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POLYCRISIS RESILIENCE SERIES · RESEARCH REPORT

Closing the Global Productivity Gap Through Technology Adoption

How technology diffusion can narrow the gaps between countries and strengthen Polycrisis Resilience, 2026–2100



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The concept. Polycrisis Resilience and the H Heuristics Polycrisis Resilience Framework are concepts developed by Hunter Hughes, Founder of H Heuristics.

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THE REPORT AT A GLANCE

THE DEFINITION

The **global productivity gap** is the difference in output per worker between lower- and higher-income economies. **Technology adoption** means putting existing tools and methods to work.

Technology diffusion can become a principal mechanism through which convergence builds Polycrisis Resilience.

SIX ENABLERS OF ADOPTION

- Power and connectivity
- Skills and management
- Finance
- Competition
- Institutions
- Local capability

THREE PATHWAYS TO 2100

Without absorption gaps do not narrow

2000–19 pace recent catchup continues

Enabled adoption backed by its conditions

EXECUTIVE SUMMARY

Executive Summary

A worker in a low-income country produces about one-twentieth of what a worker in a rich country produces. Technology that already exists could close part of that gap, but only where the conditions for using it are in place.

Much of what makes a society fragile in a crisis comes down to how much its people can produce. A farmer with a better seed, a shop with a mobile payment account, a factory with steady power and a clinic with a working computer all produce more value from the same hours of work. That extra value pays for flood defences, hospitals, savings and the public services that decide whether a shock becomes a catastrophe. This report asks whether adopting technologies that already exist can close the global productivity gap, and whether doing so makes the world better able to withstand interconnected crises, which is the idea of Polycrisis Resilience. The answer is a conditional yes. Technology spreads across borders faster than ever, but productivity has not followed automatically, and the evidence shows exactly where the chain breaks.

5%
is output per worker in low-income countries as a share of the high-income level in 2024: about $6,000 a year against $118,000, and no better than in 1991

24%
is the same ratio for developing economies without China and India, against 25% in 1991. Two giants account for nearly all the catch-up

22 years
is how far low-income countries are behind high-income ones in internet use, and 25 years in fixed broadband; none of the 25 low-income economies has half its people online

135 m
fewer child deaths in 2025–2100 if the typical developing economy closed its productivity gap at the pace of the top tenth, compared with no catch-up

Principal findings

- **The gap is mainly a productivity gap.** Differences in output per worker explain 86% of the differences in income per person between countries; differences in the share of people with jobs explain the rest (Figure 2). Output per worker in developing economies rose from 14% of the high-income level in 1991 to 27% in 2024, but without China and India it stayed at 24% (Figure 1).
- **Most of the gap is not about machines or buildings.** Splitting the gap into physical capital, skills and everything else, 71% of the shortfall in developing economies sits in the 'everything else' term economists call total factor productivity, 22% in skills and only 7% in capital per worker (Figure 4). That term is mostly technology and how well it is used: methods, management, organisation and the efficiency of the whole system.
- **Basic technologies spread quickly. Productive ones lag.** In lower-middle-income countries mobile subscriptions stand at 77% of the high-income level and internet use at 60%, but fixed

broadband is at 6% and electricity use per person at 10% (Figure 9). Among firms in low-income countries 57% use e-mail with customers and 26% have a website, against 94% and 68% in high-income countries, and 56% own or share a generator (Figure 10).

- **New technologies spread faster than old ones.** It took the United States 43 years for the telephone to go from 10% to 50% of households, 17 for electricity and 9 for the internet (Figure 6). Mobile phones let low-income economies skip landlines almost entirely (Figure 8).
- **Adoption is linked to productivity growth, but the link is modest and conditional.** Across 153 economies and four five-year periods, an extra percentage point a year of internet adoption goes with 0.37 points a year of extra productivity growth in developing economies after allowing for catch-up, and with nothing measurable in high-income ones (Figure 12). Among 100 developing economies, the countries with the biggest gains in internet use were no more likely than others to grow faster (26 of 50 fast adopters also grew fast) (Figure 11). Getting people online is necessary groundwork. It is not enough.
- **Productivity buys resilience.** Output per worker explains 70% of the variation in countries' lack of coping capacity but only 3% of natural-hazard exposure (Figure 13). Within a country, a 10% rise in output per worker goes with a 3.2% fall in child mortality. Tax revenue per worker is $676 in low-income countries and $18,391 in high-income ones (Figure 14), which is why the productivity gap is also a gap in the ability to protect people.
- **Three pathways to 2100 lead to very different worlds.** If adoption does not turn into catch-up, developing economies fall from 27% to 20% of high-income output per worker by 2100; if they keep their 2000–19 pace they reach 39%; if adoption is backed by the conditions that make it pay, at the pace of the best-performing tenth of economies, they reach 54%. Cumulative child deaths in 2025–2100 are 285, 187 and 150 million. These are conditional illustrations, not forecasts (Section 11).

How to read this report

Sections 1 to 3 state the question and measure the gap and its sources. **Sections 4 to 6** examine adoption: the theory, the record and the difference between access and use. **Section 7** tests whether adoption raises productivity, **Section 8** looks at five technology families and **Section 9** links productivity to resilience. **Sections 10 to 13** cover barriers, three pathways to 2100, a strategy and what to watch. All data are public and limits are stated where they apply.

CONCEPTS

The two definitions used in this report

The global productivity gap is the difference between how much a typical worker in a lower-income economy produces and how much a typical worker in a higher-income economy produces, measured in the same prices.

Technology adoption is the process through which firms, farms, households and governments start using tools, methods and ways of organising work that already exist elsewhere, rather than inventing them.

In the H Heuristics framework, closing the productivity gap is a proactive vulnerability-reduction strategy: higher productivity expands the economic resources that households, firms and governments have to prepare for, absorb and recover from shocks. (Hughes, 2026a)

SECTION 01

Why the Gap Is a Resilience Issue

The structural inequality between rich and poor economies is not mainly one of effort or of resources in the ground. It is a difference in how much a day's work yields, and that difference decides how well societies withstand shocks.

