

RESEARCH REPORT

Demographic change and the supply of productive labor

Population projections do not directly determine labor input. Evidence from four economies and an exact accounting exercise separate demographic change from participation, employment, hours, migration, and the productivity improvements required to sustain output.

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A change in the working-age population is an important constraint on economic growth, but it is not a complete forecast of labor input or output. People participate at different rates, find work with different probabilities, supply different hours, and use different amounts and kinds of capital. Migration changes the number and composition of residents, while skills and organization influence what their work can produce. The economic question is how these margins interact over a stated horizon.

This report examines population projections for the United States, Japan, Germany, and Korea and separates demographic change from participation, employment, hours, and productivity. An original accounting exercise shows the scope and limits of offsetting responses. The exercise is hypothetical; it is neither a demographic forecast nor a calibration to one of the four economies. It establishes the size of adjustments required under explicit assumptions and identifies the evidence needed to judge their feasibility.

The principal conclusion is that some effects can be offset without being erased. Participation and productivity can support output when the population available for work declines, but they do not automatically replace particular skills, restore every local service, or prevent the age structure from changing. Policies also work on different calendars. A change in births affects the workforce much later than a change in participation or migration, and an investment affects production only when the necessary services are in use.

Four projections and their different boundaries

The U.S. Congressional Budget Office's January 7, 2026 demographic outlook projects an aging population and places increasing weight on net immigration as natural increase weakens. Its headline population measure is the Social Security area population, which extends beyond residents of the states. It separately discusses the civilian noninstitutionalized population used in economic projections. These are related but distinct statistical populations, and the report's assumptions reflect laws and policies as of September 30, 2025. [CBO, The Demographic Outlook: 2026 to 2056.](#)

Japan's 2023 IPSS projection uses the 2020 census as its base and includes non-Japanese residents. Under its medium-fertility, medium-mortality scenario, the population aged 15-64 falls from 75.09 million in 2020 to 45.35 million in 2070. That is an age-defined population, not a projected count of employed people. The projection contains alternative fertility and mortality assumptions and separate conditional exercises; the central path should not be presented as a certain outcome. [IPSS, 2023 projection summary, age-group results](#).

Destatis's December 11, 2025 release on Germany's sixteenth coordinated projection reports that one quarter of the population will be aged 67 or older in 2035 across its variants. It defines working age in the accompanying discussion as 20-66. That boundary differs from Japan's 15-64 band, so the two working-age totals should not be compared as though they counted the same ages. [Destatis, projection release of December 11, 2025](#).

Korea's official projection published December 14, 2023, with 2022 as its base, projects a decline of 3.32 million in the working-age population over 2022-32 and a rise of 4.85 million in the elderly population over that interval. Its assumptions and horizon differ from the other sources. The results describe a particular projection exercise rather than observations already realized by 2032. [Statistics Korea, Population Projection for Korea, 2022-2072](#).

The four records establish a shared reason to examine age composition while also demonstrating why a harmonized comparison requires care. The base year, resident coverage, age boundary, and migration assumptions are not identical. This report preserves those differences and does not produce a league table from their headline values. Its comparative question is which labor-supply margin a particular projection leaves open, not which country has the smallest number under a different definition.

Population is a starting quantity

A working-age band is a convention used to organize demographic data. Some people below its upper boundary are studying, caring for relatives, retired, or unable to work. Some people above it are employed. A change in the number inside the band therefore does not translate one for one into the change in employment. An economic projection must connect the population profile to age-specific participation and work rather than treat the demographic boundary as a compulsory retirement date.

The distinction is especially important when comparing the German 20-66 and Japanese 15-64 definitions. The additional years at the lower and upper ends have different participation patterns. Harmonization would require the underlying single-year or consistent age-group data and matched labor-market measures. Applying a ratio calculated for one band to the other could create an apparent policy advantage that is partly definitional.

The age mix inside a broad band can matter even if its total is stable. A movement toward ages with higher participation can support labor-force growth without an increase in the band population. Later, a movement toward retirement can reverse that contribution. A useful projection therefore follows cohorts and rates within the band rather than assign one unchanging average participation rate to every future population structure.

Population also has a geographical distribution. National stability can coexist with shrinking working-age populations in particular regions. Employers may then face recruitment costs, while infrastructure and housing

in another region remain underused. Moving a worker is not frictionless: housing, family ties, qualifications, and local services affect whether a vacancy and an available worker can be matched. Aggregate population arithmetic cannot resolve that spatial allocation by itself.

For business planning, the relevant population is often narrower still. A firm needs particular skills within an accessible labor market and a plausible recruitment horizon. An increase in national adult population can offer little immediate relief to a specialized maintenance shortage. Conversely, a smaller local cohort can be partly offset by retention, training, remote provision, or a different production method. The demographic projection identifies pressure; the operational assessment identifies the feasible response.

