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How Peaks and Troughs in the School-Age Population Produce Resource Mismatches in Compulsory Education: A Cross-Stage Lag-Transmission Analysis

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Abstract: Against the combined backdrop of population decline, low fertility, and rising mobility, the main challenge in compulsory education is shifting from aggregate shortage to temporal, spatial, and structural mismatch. Taking birth cohorts as its starting point, this article traces a sequence of cohort change, institutional transition, spatial redistribution, and rigidity amplification. Cohort differences generate demand fluctuations; entry ages and school structures create lags between and within stages; migration and school choice relocate demand; and rigidities in facilities, staffing, authorized posts, and finance magnify mismatch. The article therefore calls for continuous cohort monitoring, coordination across stages, school planning based on the population actually served, and more flexible arrangements for places, facilities, teachers, and funding. These measures would strengthen the responsiveness, efficiency, and equity of compulsory education provision.

Keywords: School-age population peaks and troughs; Cross-stage lagged transmission; Compulsory education; Resource mismatch

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1. Introduction

Basic education is the foundation of the national education system, and the allocation of compulsory education resources is essential to educational equity and the quality of public services. The *Outline for Building a Strong Education Nation (2024–2035)* calls for monitoring and early-warning mechanisms for changes in the school-age population at each stage of basic education, closer coordination between short-term and medium- to long-term resource planning, and dynamic adjustment and reallocation across educational stages [1]. The policy emphasis is therefore moving away from a model designed mainly for expansion and toward one capable of responding to demographic change, stage transitions, and population mobility.

By the end of 2025, births in China had fallen to 7.92 million and the natural population growth rate to -2.41 per thousand [2]. Yet compulsory education still enrolled 156.8763 million students and employed 10.6976 million full-time teachers [3]. This contrast between demographic contraction and a large, inertial school system is consequential. Projections indicate that preschool, primary, lower-secondary, upper-secondary, and higher-education populations peak successively rather than simultaneously [4]. Decline among younger children may thus coincide with continued pressure at later stages, while migration and school choice alter where students enroll. Because buildings, staffing, authorized posts, and finance adjust slowly, local shortages can coexist with underused facilities and aggregate teacher surpluses with subject- or stage-specific shortages.

Following birth cohorts across educational stages, this article asks how peaks and troughs generate cross-stage lags, how migration and school choice relocate demand, and how supply rigidities convert demographic change into resource mismatch. It thereby reframes allocation from static aggregate balance toward cyclical and adaptive adjustment.

2. How peaks and troughs are transmitted across educational stages

Peaks and troughs do not appear simultaneously across stages or places. Birth cohorts become educational demand through aging, institutional transition, and spatial mobility, while the organization of supply determines whether the system can respond in time. Cohort change, institutional transition, spatial redistribution, and rigidity amplification together form the mechanism through which demographic change becomes resource mismatch.

2.1. Birth-cohort change is the demographic source of fluctuating educational demand

Cohorts born in different years vary in size: large cohorts create potential peaks, while consecutive small cohorts or sustained low births create troughs. Because children enter preschool, primary, and lower-secondary education in sequence, enrollment is a delayed expression of earlier births. Demand within each stage also reflects overlapping cohorts: six in primary and three in lower-secondary education. A decline in entry-grade enrollment therefore does not immediately reduce the whole stage; contraction becomes general only as smaller cohorts replace larger ones. Cohort differences set the direction of change, while cohort overlap makes it cumulative and delayed.

2.2. Institutional transitions create lags in the movement of peaks and troughs

A cohort becomes educational demand only after passing through school-entry ages, stage lengths, and promotion points. Under standard entry ages, it affects preschool about three years after birth, primary school around age six, and lower-secondary school around age twelve. Stable age boundaries create an inter-stage lag, while grade structures extend change within each stage and create an intra-stage lag. Thus, falling enrollment at an earlier stage may coexist with high demand at a later one, and the preceding stage becomes a useful signal of future demand.

2.3. Migration and school choice change the spatial location of peaks and troughs

Birth cohorts define the potential scale of demand, but where enrollment pressure actually appears depends

on family migration, residential change, and school choice. Registered population, resident population, and actual school enrollment often diverge, so local births cannot be treated as a direct measure of local educational demand. Population inflow raises local peaks, while outflow deepens enrollment troughs. Within counties, students also move from villages to county seats and central towns, and from ordinary schools to more highly regarded schools. A county may therefore experience overall decline while schools in the county seat, new residential areas, or popular catchments remain under sustained pressure; rural schools, older urban neighborhoods, and peripheral schools may begin to contract much earlier. Institutional transition gives peaks and troughs a temporal pattern, while spatial redistribution gives them regional and interschool variation.