IN BRIEF

- Productivity is the value a worker produces; it is the basis for wages, taxes, savings and public services.
- Technologies that took decades to spread in rich economies can reach emerging economies much faster, sometimes skipping stages.
- In the Polycrisis Resilience framework, closing the productivity gap is a proactive way to reduce vulnerability.

1.1 A structural inequality

Global productivity disparities are one of the underlying structural inequalities of the international economic system. In 2024 a worker in a high-income economy produced about $118,000 of goods and services a year, measured in international dollars of constant 2021 purchasing power. A worker in an upper-middle-income economy produced $44,000, in a lower-middle-income economy $22,000 and in a low-income economy $6,000 (World Bank, 2026). The differences come from technological capabilities, infrastructure, industrial development, schooling and access to productive capital. Together they determine how much output a country can generate from its available labour and resources.

These gaps are large in absolute terms and persistent over time. The world has about 3.5 billion workers, and 1.3 billion of them, nearly two in five, live in low- and lower-middle-income economies where output per worker is under one-fifth of the high-income level. Low productivity does not mean working less. People in poorer countries often work more hours, but with less equipment, weaker infrastructure, less schooling and older methods.

1.2 Technology adoption as an opportunity

Technology adoption offers an important opportunity to narrow these disparities. The point is easy to miss, so it is worth stating plainly: a country does not need to invent the tools it uses. Technologies that took decades to become widespread in advanced economies can often be adopted much more quickly elsewhere, particularly when newer infrastructure and accessible digital technologies allow economies to bypass legacy development pathways. Mobile networks reached villages that never had landlines. Solar panels power homes that were never connected to a grid. Mobile money lets people who have never seen a bank branch save, pay and borrow. Emerging economies can accelerate productivity growth by adopting what exists rather than relying only on slow domestic invention (Gerschenkron, 1962; Abramovitz, 1986; Comin and Hobijn, 2010).

1.3 Why this is a Polycrisis Resilience question

A polycrisis is a cluster of crises in different systems, such as climate, health, finance, energy, food and security, whose causes and effects are tangled together so that the combined damage exceeds the sum of the parts (Lawrence et al., 2024; Lawrence et al., 2022). Disaster researchers describe harm as the product of hazard, exposure and vulnerability (UNDRR, 2017; IPCC, 2023). Hazards are largely outside any country's control. Vulnerability is not. It is the part that depends on the economic conditions in which a shock lands: buildings, power, health systems, savings, public finances and institutions.

Within the H Heuristics Polycrisis Resilience framework, closing the global productivity gap is therefore a proactive vulnerability-reduction strategy (Hughes, 2026a). Higher productivity can expand economic resources, improve household living standards, strengthen public finances, support infrastructure investment and increase the capacity of societies to withstand interconnected disruptions. The earlier report in this series examined the wider process of global economic convergence (Hughes, 2026f). This report examines one of its most important mechanisms, the diffusion of technology.

THESIS

The central argument

Technology diffusion can become one of the principal mechanisms through which global economic convergence contributes to Polycrisis Resilience.

Link 1. Adopting existing technologies raises output per worker faster than inventing new ones can.

Link 2. Higher output per worker pays for the buffers, infrastructure and services that reduce vulnerability.

Condition. Neither link is automatic. Adoption turns into productivity only when power, skills, finance, competition and institutions are in place, and the evidence below shows how often they are not.

1.4 What this report does

The report uses public data on 217 economies. It measures the productivity gap from 1991 to 2024 and traces its sources, asks how fast and how deeply technologies have spread, and tests whether adoption goes with faster productivity growth. It then links productivity to resilience, models three pathways to 2100 and proposes a strategy.

SECTION 02

How Large Is the Global Productivity Gap?

Measured as output per worker, the gap between low-income and high-income economies is about twenty to one. It has barely moved for low-income countries and has closed mainly in two very large economies.

IN BRIEF

- Output per worker is $6,000 in low-income and $118,000 in high-income economies (2024).
- 86% of the differences in income per person between countries is a difference in output per worker.
- Developing economies caught up from 14% to 27% of the high-income level, but only 24% without China and India.

2.1 Measuring productivity

Productivity is output per unit of input. The most common simple measure, and the one used here, is output per worker: the total value of goods and services an economy produces in a year divided by the number of people in work. Output is measured in 'international dollars' that adjust for differences in prices between countries (purchasing power parity), so that a dollar buys the same bundle of goods everywhere, and is fixed at 2021 prices so that inflation does not distort comparisons over time (World Bank, 2026). This is the right measure for the question asked here because it captures how much each working person adds to the economy's capacity to pay for protection and recovery.

Output per worker is not the only measure. Economists also use output per hour, which corrects for the fact that workers in some countries work longer; and 'total factor productivity', which asks how much output a country gets from its capital and labour combined. Section 3 uses the second.

2.2 The gap in 2024

The table below sets out output per worker for each World Bank income group in 1991 and 2024, and for developing economies as a whole with and without China and India, which together hold roughly 40% of the world's workers and have dominated the aggregate picture.

