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Bridging the Gap: A Structural Analysis of Vocational Education Alignment with Industrial Upgrading in Mountainous Regions

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Abstract. As the world enters the Fourth Industrial Revolution, the demand for highly skilled talent in the context of industrial upgrading is becoming increasingly urgent. However, in mountainous and rural areas, the imbalance between vocational education and economic development remains a prominent issue. This paper focuses on the structural mismatch between vocational education programs in mountainous areas and local industrial upgrading, pointing out that the current contradiction is not merely a shortage of talent, but rather a misalignment between local needs and three key aspects: program categories, the timing of adjustments, and skills development. By examining the characteristics of mountainous regions—such as fragmented and small-scale industries, limited enterprise absorption capacity, scarce educational resources, and labor outflow—the article analyzes why traditional program structures struggle to respond promptly to emerging skill demands in specialized agriculture, ecological industries, cultural-tourism integration, and digital marketing. Based on this analysis, the article proposes establishing mechanisms for regional collaborative planning, forward-looking industry monitoring, interdisciplinary skills development, and more targeted fiscal support to enhance the capacity of vocational education to serve the endogenous development of mountainous regions.

Keywords: Mountainous Regions, Vocational Education, Industrial Upgrading

1. Introduction

The quality of alignment between vocational education and local industry has long been recognized as a major determinant of regional development. In advanced industrial regions, this alignment often benefits from dense labor markets, stronger enterprise participation, better educational resources, and clearer occupational pathways. In mountainous regions, however, the relationship is more fragile. Settlement patterns are dispersed, industrial structures are narrower, the scale of firms is smaller, and local governments frequently operate under tighter fiscal constraints. Under these conditions, vocational education is expected to perform several functions at once: to prepare young people for employment, to serve as an institutional support for industrial upgrading, and to reduce the outflow of labor from less-developed areas. Yet these goals often conflict in practice.

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This problem is especially salient in contemporary China. On the one hand, vocational education has been placed at the center of national strategies related to manufacturing transformation, rural revitalization, and employment stabilization. The 2021 revision of the national vocational education professional directory emphasized closer correspondence among majors, occupations, positions, and the modern industrial system. On the other hand, many local economies—especially those in mountainous areas—are changing faster than school structures can adapt. Traditional labor-intensive production is increasingly combined with digital operations, service integration, ecological governance, equipment maintenance, cold-chain logistics, e-commerce, and tourism experience design. These changes create new skill needs that are not well captured by older, generic, or administratively convenient major structures.

This paper focuses on that gap. Its central question is not simply whether vocational education in mountainous regions is insufficient, but whether it is structurally aligned with the direction of industrial upgrading. A region may have many students and many schools, yet still fail to generate development-relevant human capital if the composition of training does not match the composition of local demand. Conversely, a region with relatively limited educational capacity may still support upgrading if it can concentrate its scarce resources on strategically important skill domains. This concern is also consistent with evidence from China that vocational and academic pathways lead to different labour-market outcomes and with rural evidence showing that the effects of vocational education depend on local social and labour-market conditions [1, 2].

The paper makes three contributions. First, it reframes the problem of vocational education in mountainous regions as one of structural alignment rather than simple educational expansion. Second, it proposes an analytical framework for understanding mismatch in terms of category, timing, and capability. Third, it explains why mountainous regions are more prone to persistent mismatch, even when national policy encourages closer integration between education and industry.

The remainder of the paper is organized as follows. Section 2 reviews relevant literature on vocational education, mismatch, and regional development. Section 3 outlines the analytical framework and the public data logic that can support this line of inquiry. Section 4 presents the structural analysis of mismatch in mountainous regions. Section 5 discusses policy implications, and Section 6 concludes.

2. Literature review

Research on vocational education has increasingly moved beyond the old contrast between vocational and academic tracks to examine how institutional design, labor market context, and regional structure shape educational returns. One line of scholarship studies labor market outcomes. Evidence from China shows that vocational education can matter for earnings and employment, but the magnitude and distribution of returns vary by cohort, city, and regional context. Wang and Wang show that vocational and academic pathways lead to different labor market outcomes in China, while Dai and Martins identify positive returns to vocational education using city-level education supply shocks [1, 3]. Chen and Pastore further demonstrate that returns to vocational education in China are dynamic rather than fixed over time. In rural China, Wang, Zhang, and Xu find that the effects of upper-secondary vocational education also depend on surrounding social and labor-market conditions [2, 4]. Beyond individual labour-market returns, Wang, Zheng, Ma, and Lu connect higher vocational education to the broader agenda of rural revitalization in China, which is particularly relevant for mountainous regions where employment, industrial restructuring, and local development are closely intertwined [5]. Comparative evidence also suggests that the performance of vocational graduates is not constant across economic environments. Ariansyah et al., for example,

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compare the labor market performance of vocational and general school graduates in Indonesia under both stable and crisis conditions, reminding us that the value of vocational training is shaped by wider economic circumstances rather than by educational type alone [6]. A labour-market perspective from India points in a similar direction, Agrawal and Agrawal showing that the relationship between vocational education and employment outcomes is also shaped by broader labour-market conditions [7].