An exact decomposition of the production relationship

For a consistently defined production and population boundary, output can be written as $W \times p \times e \times h \times q$. W is the covered adult population; p is its labor-force participation rate; e is the employed share of that labor force; h is annual hours per employed person; and q is output per hour. W here includes the ages whose work is counted. It is not automatically a national 15-64 or 20-66 working-age band.

The identity separates five margins. Population changes the potential base. Participation determines how much of that base supplies or seeks labor. Employment determines how much of the labor force works. Hours determine the intensity of that work. Productivity relates output to the total hours supplied. The expression is accounting, not a theory that makes those margins independent or establishes that any of them can be adjusted at no cost.

Consider a hypothetical starting population of 100 units, participation of 70 percent, an employed share of 95 percent, annual hours of 1,800, and output per hour of 50. Employment is $100 \times 0.70 \times 0.95 = 66.5$. Total hours are 119,700, and output is 5,985,000 units. The population unit can be scaled without changing the percentage results; the exercise is not expressed in actual national population counts.

Now reduce the covered population to 90, raise participation to 75 percent and the employed share to 96 percent, reduce average hours to 1,750, and raise productivity to 55. Employment becomes 64.8, total hours 113,400, and output 6,237,000. Employment falls by about 2.56 percent and total hours by about 5.26 percent, while output rises by about 4.21 percent. Those changes follow exactly from the stated assumptions.

Hypothetical factor	Initial	Later	Ratio, later to initial
Covered adult population	100	90	0.90000
Participation rate	0.70	0.75	1.07143
Employed share of labor force	0.95	0.96	1.01053
Hours per employed person	1,800	1,750	0.97222

Hypothetical factor	Initial	Later	Ratio, later to initial
Output per hour	50	55	1.10000
Total output	5,985,000	6,237,000	1.04211

Multiplying the five ratios produces the output ratio. Adding their ordinary percentage changes does not produce an exact decomposition because interaction terms matter. Taking natural logarithms provides an exact additive alternative. The contributions, in log percentage points, are approximately minus 10.5361 for population, plus 6.8993 for participation, plus 1.0471 for employment, minus 2.8171 for hours, and plus 9.5310 for productivity. Their sum corresponds to the logarithm of the 1.04211 output ratio.

These values are assumptions and arithmetic, not estimated policy effects. The participation improvement is substantial, the unemployment reduction may or may not be feasible, and the productivity path requires an explanation. The example demonstrates that a population decline need not imply an identical output decline. It does not establish that the offsetting changes will occur spontaneously or that output growth alone resolves every consequence of aging.

How much productivity is required?

With the later employment and hours assumptions, holding output at the initial 5,985,000 would require productivity of 5,985,000 divided by 113,400, or 52.77778 per hour. That is a 5.56 percent improvement over 50. The assumed increase to 55 exceeds that threshold and permits output to rise. If participation and employment had remained unchanged and hours had also stayed fixed, offsetting a 10 percent population decline would instead require an 11.11 percent productivity increase.

The difference shows why the margins should be analyzed jointly. It would overstate the required productivity improvement to ignore a plausible participation gain; it would understate it to assume such a gain without evidence. A scenario should identify which adjustment is demographic, which is behavioral, which depends on policy, and which is a technical or organizational assumption. That separation makes the implied burden on each margin reviewable.

The result also depends on the output objective. Holding total GDP constant differs from holding GDP per person constant when total population changes. Maintaining a given public service standard can require a different mix of workers and capital as the age profile changes. An economy-wide productivity improvement may create resources to finance care without supplying the particular nurses or care workers needed locally. Aggregate feasibility and sector feasibility are different tests.

Productivity growth can arise through more capital services, better skills, improved organization, or movement toward higher-value activities. Those routes have different resource and timing requirements. A national projection that assumes a higher productivity path should explain which investments and adjustments can support it and where there are constraints. Treating an unexplained residual as an automatic solution merely moves uncertainty from one line of the forecast to another.

Participation has scope and limits

Participation can rise when barriers to work decline, health improves, or jobs become more compatible with personal circumstances. Childcare, transport, working arrangements, qualifications, and the availability of suitable positions can all matter. The relevant policy question is which constraint prevents an otherwise feasible match. A broad target to increase participation does not identify the service, incentive, or institutional change needed to achieve it.

The starting rate places a practical limit on the arithmetic. A group already participating at a high rate cannot deliver an indefinitely repeated increase. A five-percentage-point rise is also not a five-percent rise: moving from 70 to 75 percent increases the participating share by about 7.14 percent. Confusing points and percentages can materially change an assessment of how much population decline a proposed participation response offsets.