The first message of the table is the size of the spread. A worker in a low-income country produces $6,026 a year; in a lower-middle-income country $21,802; in an upper-middle-income country $44,098; in a high-income country $118,396. The richest handful of economies, Luxembourg, Ireland, Singapore, Macao and Norway, sit far above even that, with $265,000 or more per worker, while the ten least productive economies, including Burundi, Central African Republic, Madagascar, produce about $4,000 per worker. The second message is how little the low-income ratio has moved. In 1991 a low-income worker produced 6% of what a high-income worker produced;

Table 1 Output per worker by income group, 1991 and 2024

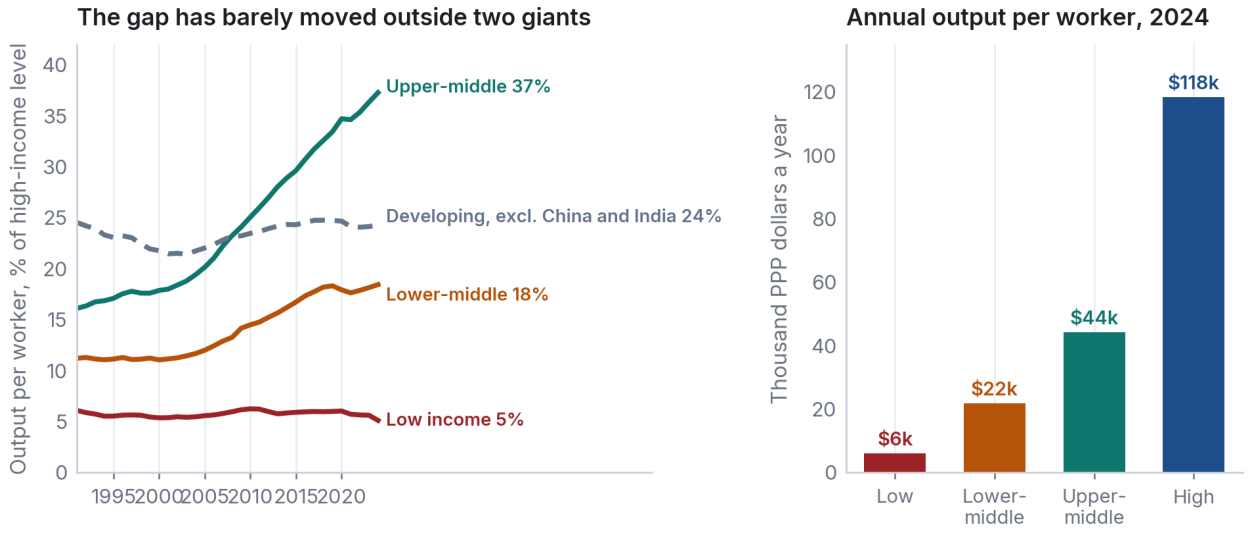
Income group	Workers, bn (2024)	Output per worker 1991	Output per worker 2024	% of high-income 1991	% of high-income 2024
Low income	0.22	$4,731	$6,026	6%	5%
Lower-middle income	1.12	$8,723	$21,802	11%	18%
Upper-middle income	1.44	$12,543	$44,098	16%	37%
High income	0.69	$77,977	$118,396	100%	100%
Developing economies, all		$10,909	$32,136	14%	27%
Developing economies, without China and India		$19,108	$28,738	25%	24%

Source: World Bank WDI, GDP per person employed, constant 2021 PPP dollars (World Bank, 2026); H Heuristics calculations. Group values are total output divided by total employment, using implied employment; groups are current World Bank classes.

in 2024 the figure was 5%. Output per worker in low-income countries has grown, but only as fast as in rich countries, so the gap has not closed.

Figure 1 The productivity ratio has risen for middle-income economies, but not for low-income ones and not outside China and India

Left: output per worker as % of the high-income group, 1991–2024. Right: output per worker in 2024, thousand PPP dollars



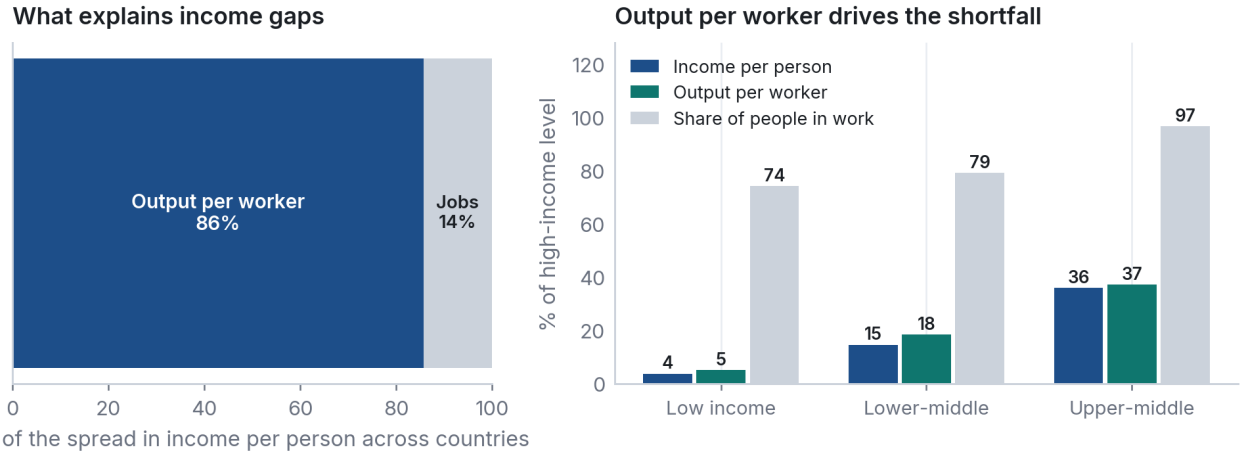
Source: World Bank WDI GDP per person employed (constant 2021 PPP $) (World Bank, 2026); H Heuristics calculations. Group values are total output ÷ total employment; economies with data in each year.

2.3 Income gaps are productivity gaps

Income per person equals output per worker multiplied by the share of the population that is working. If poorer countries were poorer because fewer of their people have jobs, the second term would explain the gap. It does not. Across 176 economies in 2023, differences in output per worker account for 86% of the variation in income per person, and differences in the share of people at work for 14% (Figure 2). In low-income countries, income per person is 4% of the high--income level: output per worker is 5% and the employed share of the population is 74% of the rich-country figure. Employment gaps matter at the margin, especially for women and young people. The core of the problem is that each job yields too little.

Figure 2 Output per worker, not the number of jobs, explains most of the income gap between countries

Left: what explains the spread of income per person. Right: income per person, output per worker and the working share of the population, as % of high-income level



Source: World Bank WDI (World Bank, 2026); H Heuristics calculations. Left: share of cross-country variance in log income per person accounted for by log output per worker and by log employment ratio (2023, 176 economies). Right: group ratios to the high-income group (2024).