A second body of work focuses on mismatch. Brunello and Wruuck review the literature on skill shortages and skill mismatch, showing that mismatch is not merely a question of aggregate supply but of weak information flows, institutional frictions, and delayed adjustment [8]. Levels, Van der Velden, and Allen provide evidence that educational mismatch is deeply connected to skill utilization, while Bol, Ciocca Eller, Van de Werfhorst, and DiPrete emphasize the importance of school-to-work linkages for reducing mismatch and improving labor market outcomes [9, 10]. These studies are useful because they shift attention from enrollment volume to the quality of coordination between education and employment systems.

A third strand highlights the regional dimension of vocational training. Schuster and Margarian show that vocational training choices are shaped by regional opportunities and constraints rather than individual preference alone [11]. Corradini, Morris, and Vanino argue for a more explicitly regional approach to skills policy, noting that national policy goals are often filtered through uneven local institutional capacity [12]. This concern is also related to the training incentives of firms themselves. Muehlemann and Wolter discuss firm-sponsored training and poaching externalities in regional labor markets, suggesting that employer investment in training is closely tied to local market structure [13]. This point matters for mountainous regions, where firms are often small in scale and may have limited incentives or capacity to invest in structured training. At the same time, the institutional form of vocational training cannot simply be copied across contexts. Pilz and Wiemann, in their discussion of training models in German companies in China, India, and Mexico, show that training arrangements are shaped by local institutional settings rather than transferred in a uniform way [14]. This caution is further echoed by the broader literature review on the international transfer of vocational education and training [15]. These studies imply that vocational education in mountainous regions should be understood not only as a schooling issue, but also as a problem of regional labor markets, employer incentives, and institutional adaptation.

Recent work also draws attention to curriculum responsiveness. Buehler, Lehnert, and Backes-Gellner show that curriculum updates in vocational education can shape graduates' skills and wages, implying that content revision is not a marginal issue but a core component of labor-market relevance [16]. Hickmann, Detemple, and Wicht further indicate that regional digitalization changes the opportunity structure facing vocational learners [17]. Recent work on employability also suggests that vocational training should not be evaluated solely by whether students obtain jobs, but also by whether the competencies developed are meaningful in specific regional contexts. Tran et al. describe employability as being shaped "in context," emphasizing that employer expectations in regional settings are embedded in local economic structures [18]. For mountainous areas, this insight is important because local industries often require workers to move across technical, service, and coordination tasks rather than perform one narrowly defined occupation. Together, these studies suggest that vocational education systems must respond not only to sectoral demand but also to shifts in technology, local context, and work organization.

Despite these advances, an important gap remains. Much of the literature examines national systems, cross-country institutional transfer, or individual labor market outcomes. Fewer studies focus specifically on mountainous regions as development spaces with distinctive industrial and

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institutional characteristics. Where the regional dimension is considered, it is often discussed in general terms rather than in relation to the concrete structure of mountain-area economies. Yet mountainous regions are not merely poorer versions of urban economies. Their industrial pathways often rely on combinations of specialty agriculture, ecological resource use, cultural tourism, basic public services, transport connectivity, and small-scale processing. The skill needs generated by these sectors are heterogeneous, seasonal, and often composite. This makes them particularly sensitive to how vocational majors are designed, updated, and linked to local employers.

The present paper addresses this gap by integrating three literatures—vocational outcomes, mismatch, and regional skills policy—into a structural analysis of mountainous regions.

3. Analytical framework

This paper conceptualizes vocational education alignment as the degree to which program structure, training content, and institutional organization correspond to the current and emerging needs of local industrial upgrading. Alignment is not a binary condition. It can vary in intensity and can improve or worsen over time.

Three dimensions are especially important.

First, category alignment. This refers to whether the broad composition of vocational programs reflects the broad composition of the local economy. If a mountainous region is moving toward specialty agriculture, agro-processing, tourism services, digital marketing of rural products, equipment maintenance, and ecological restoration, then a program portfolio dominated by generic accounting, basic administration, or disconnected low-cost majors may indicate weak category alignment.