Older workers are heterogeneous. Some can and wish to remain in employment with appropriate arrangements, while health, physical demands, or care responsibilities limit others. A uniform assumption about additional working years can therefore overstate feasible labor supply or impose uneven burdens. An assessment should examine occupation, health, working conditions, and the availability of less demanding tasks rather than presume that a statutory age change produces an equal change in hours supplied.

Participation can also change the composition of measured productivity. New entrants may initially produce less per hour than experienced workers, even when their employment raises aggregate output and household income. Training can improve their contribution over time. A short-run decline in average productivity would not necessarily show that participation policy failed. The appropriate evaluation follows both the average and the additional output and opportunity created.

The transition has fiscal effects as well. More employment can raise revenue and reduce some transfers, while enabling services such as childcare or training have costs. These effects depend on earnings, hours, tax design, and the counterfactual. The gross wage of an additional worker is not automatically the net fiscal gain. A sustainable participation strategy should account for the resources needed to make the additional work feasible.

Migration changes both supply and demand

Migration can add people at working ages sooner than a change in births can. Its contribution to labor supply depends on the ages and skills of arrivals, participation, employment, hours, and the duration of residence. Gross arrivals should be distinguished from net migration, which also reflects departures. A population projection with a migration assumption does not directly provide the number of additional workers available to a particular industry.

The American CBO projection and the Japanese IPSS scenarios both explicitly incorporate international migration, though their population perimeters and assumptions differ. Their results should therefore not be read as a choice between an aging path with migration and a path without any demographic adjustment. The

effect of migration must be assessed relative to the migration already included in the stated baseline. Counting that baseline contribution again as an additional offset would double-count it.

New residents also require housing, transport, education, healthcare, and other services. Those demands can support employment while creating local capacity pressures. The timing matters: additional labor can become available before housing construction or credential recognition is complete. A national gain can coexist with short-term local strains. The response requires coordination of service and housing capacity rather than an assumption that the population effect is exclusively on labor supply.

Qualifications and experience may not transfer immediately between countries. Recognition, language, licensing, and familiarity with local production can affect the speed of integration. A skilled entrant working below their capability still contributes economically but may not fill the intended shortage. The appraisal should follow actual matching and subsequent progression, rather than equate an educational credential or admission category with a fully productive placement on arrival.

Migrants also age. A sustained effect on the age structure depends on future flows and the characteristics of residents over time. That does not diminish the contribution of current entrants; it defines the horizon of the claim. Migration can materially support workforce adjustment without permanently fixing every dependency ratio. A credible scenario should follow cohorts rather than treat an arrival as an indefinitely young addition to the population.

Skills, capital, and the production constraint

Capital deepening can increase output from a smaller number of hours, but the asset must supply useful services. Automation may reduce repetitive tasks while requiring more maintenance, engineering, or supervision. A business replacing retiring staff needs to compare the full process, including exceptions and downtime, rather than assume that a machine's nominal capacity replaces the same number of workers in every setting.

Skills are complementary to that capital. A production system can be limited by one occupation even when aggregate labor is available. Training must occur before critical experience is lost, and the knowledge held by departing workers may not be captured in formal qualifications. A succession plan should identify tasks, failure modes, and the time needed to develop competent replacements. Aggregate educational attainment cannot establish that this transition is complete.

The supplier network creates another dependency. A plant may automate its own operations while relying on smaller suppliers with aging workforces and limited investment capacity. If a critical maintenance or component supplier exits, the lead firm's capital may be less productive. Workforce planning should therefore examine connected capabilities and not confine demographic risk to direct employees.

Care and other personal services can face a different capital-labor relationship from standardized manufacturing. Technology can improve scheduling, administration, or physical assistance without removing the need for time with people. A scenario that applies an economy-wide productivity gain uniformly to these

services can overstate the available labor saving. The distribution of demand across activities matters alongside aggregate output per hour.

Demographic change can alter that demand distribution. An older population may require a different mix of healthcare, housing adaptation, transport, and financial services. Some activities expand while others contract. Labor and capital need to move, and the skills required may not match those released elsewhere. The adjustment cost should be considered when translating an aggregate labor-supply scenario into an investment or public-service plan.

Reading the scenarios over time

Near-term age structure is partly determined by people already born. A change in fertility today does not provide adult workers next year. It can affect household demand and labor participation earlier, including through care needs. A policy evaluation should distinguish those immediate effects from the later arrival of larger cohorts into employment. Presenting a fertility measure as a near-term replacement for retiring staff confuses the calendar.

Longer horizons introduce greater uncertainty. Mortality, migration, fertility, participation, technology, and institutions can all change. Small annual differences compound over decades. The official projections' alternative variants help make that uncertainty visible, but they are not probabilities assigned to every future economic path. A business should use scenarios aligned with its investment horizon rather than select the most favorable far-future population number.