2.4 Who closed the gap, and who did not

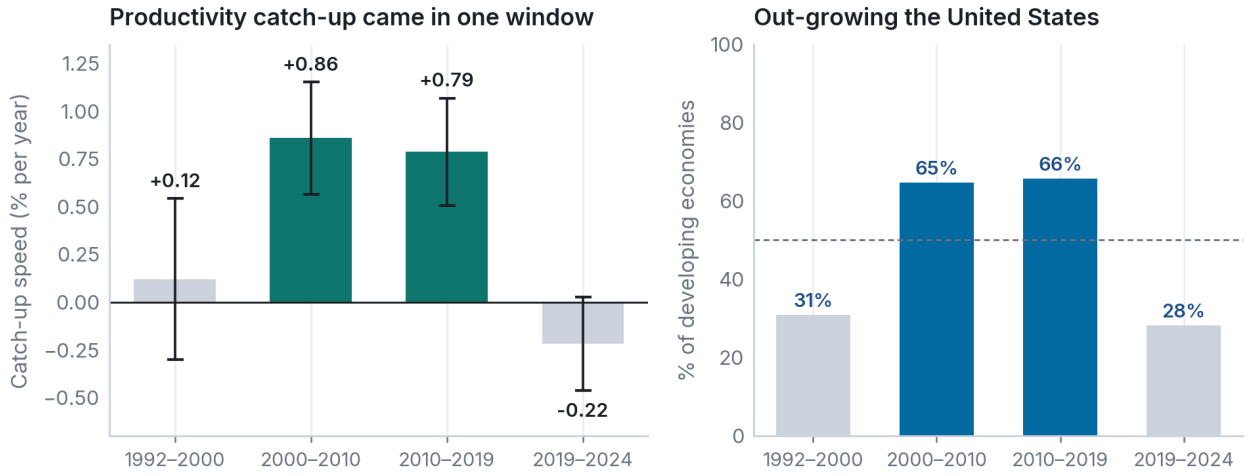
The aggregate hides a very uneven story. Developing economies as a group went from 14% to 27% of the high-income level between 1991 and 2024. But when China and India are removed, the group stood at 25% in 1991 and 24% in 2024: output per worker grew 1.2% a year, the same as the 1.3% in high-income economies. The economies that caught up fastest in output per worker between 2000 and 2023 were mostly in Central Asia, the Caucasus and East Asia: Turkmenistan, Georgia, Kazakhstan and China, which rose from 7% to 29% of the US level. Among 101 developing economies with more than a million people, 45 gained more than one percentage point against the United States, 34 lost more than one and 22 barely moved; countries including Gabon, Libya and Mexico lost ground. Of 20 low-income economies with data, only 5 more than doubled their output per worker between 1991 and 2023, and 9 grew by less than 20% in 32 years.

2.5 Catch-up came in one window

The timing is as important as the geography. Regressing each economy's annual growth in output per worker on its starting level, the slope shows how fast poorer economies grew relative to richer ones. In the 1990s there was no catch-up (the estimate is +0.12, not distinguishable from zero). In 2000–2010 and 2010–2019 there was clear catch-up: a developing economy at half the productivity of another grew roughly 0.6 percentage points a year faster. After 2019 the slope turned slightly the other way (-0.22). The share of developing economies growing faster than the United States followed the same pattern: 31% in the 1990s, 65% in 2000–10, 66% in 2010–19 and 28% in 2019–24 (Figure 3). The 2000–2019 window overlaps with the commodity boom, China's rise, the spread of mobile phones and cheap capital. Whether it was the new normal or an exception is the question that technology adoption has to answer (Patel et al., 2021; Kremer et al., 2022).

Figure 3 Productivity catch-up was strong in 2000–2019 and disappeared after 2019

Left: catch-up speed, % per year (positive = poorer economies growing faster). Right: share of developing economies outpacing the US



Source: World Bank WDI GDP per person employed (World Bank, 2026); H Heuristics calculations. Left: slope of annualised growth on log starting output per worker, economies above 1 million people (188–196 per period), 95% ranges from robust standard errors. Right: share of developing economies whose growth exceeded the US.

SECTION 03

Where the Gap Comes From

A worker's output depends on the machines, skills and know-how around that worker, and on how efficiently those are used. Development accounting shows that know-how and efficiency, not machines, account for most of the difference.

IN BRIEF

- About 71% of the output-per-worker gap in developing economies is 'productivity' in the narrow sense, 22% skills and 7% physical capital.
- In low-income countries 61% of workers farm, and a farm worker produces about 31% of what a worker in other sectors produces.
- Inside every economy there is a gap between frontier firms and the rest.

