis indicates that investments in the quality of educational 279 infrastructureparticularly in rural contextsgenerate durable spillover effects on broader 280 development outcomes such as electrification and basic service provision. These results 281 suggest that development strategies should integrate educational planning with 282 complementary infrastructure investments, especially in regions with

historically low 283 baseline conditions. Strengthening educational quality in underserved rural areas can play a 284 critical role in reducing regional disparities and promoting inclusive and sustainable 285 development over time. 286 287 References 288 Angrist, J. D., & Pischke, J.-S. (2009). Mostly harmless econometrics: An empiricist's 289 companion. Princeton University Press. 290 291 Asadullah, M. N., & Chaudhury, N. (2015). The impact of education policies on school 292 participation and outcomes in developing countries. 2 International Journal of Educational 293 Development. 294 295 Asher, S., Lunt, T., Matsuura, R., & Novosad, P. (2019). Socioeconomic High-Resolution 296 Rural–Urban Geographic Dataset (SHRUG). Development Data Lab. 297 298 Asher, S., & Novosad, P. (2020). 7 Rural roads and local economic development. American 299 Economic Review. 300 301 Adukia, A., Asher, S., & Novosad, P. (2020). Educational investment responses to economic 302 opportunity. American Economic Journal: Applied Economics. 303 304 DevDataLab. (2024). SHRUG v2.1: Socioeconomic High-Resolution Rural–Urban 305 Geographic Dataset. Development Data Lab. 306 307 Duflo, E. (2001). Schooling and labor market consequences of school construction in 308 Indonesia. American Economic Review. 309 310 Duflo, E., Dupas, P., & Kremer, M. (2017). The long-term impacts of secondary school 311 scholarships in Ghana. J-PAL Working Paper. 312 313

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