2.4. Supply rigidities amplify demographic fluctuations

Population change does not by itself create mismatch. The risk arises when mobile demand meets slow-adjusting provision. School construction entails lengthy planning, land, approval, and building processes, and completed facilities cannot move with the population. Teacher deployment is constrained by authorized staffing, educational stage, subject specialization, and post structure; budgets and planning are commonly organized by fiscal year and administrative boundary. Peaks can therefore produce shortages, larger classes, and insufficient teachers, while troughs leave buildings, posts, and investments structurally underused.

3. Main forms of resource mismatch under lagged transmission

Once these four mechanisms enter the compulsory education system, the continuity and mobility of demand interact with the segmented and fixed nature of provision. Five forms of mismatch become particularly visible.

3.1. Continuous transmission across stages conflicts with segmented governance

The same cohort moves successively through preschool, primary, and lower-secondary education, so changes at one stage should provide advance warning for the next. In practice, enrollment forecasting, place planning, teacher allocation, and construction are commonly organized separately by stage. Primary enrollment may already be falling while lower-secondary schools continue to receive a large cohort; some preschool and primary resources may become underused while lower-secondary schools still need additional classes and staff. Cutting resources too early on the basis of declining entry-grade enrollment overlooks the delayed release of cohort change within a stage. Yet maintaining permanent capacity at a later stage solely because current enrollment is high may ignore the contraction already visible among younger children.

3.2. Overall contraction coexists with local concentration

A decline in the school-age population does not occur evenly across regions or schools. Population mobility tends to concentrate students in county seats, urban districts, new residential areas, and the catchments of better-regarded schools. Outflow areas may see shrinking classes and unused buildings, whereas inflow areas add classes, raise class sizes, and convert specialist rooms into ordinary classrooms. A county or city can therefore have enough school places in aggregate while still containing popular neighborhoods with students but too few places and peripheral areas with schools but too few students. If planning continues to rely on household registration, regional averages, or total enrollment, local pressure may be concealed by overall decline, and structural underuse may be obscured by congestion in a small number of schools.

3.3. Short-term expansion may turn into long-term underuse

When a cohort peak reaches a particular stage or locality, expanding buildings, classes, and staffing may be necessary. Once these resources become fixed assets or permanent posts, however, they cannot follow the cohort as easily as students do. If permanent provision is built to meet a temporary peak, a new school may open after demand has already passed its high point. Conversely, restricting current supply because of concern about future idleness may produce oversized classes, very large schools, and longer journeys across catchment boundaries. Immediate public-service obligations are therefore in tension with long-term utilization, and the expansion that relieves pressure today may become unused space, surplus staffing, and fiscal burden after the peak has moved on.

3.4. Teacher numbers may not match curricular structure

Teacher allocation is not only a matter of headcount; it also concerns stage, subject, post, age profile, and location. A trough usually reaches the lower primary grades first, potentially creating a temporary surplus of primary teachers while lower-secondary demand remains high. Even when the overall student population falls, shortages may persist in science, physical education, the arts, mental health, and special education. Students can change schools and stages with their families, but teachers are less mobile because of staffing rules, qualifications, subject backgrounds, and family circumstances. Mechanical reductions in authorized posts can thus produce fewer students but sharper structural shortages, while retaining peak-period staffing without adjustment can reduce efficiency.

3.5. The pursuit of scale efficiency can conflict with educational accessibility

In areas of population outflow, consolidating schools can improve the use of buildings and teachers and strengthen curriculum provision and professional support. At the same time, moving provision toward county seats or central towns may lengthen journeys, increase transport costs, and create safety risks for younger children, children in mountainous areas, and families with limited caregiving capacity. Keeping every small school open may preserve nominal proximity, but incomplete staffing and a narrow curriculum can also result in low-quality provision. Families do not bear the costs of school reorganization equally, because their capacity to move, provide transport, or exercise school choice differs. Efficiency cannot substitute for safe access and the basic educational rights of children; school reorganization must balance quality, sustainability, and genuine accessibility.

4. Optimizing compulsory education resource allocation

The cross-stage transmission of demographic peaks and troughs shows that compulsory education planning cannot remain confined to current aggregate balance or adjustment within a single stage. Population monitoring, demand forecasting, school location, teacher deployment, and asset use need to be connected, shifting policy from retrospective gap-filling to forward assessment and creating a dynamic system aligned with birth-cohort cycles.