3.1 Three building blocks of output per worker

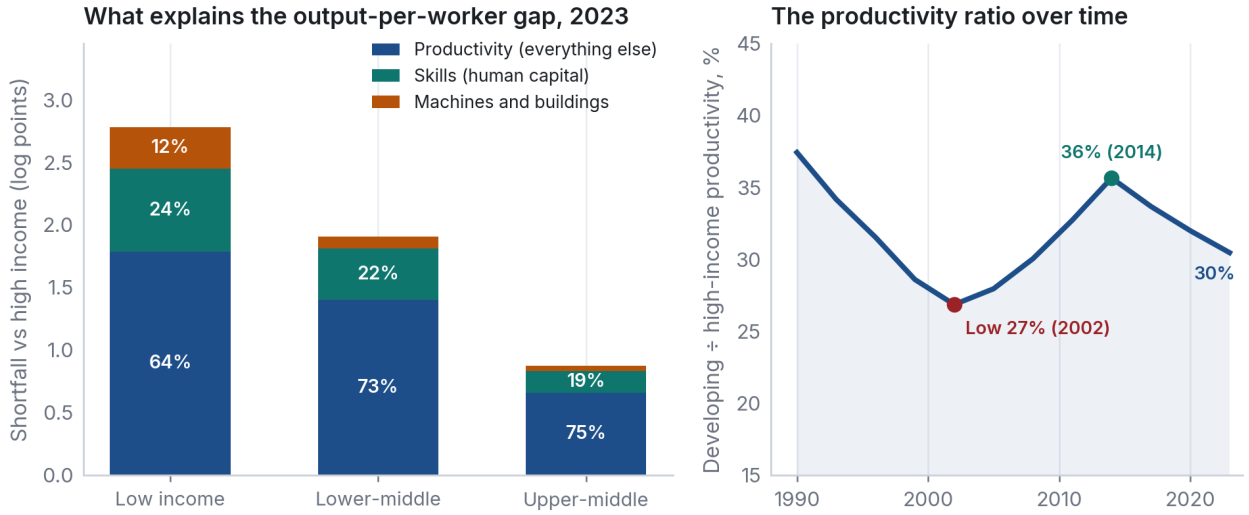
To understand where the gap comes from, economists split output per worker into three parts. The first is *physical capital* per worker: machines, buildings, roads and equipment. The second is *human capital*: the skills and health that workers bring, proxied here by years of schooling and the returns to them. The third is everything else, which economists call *total factor productivity* (TFP): how much output a country gets from a given set of inputs. TFP reflects technology, management, organisation, institutions, the quality of the infrastructure that connects workers and firms, and how efficiently resources are allocated between uses. It is measured as a residual, so it also absorbs any measurement error, and it should be read as the part of the gap that machines and schooling do not explain (Hall and Jones, 1999; Caselli, 2005).

Using the Penn World Table 11.0, which provides comparable capital, schooling and output data for 2023 (Groningen Growth and Development Centre, 2025; Feenstra et al., 2015), the shortfall in output per worker of a typical developing economy relative to a typical high-income one is 1.68 in logarithms (a factor of about 5). Of that, capital per worker accounts for 7%, schooling for 22% and TFP for 71% (Figure 4). The result holds if the weight on capital is varied: with a capital share of one-quarter or two-fifths, TFP still accounts for 64% to 71% of the gap. Across all 133 economies in the sample, TFP accounts for 79% of the variance in output per worker, schooling for 19% and capital for 2%.

Over time the productivity ratio has moved in a recognisable way. The ratio of developing to high-income TFP fell from 37% in 1990 to a low of 27% around 2002, recovered to 37% in 2014 and slipped back to 30% by 2023. This follows the pattern of catch-up in Section 2. A high-income worker has about 9 times the capital of a lower-middle-income worker, but capital per unit of output in developing economies is 73% of the high-income ratio, so the shortage is far smaller than the shortage per worker.

Figure 4 Most of the output-per-worker gap is productivity in the broad sense, not machines; the ratio fell until 2002, recovered until 2014 and has slipped since

Left: shortfall relative to high-income economies, 2023, split into three parts. Right: developing-economy TFP as % of high-income, 1990–2023



Source: Penn World Table 11.0 (Groningen Growth and Development Centre, 2025; Feenstra et al., 2015); H Heuristics calculations. Output per worker = (capital ÷ output)^(α/(1−α)) × human capital × TFP, α = 1/3. Averages of logs across economies above 1 million people (86 developing, 47 high-income in 2023); labelled shares are of each group's shortfall.

3.2 Inside the economy: farms and firms

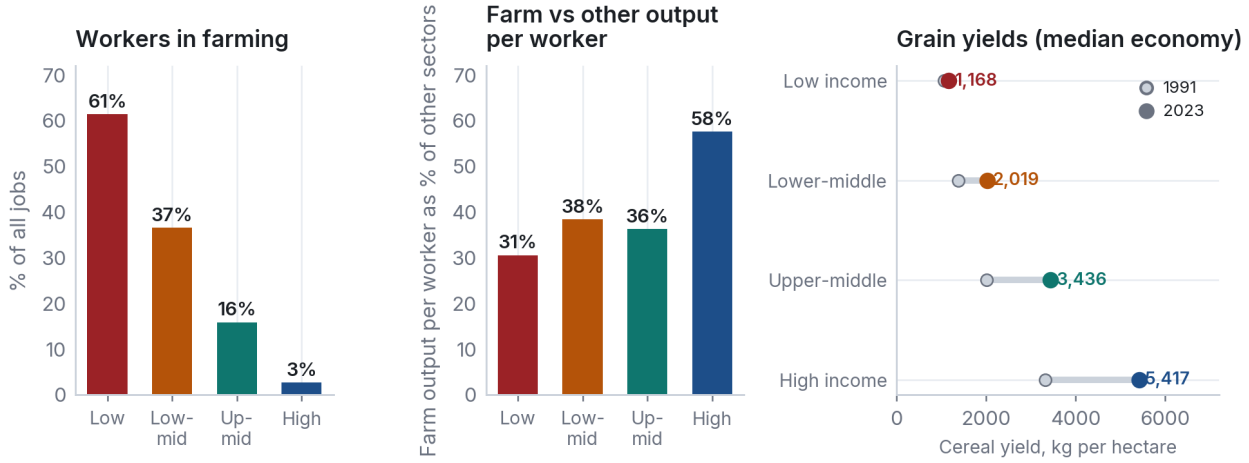
Within every country there is also a productivity gap between sectors. In low-income economies the median share of workers in farming is 61% but farming generates only 29% of value added, so a farm worker produces about 31% of what a worker in the rest of the economy produces. In high-income economies 3% of workers farm, and a farm worker's output is 58% of the average elsewhere (Figure 5). Part of this 'agricultural productivity gap' reflects hours, schooling and measurement, but a large part remains after adjusting for them, and moving workers from low-productivity farms to higher-productivity activities is one of the main routes to catch-up (Gollin et al., 2014).