Second, temporal alignment. Even if schools eventually create relevant majors, they may do so too slowly. Industrial upgrading is often uneven but fast-moving. Tourism-service integration, cold-chain logistics, rural e-commerce, and digitalized agriculture can emerge rapidly under policy support. When professional directories, teachers, equipment, and approval procedures adjust more slowly than industrial demand, a time lag appears.

Third, capability alignment. Industrial upgrading usually raises the skill content of jobs. The issue is therefore not only whether a major exists, but whether it develops the right combination of technical, digital, service, and problem-solving abilities. This concern is consistent with Girsberger, Koomen, and Krapf, who distinguish among interpersonal, cognitive, and manual skills and show that these skill dimensions relate differently to employment and wages [19]. For mountainous regions, the implication is that vocational education should not be reduced to manual task preparation alone; instead, it should cultivate broader skill combinations that fit small-scale, flexible, and service-integrated local industries. In many mountain regions, employers need workers who can operate across task boundaries: for example, agricultural production plus branding and online sales; tourism operations plus hospitality and platform management; or equipment maintenance plus data-based monitoring. Narrow training centered on routine tasks may not support this transition.

4. Structural misalignment in mountainous regions

4.1. Why mountainous regions face a distinctive alignment problem

Mountainous regions face a more complicated matching problem than major urban agglomerations. Their industrial base is usually smaller, more spatially scattered, and more dependent on natural conditions. Local firms are often small and less able to shape curricula, offer large-scale

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apprenticeships, or absorb large numbers of specialized graduates. Public services and transport links may be uneven, which raises the cost of both education delivery and enterprise collaboration.

At the same time, the development agenda of mountainous regions has become more ambitious. Traditional subsistence or low-value agriculture is increasingly expected to evolve toward specialty agriculture, green food processing, cultural tourism, elder care, environmental services, and digital commerce. This means that vocational education is no longer simply preparing youth for existing jobs; it is also expected to support new industrial possibilities. Alignment therefore becomes a developmental issue, not just an employment issue.

4.2. Category gaps: what schools offer versus what upgrading requires

A first source of mismatch is the category gap between locally relevant industries and the structure of school offerings. In many mountain areas, the industrial demand generated by upgrading is highly specific. Specialty agriculture requires agricultural machinery use, seed and breeding knowledge, quality control, packaging, storage, cold-chain operation, and e-commerce. Tourism-led development requires hospitality, customer communication, scenic-area operations, transport coordination, digital booking systems, local cultural interpretation, and safety management. Ecological industries require environmental monitoring, conservation practices, and low-carbon project implementation.

However, vocational institutions often maintain a more standardized set of majors that are easier to staff and manage. These include generic business, finance, elementary computing, preschool education, and other broad service majors that may be popular with students but are only partially related to the local upgrading agenda. This does not mean that such majors are useless. Rather, it means that when they dominate the program structure, they can crowd out more development-relevant majors that require specialized equipment, field practice, or close enterprise collaboration.

The consequence is a structural imbalance. Regions trying to build local value chains may instead train students for occupations that are portable but weakly embedded in the local economy. Graduates then either accept under-matched local jobs or leave, reinforcing the idea that local vocational education cannot serve as a foundation for endogenous growth.

4.3. Temporal gaps: industrial transformation moves faster than curriculum change

A second source of mismatch is the time lag between industrial transformation and educational adjustment. Public policy can accelerate sectoral change quite quickly. Once a region begins promoting tourism, processed agricultural products, digital village platforms, or ecological restoration, firms start to demand new combinations of skills. Yet school adjustment requires approval procedures, teacher recruitment, training of instructors, equipment purchases, and the redesign of teaching plans. Even where national authorities encourage dynamic adjustment, local implementation can be slow.

This lag is especially serious in mountainous regions for three reasons. First, the local teacher base is narrower, which makes it harder to launch or update technically specialized majors. Second, many relevant industries are themselves new and may not yet provide stable signals about long-term labor demand. Third, schools under enrollment pressure may hesitate to close established majors even when their local relevance declines.

As a result, vocational education may appear formally modernized while substantively lagging behind. A major title may be updated, but teaching content may still reflect older occupational

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realities. Or a school may add one "digital" or "smart" major as a symbolic response while the bulk of training remains unchanged.

4.4. Capability gaps: upgrading needs composite skills, but training often remains segmented

A third source of mismatch lies in capability formation. Industrial upgrading in mountainous regions rarely creates demand only for highly abstract knowledge or only for low-level manual work. More often, it requires composite competences. Workers need to move across production, service, communication, and digital tasks. For example, a graduate employed in local tourism may need hospitality skills, platform operation skills, emergency response awareness, and basic marketing competence. A worker in specialty agriculture may need production knowledge, traceability management, packaging skills, and online sales literacy.