The labor-supply margins can also interact. More participation may reduce average hours; migration can affect capital needs; training can temporarily reduce current production; and higher productivity can change demand for labor. The exact accounting identity remains useful, but a scenario that varies every factor independently should be described as a sensitivity exercise. A behavioral forecast requires additional relationships and evidence.

Age composition can conceal improvements within groups

An aggregate participation rate can fall even when participation rises at every age. Consider a second hypothetical population with two adult groups. Initially, 70 percent belong to a group participating at 80 percent, and 30 percent to a group participating at 30 percent. Aggregate participation is $0.70 \times 0.80 + 0.30 \times 0.30 = 65$ percent. This population is separate from the earlier output example and supplies no additional national estimate.

Suppose the shares change to 60 and 40 percent, while participation in each group increases by two percentage points, to 82 and 32 percent. Aggregate participation becomes $0.60 \times 0.82 + 0.40 \times 0.32 = 62$ percent. The aggregate falls by three percentage points even though both groups participate more. The shift toward the lower-participating group outweighs the improvement within groups.

A symmetric decomposition makes that result exact. The within-group contribution is two percentage points because each group's increase is two points and the average population shares sum to one. The composition contribution is minus five points: the ten-percentage-point shift in population weights is multiplied by the difference between the average group participation rates, 81 and 31 percent. Together, plus two and minus five produce the observed minus three.

This distinction affects policy evaluation. A declining aggregate rate does not by itself show that retention or access measures failed; successful within-group improvements can be overwhelmed by composition. The reverse is also possible: a favorable age shift can raise the aggregate without any improvement in participation at a given age. Age-standardized measures can help isolate the within-group movement, but the actual aggregate remains relevant to the total labor supply. Both should be reported when the distinction changes the interpretation.

Dependency and the financing of services

An age-based dependency ratio is a demographic indicator, not a direct count of beneficiaries divided by taxpayers. Some older people work and pay taxes, while some younger adults receive support or remain outside paid employment. Taxes can also be raised on consumption, capital income, and other bases. Translating an age ratio into fiscal pressure therefore requires the relevant program rules, benefit amounts, revenues, and behavior.

The resource constraint remains real. More care demand can require labor, equipment, buildings, and public or private finance. A rise in aggregate productivity can help purchase those resources, but the workforce and services must still be available. A budget transfer can move purchasing power without creating a trained worker or a care place immediately. The sequence between finance and actual service capacity should therefore be explicit in an aging strategy.

Policy can also affect unpaid work. If family members provide more care, measured paid labor supply can decline while essential services continue outside the production boundary used in standard output statistics. Expanding formal care may raise measured employment and release relatives for other work, but it requires resources and can change the way activity is recorded. The evaluation should distinguish the additional service, the movement from unpaid to paid provision, and the labor made available elsewhere.

These distinctions are relevant to interpreting the four projections without overextending them. The sources establish age structure under specified assumptions. They do not provide a complete forecast of contribution revenue, service utilization, or the allocation of unpaid work. Connecting the demographic path to those outcomes is a further analytical step, requiring institution-specific evidence and a consistent account of who supplies and receives each service.

A further distinction is the income available to residents. Domestic output can be owned partly by foreign investors, while residents can receive income from assets abroad. A productive capital stock can therefore support national income through channels beyond the domestic workforce, but the ownership and risk of those returns matter. An aging assessment concerned with household resources should connect output with

disposable income and public transfers instead of assuming that a given change in GDP accrues equally to every resident. That distributional step is separate from the population and production identities developed here.

Conclusion

Population aging and smaller working-age cohorts create substantial adjustment requirements in the four economies, but demographic counts are not identical to labor input. Participation, employment, hours, skills, migration, and capital services determine how the population translates into productive work. Their statistical boundaries and time horizons should remain explicit.

The original calculation demonstrates that output can rise while employment and total hours fall, provided the assumed participation and productivity improvements are achieved. It also identifies the productivity threshold needed to maintain output under a stated labor path. The practical task is to test whether those adjustments are feasible for particular workers, industries, and places, while recognizing that aggregate output does not resolve every service or distributional consequence of demographic change.

For the sector relationship between output and jobs, see [Investment and the employment content of Indian growth](#). For capital intensity and hourly productivity, see [Explaining productivity differences across the Atlantic](#).

Source addresses

The links below retain the source addresses cited in the analysis. References should be read within their stated periods and scope.

<https://www.cbo.gov/publication/61879>

https://www.ipss.go.jp/pp-zenkoku/i/zenkoku2023/pp2023e_Summary.pdf

https://www.destatis.de/EN/Press/2025/12/PE25_446_12.html?nn=263424

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