Farm technology is a clear example of unused existing know-how. The median low-income economy produced 1,168 kilograms of cereal per hectare in 2023, against 5,417 in high-income economies. Since 1991 low-income yields have risen by 11% and high-income yields by 63%. Fertiliser use is about 7 kilograms per hectare in the median low-income economy, against 130 in high-income ones. Where yields did rise strongly, as in Brazil, South Africa, Cambodia or Paraguay, they did so with improved seeds, machinery, fertiliser and farm services, which are all technologies that exist and can be adopted (Duflo et al., 2011; Suri, 2011).

The same pattern repeats inside manufacturing. In India and China, the efficiency with which capital and labour are allocated across firms is so low that moving to the United States' allocation could raise manufacturing TFP by tens of per cent (Hsieh and Klenow, 2009). In a randomised study of Indian textile plants, firms given free management consulting raised productivity by about 17% in the first year, and the practices were simple, such as keeping records and maintaining machinery (Bloom et al., 2013). These results do not say that technology is unimportant. They say that technology is mixed up with management, organisation and competition, which is why adoption alone does not produce productivity.

Figure 5 A large share of workers farm at a fraction of the productivity of other sectors, and grain yields in poor countries have barely risen since 1991

Left: farm share of jobs. Middle: farm output per worker as % of other sectors. Right: cereal yield, kg per hectare, 1991 and 2023



Source: World Bank WDI (World Bank, 2026). Median economy per group, latest year 2017–24 for sector shares (22–58 economies per group); cereal yield 1991 and 2023. Relative farm productivity = (farm value-added share ÷ farm employment share) ÷ (non-farm value-added share ÷ non-farm employment share).

3.3 Seven explanations of the gap and what the evidence says

Economists have proposed several explanations for why output per worker differs so much between countries. They are not exclusive and they reinforce one another: poor infrastructure raises the cost of better machines, weak management wastes them, and weak institutions discourage the investment that would fix both.

Table 2 Seven explanations of the productivity gap, and the evidence on each

Explanation	Claim	What the evidence shows
Capital shortage	Poor countries lack machines and buildings	Explains about 7% of the gap; capital per unit of output is not far apart (Caselli, 2005)
Skills shortage	Workers lack the schooling to use better methods	Explains about 22% of the gap, and complements technology (Acemoglu and Zilibotti, 2001)
Technology gap	Poor countries use older methods	Likely the largest part of the TFP residual; adoption lags have narrowed but intensity of use has not (Comin and Mestieri, 2018; Parente and Prescott, 1994)
Weak management	Firms are run with poor practices	Randomised management help raised productivity in Indian plants (Bloom et al., 2013)
Misallocation	Resources sit in low-productivity firms and farms	Large potential TFP gains in China and India (Hsieh and Klenow, 2009); farm productivity gap (Gollin et al., 2014)
Weak infrastructure	Unreliable power, transport and connectivity raise costs	56% of firms in low-income countries run a generator, against 14% in high-income ones (World Bank, 2026)
Weak institutions	Poor governance blocks investment and competition	Social infrastructure, meaning institutions and policies, is strongly linked to productivity levels (Hall and Jones, 1999)

Source: H Heuristics synthesis of the cited literature and the calculations in this report.

SECTION 04

Adoption as a Catch-Up Mechanism

Poorer economies do not have to repeat the history of richer ones. They can borrow what already works. The theory explains why adoption is cheaper than invention, and why it still often fails.

IN BRIEF

- Adopting a technology is far cheaper than inventing it, which is the source of the 'advantage of backwardness'.
- Technology travels through trade, investment, people, copying and learning by doing.
- Adoption has two parts: how soon a technology arrives, and how intensively it is used. Poor economies have mostly closed the first gap, not the second.

4.1 Why adopting is cheaper than inventing

Inventing a technology requires research, experiments that fail, and years of improvement before it works at scale. Adopting it means paying for the finished product and learning to use it. The economic historian Alexander Gerschenkron described this in the 1960s as the advantage of relative backwardness: a latecomer can skip the costly experiments and install the best equipment directly, and Moses Abramovitz added that this potential for catching up is realised only if a country has the 'social capability' to absorb the technology, meaning education, institutions and the ability to invest (Gerschenkron, 1962; Abramovitz, 1986). The idea explains why economies such as postwar Japan, South Korea, Taiwan and later China could grow at 7–10% a year for decades, far faster than the frontier, and why growth of that speed is not seen in the leading economies (Baumol, 1986).

The same logic applies to the mechanisms in this report. When the typical developing economy raises output per worker by adopting an existing technology, it receives the full productivity benefit but pays only a fraction of the research cost. If adoption were free and instant, the productivity gap would close quickly. It has not closed, which means that something makes adoption slow, partial or unproductive. Economists have found at least four obstacles, discussed in the rest of this section: barriers to using the technology, incomplete channels of diffusion, mismatch between the technology and local conditions, and the need for complementary inputs.

4.2 How technology travels

Economists distinguish several channels through which technology moves between countries (Keller, 2004). **Trade** brings imported machines, parts and software, and exposes firms to competitors who use better methods. **Foreign direct investment** brings entire production systems, including management practices and supplier standards, and trains local workers who may later move to local firms. **People** carry know-how: returning migrants, diaspora networks, foreign-educated students and visiting experts. **Imitation and reverse engineering** allow firms to copy what they see. And **learning by doing** within firms and industries spreads practical skills. Digital technologies add a sixth: **information** that travels at near-zero cost, from video tutorials for farmers to online marketplaces that show prices, standards and buyers. Each channel can be strengthened or blocked by policy.

One result stands out in the data of this report. Every channel has a lag: technologies reach the typical low-income economy years or decades after they reach rich ones (Section 5). The lag is partly about cost and partly about readiness, since a country needs the electricity, the connectivity and the trained people before a technology pays. The key question for the strategy is therefore how much of the lag is a matter of waiting for prices to fall, and how much can be shortened by deliberately building the conditions for adoption.