Yet vocational training systems often remain segmented by traditional occupational boundaries. Curricula may emphasize narrow task proficiency without building the broader adaptability required in emerging local industries. This is a serious problem in mountainous regions because firms are small and employees frequently perform multiple functions. In large metropolitan firms, specialization can compensate for narrow training. In smaller mountain economies, it cannot.

4.5. Why mismatch persists

If the mismatch is visible, why does it persist? The answer is institutional as much as economic.

First, there is a scale problem. Specialized majors linked to local upgrading may have small enrollments and high per-student costs, making them financially difficult to sustain. Second, there is a resource problem: teacher recruitment, equipment investment, and industry placements are harder in remote areas. Third, there is an incentive problem. Schools are often evaluated through enrollment stability, completion rates, or formal compliance rather than by long-term regional industrial relevance. Fourth, there is a mobility problem. The most capable students may use vocational education as a pathway out of the local economy, which weakens the feedback loop between training supply and local labor absorption.

These mechanisms show that mismatch cannot be solved simply by asking schools to "serve local development" in general terms. Without institutional arrangements that reduce risk and coordinate actors, local adaptation remains difficult.

5. Policy implications

Three policy implications follow from the analysis.

First, mountainous regions need a regionalized rather than isolated school-by-school approach to vocational planning. Instead of requiring each institution to mirror the full industrial system, policymakers should support inter-school specialization and regional program clusters. One school may focus on tourism operations, another on agro-processing and logistics, and another on ecological technologies. This reduces duplication and allows scarce resources to be concentrated. Such a regionalized approach also echoes Schuster and Margarian, who show that vocational training choices are shaped by regional opportunities and constraints rather than by individual preference alone [11].

Second, program adjustment should be tied to forward-looking local industrial intelligence, not only to past enrollment trends. Governments can build simple monitoring platforms based on public industrial data, employer surveys, and county or prefectural development plans. The purpose is not

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to predict labor demand perfectly but to identify sectors where skill shortages are likely to constrain upgrading.

Third, curriculum reform in mountainous regions should prioritize composite and transferable competences. Since local firms are small and job boundaries are flexible, students need technical skills combined with digital literacy, communication, customer service, coordination, and problem-solving. In this sense, better alignment does not mean narrower training; it means strategically broader training rooted in local industrial reality. This point is also consistent with the distinction between narrow and broad vocational education programmes discussed by Coenen, Heijke, and Meng [20].

Fourth, school-enterprise cooperation must be made more realistic for peripheral regions. In many mountain areas, the issue is not unwillingness but weak enterprise capacity. Public policy may therefore need to subsidize placements, shared training centers, mobile teaching arrangements, and dual-instructor systems. This is also consistent with studies showing that employer participation in training is shaped by regional labor-market incentives and that training models such as dual arrangements need local adaptation rather than direct transplantation [13, 14].

Finally, fiscal policy matters. If vocational education in mountainous regions is expected to support industrial upgrading and social stabilization simultaneously, funding formulas should reflect those additional burdens. Equal treatment in nominal terms can reproduce inequality in practical terms.

6. Conclusion

This paper has argued that the relationship between vocational education and industrial upgrading in mountainous regions should be understood as a problem of structural alignment rather than simple educational shortage. Using a conceptual framework built around category, temporal, and capability alignment, it shows why mountainous regions are particularly vulnerable to persistent mismatch. Their industries are narrower yet changing, their educational institutions operate under tighter constraints, and their labor markets are more vulnerable to outward migration.

The paper does not claim that every mountainous region faces the same problem or that vocational education alone can solve regional underdevelopment. Its main claim is more specific: when vocational program structures lag behind the demands of local industrial transformation, human capital policy cannot effectively support endogenous development. In that sense, the "gap" is not only between schools and firms, but between static educational structures and dynamic regional economies. This broader claim is compatible with existing evidence from China, which shows both that vocational pathways lead to distinct labour-market outcomes and that the effects of vocational education in rural areas are shaped by local labour-market conditions [1, 2].

For future research, the next step is to operationalize the framework with public provincial or prefectural panel data, using the national professional directory, program filing data, and industrial structure indicators to construct an observable alignment index. Such work would make it possible to move from structural diagnosis to comparative empirical evaluation. Even at the current stage, however, the policy direction is clear: if mountainous regions are to upgrade sustainably, vocational education must become more adaptive, regionally coordinated, and development-oriented.

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