4.1. Continuous cohort monitoring can improve the lead time of demand assessment

Because inter-stage and intra-stage lags prevent current enrollment from fully revealing future trends, planning should use the birth cohort as its basic unit. Data on births, preschool enrollment, primary entry,

primary graduation, lower-secondary entry, and resident population movement should be linked into a continuous monitoring chain from birth through the completion of compulsory education. A rolling framework of annual monitoring, three-year early warning, six-year projection, and nine-year coordination could be established. Annual monitoring would capture changes in admissions, transfers, and class size; the three-year horizon would assess primary-entry demand; the six-year horizon would trace cohort replacement in primary schools and the pressure subsequently reaching lower-secondary schools; and nine-year coordination would inform longer-term decisions on school location, teachers, and finance. Indicators of place shortages, very small schools, teacher-structure imbalance, and travel burden should be linked to concrete resource decisions.

4.2. Flexible provision across stages can correct the mismatch between continuous demand and segmented management

The final year of preschool is a near-term signal of primary enrollment, lower primary grades reveal the future size of the primary sector, and Grades 5 and 6 anticipate pressure at lower-secondary entry. Preschool, primary, and lower-secondary education should therefore be treated as a connected public-service sequence through which the same cohort passes. Places, facilities, and teachers should be planned across stages rather than in isolation. Temporary peaks need not be met entirely through permanent investment. Reserved education land, phased construction, modular classrooms, convertible spaces, and interschool reallocation can preserve expansion options. During a trough, schools and education land should not be closed or released too quickly; decisions should be differentiated according to cohort trends, school functions, and the availability of realistic alternatives.

4.3. School planning should be based on the population actually served

Births indicate potential demand, whereas migration, housing delivery, family relocation, and school choice determine where that demand is realized. Planning should cross-check registered births, resident children, preschool enrollment, school records, housing completions, and student flows, and should assess demand at the level of streets, townships, communities, and school catchments rather than rely on regional averages. Inflow areas and new districts should retain a reasonable reserve of school places. Outflow areas should adjust cautiously in light of enrollment trends, geographic conditions, and the capacity of alternative schools. In rural and remote areas, travel time, road safety, transport provision, child age, and family caregiving capacity should operate as minimum constraints on reorganization so that spatial adjustment responds to mobility without weakening access.

4.4. Scenario-based forecasting and reversible resource use can ease the tension between short-term expansion and long-term idleness

Cohort aging is relatively predictable, but migration, housing development, entry-age variation, and school choice can still move actual demand away from projections. Planning should therefore use demand ranges under several scenarios, such as net inflow, relative stability, and sustained outflow, and update those ranges annually. Highly mobile areas can combine reserved land, phased building, and flexible space rather than fix a temporary peak in permanent capacity. In areas experiencing a trough, unused school buildings can be classified for educational reserve, functional conversion, wider public-service use, or orderly disposal according to future demand, location, and building condition. The key is to improve utilization while

preserving the possibility of restoring educational use.

4.5. Teacher restructuring and flexible finance are needed to protect quality and equity

Authorized teaching posts should not rise or fall mechanically with enrollment. Counties should adjust posts across schools using cohort projections and develop mechanisms for sharing shortage-subject teachers, itinerant teaching, teacher reserves, and temporary support. Temporarily surplus teachers can, with retraining, support smaller classes, student guidance, after-school provision, and weakly staffed subjects. Funding formulas should combine basic operating support, enrollment-based funding, structural adjustment, and compensation for demographic volatility, geographic accessibility, and responsibilities toward disadvantaged groups.

5. Conclusion and future research

Population decline, low fertility, and mobility are shifting the central allocation problem from aggregate insufficiency to misalignment between demand and provision across time, space, and structure. Cohort differences generate demand fluctuations; age thresholds and school-system structures create lags between and within stages; migration and school choice relocate demand; and supply rigidities magnify local and temporary change into broader mismatch. A falling school-age population therefore does not imply simultaneous contraction across all stages, places, and resource categories. Policy should address the full chain through which mismatch arises: monitor cohorts continuously, coordinate provision across stages, calibrate school planning to the population actually served, use scenarios and reversible assets to limit lock-in, and restructure teachers and finance to protect quality and equity.

Future research could use longitudinal data linking births, student records, resident population, and school resources to estimate the actual transmission periods of peaks and troughs in different localities. Travel burdens, educational quality, and fiscal costs should also be incorporated into evaluations of school location and reorganization. Such evidence would support differentiated resource policies for areas experiencing population inflow, outflow, or internal concentration.

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