4.3 Two margins: when it arrives, and how intensively it is used

Adoption has two dimensions. The *extensive margin* is whether and when a technology first arrives in a country, which depends on its cost, on trade and on awareness. The *intensive margin* is how widely it is used once it has arrived: how many firms, farms and households use it, and how fully. Using data on 25 major technologies over two centuries, Diego Comin and Martí Mestieri found that the lag in first adopting new technologies has shrunk markedly for poor countries, but the intensity with which they use technologies, relative to rich countries, has diverged. Their calculations suggest that this divergence in intensity is the main reason income gaps kept widening in the twentieth century (Comin and Mestieri, 2018; Comin and Hobijn, 2010). A country can 'have' mobile phones, computers or tractors in the sense that they exist in the economy while using too few of them, too slowly, in too few firms, to change productivity.

This distinction organises Sections 5 and 6. Section 5 asks about the extensive margin, how soon technologies arrive, and finds good news. Section 6 asks about the intensive margin, how deeply they are used, and finds that this is where the gap remains.

4.4 Why the benefits are not automatic

Three ideas from economics explain why a technology in the country is not the same as a technology that pays. The first is *barriers to adoption*: regulation, monopolies, trade restrictions, weak property rights and the cost of switching can block the use of better methods, and small differences in such barriers can create large differences in productivity (Parente and Prescott, 1994). The second is *appropriate technology*: technologies are designed for the conditions of the countries that develop them, which are rich, skilled and capital-intensive, and may not fit the skill mix, the power supply or the market size of poorer countries (Acemoglu and Zilibotti, 2001). The third is *complementarity*. Production often depends on many tasks, each of which must work. If one weak link, such as power that fails or a worker who lacks training, drags down the whole, then the gains from improving other links are small (Kremer, 1993). The practical message is that technologies come in bundles with their complements: electricity, spare parts, skills, finance, and trusted institutions.

Table 3 The adoption chain: from access to resilience

Link	Question	Typical indicator	Where the evidence is
1. Access	Does the technology exist in the economy?	Mobile coverage, power connection, available seed or software	Section 5
2. Use	Do people and firms actually use it?	Internet users, mobile-money accounts, firms with websites	Sections 5 and 6
3. Depth	Do they use it for productive work, reliably?	Fixed broadband, electricity use per person, secure servers	Section 6
4. Productivity	Does output per worker rise?	Output per worker, TFP, yields	Section 7
5. Resilience	Do households, firms and governments cope better with shocks?	Coping capacity, child survival, tax revenue per worker	Section 9

Source: H Heuristics framework; indicators are those used in this report.

The chain in the table is the thread of the report. Most public discussion stops at link 1 or 2, counting connections and devices. The evidence below suggests that the weaker links are 3 and 4, and that resilience (link 5) depends on whether the chain holds from end to end.

SECTION 05

The Record of Diffusion

Technologies are spreading faster than ever, and low-income economies are catching up in access to them. The lag has not vanished, and it is longest for the technologies that matter most for production.

IN BRIEF

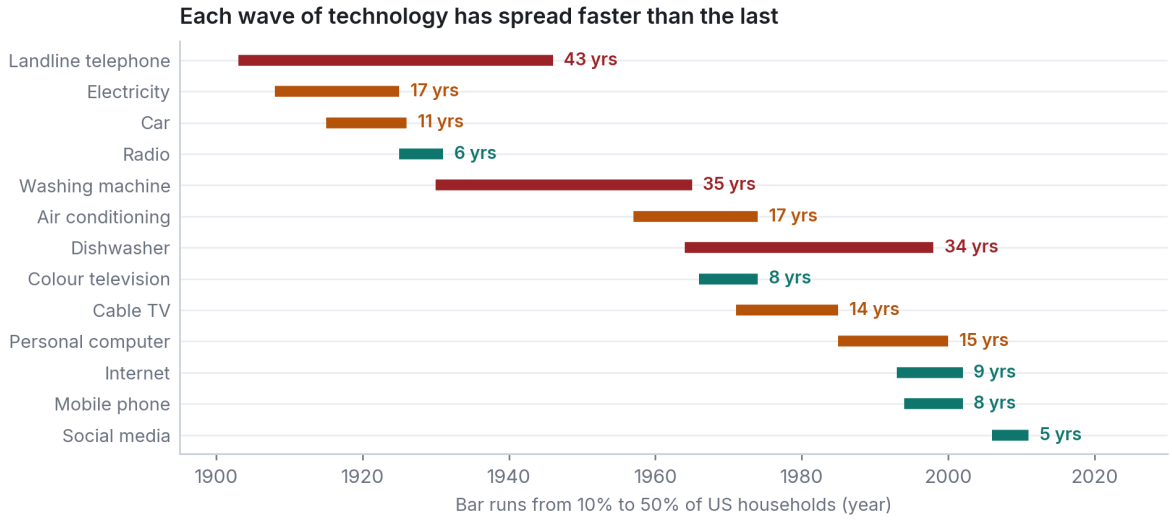
- The telephone took the United States 43 years to go from 10% to 50% of households; the internet took 9 and social media 5.
- Half of lower-middle-income economies passed 50% internet use by 2020, about 13 years after high-income ones; no low-income economy has done so.
- Mobile phones let developing economies skip landlines almost entirely.

5.1 Each wave has spread faster than the last

The history of American households gives the clearest picture of how adoption speeds have changed. Using the United States household series, the time to go from 10% to 50% of households was 43 years for the landline telephone (1903 to 1946), 17 for electricity (1908 to 1925), 35 for the washing machine, 15 for the personal computer, 9 for the internet, 8 for the mobile phone and 5 for social media (Figure 6). Long adoption times for older technologies partly reflect the need to build networks of wires and pipes. Technologies that run on existing networks spread faster, and so do those that are cheap relative to income. This matters for developing economies: the technologies of the digital age spread in less time than those of the industrial age, because the networks were already partly in place (Comin and Hobijn, 2004; Comin and Hobijn, 2010).

Figure 6 Technologies that rode on existing networks spread in a fraction of the time that older ones took

Time to reach half of US households, by technology (selected)



Source: Comin and Hobijn technology-diffusion series for US households, via Our World in Data (Comin and Hobijn, 2004); H Heuristics calculations. Each bar runs from the year 10% of US households had the technology to the year 50% did. Colours: 10 years or less, 11–20 years, more than 20 years.

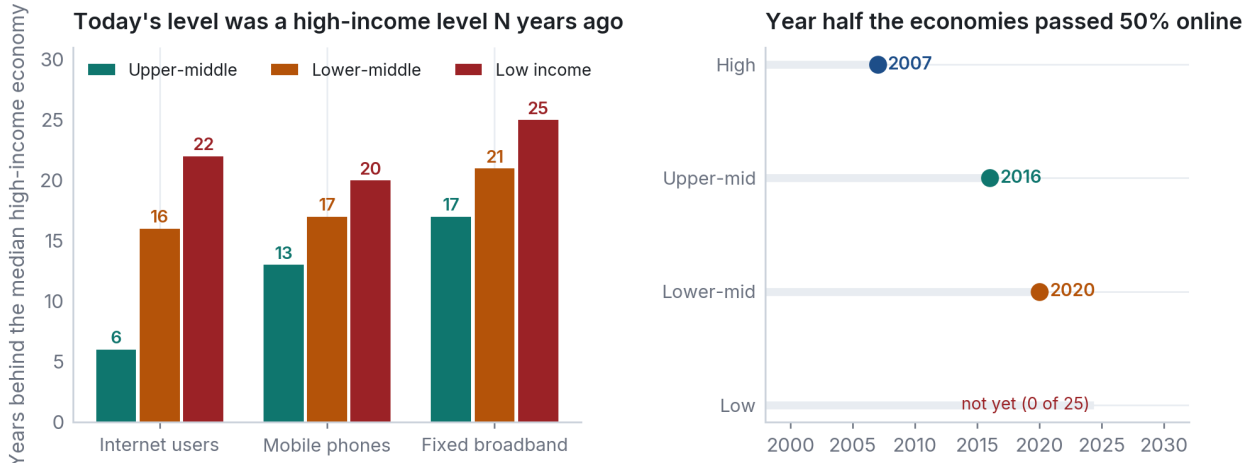
5.2 The lag for low-income economies, and how it is shrinking

The same technologies have reached other countries with a delay that can be measured. The median high-income economy passed 10% internet use in 2000, upper-middle-income economies in 2006, lower-middle-income ones in 2012 and low-income ones in 2016. The gap to 50% is wider: 2007 for high-income, 2016 for upper-middle and 2020 for the 26 of 47 lower-middle-income economies that have reached it. None of the 25 low-income economies has half its people online. For mobile phones the lags are shorter: half of all economies in each group had at least 50 subscriptions per 100 people by 2002 (high income), 2006, 2010 and 2013 (low income), a delay of 11 years between the richest and the poorest groups.

The lag can also be read in a second way. Take the level that each group has today and ask when the median high-income economy had it. Lower-middle-income economies have an internet-use level that high-income ones had 16 years ago, and low-income ones 22 years ago. For mobile subscriptions the equivalents are 17 and 20 years, although subscriptions above 100 per 100 people reflect multiple SIM cards and make this measure less clear. For fixed broadband the lags are 21 and 25 years (Figure 7). The lag is shortest for upper-middle-income economies (6 years for the internet) and grows as income falls and as the technology becomes more demanding. That is the intensive margin showing up in the data.

Figure 7 Lags are shortest for basic connections and longest for the technologies that need more infrastructure

Left: years behind the median high-income economy. Right: year half of economies passed 50% internet use



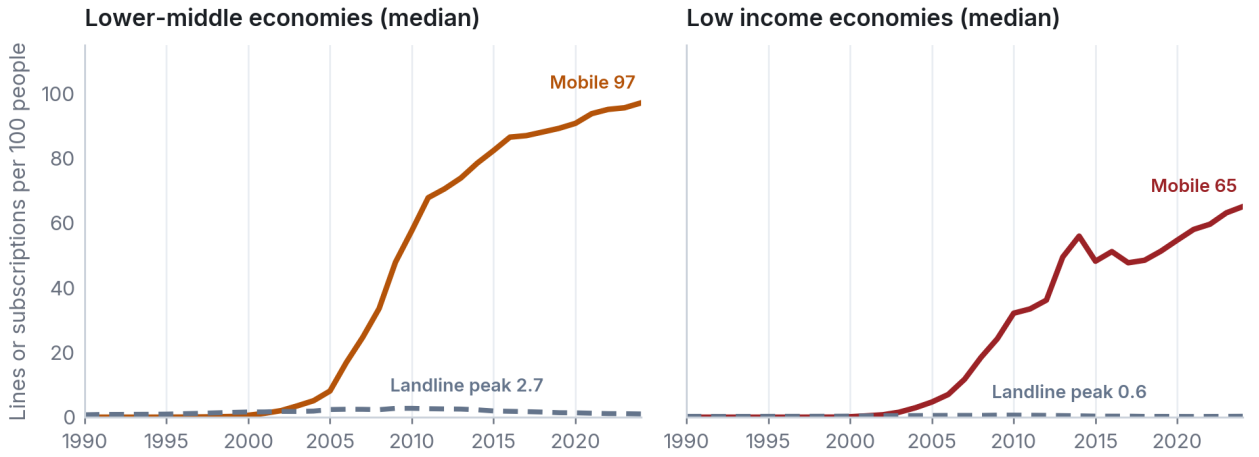
Source: World Bank WDI (World Bank, 2026); H Heuristics calculations. Left: years since the median high-income economy had the level that each group's median economy has in 2024 (series start 1990, so lags are lower bounds for fixed broadband). Right: median year economies passed 50% internet use.

5.3 The mobile leapfrog

The clearest case of bypassing is the telephone. Landlines needed copper wire to every home, and a fixed line cost far more than the average household could afford. In the median lower-middle-income economy, landline subscriptions never rose above 2.7 per 100 people, and in the median low-income economy above 0.6. Mobile subscriptions, by contrast, went from almost none in 2000 to 97 per 100 in the lower-middle-income median and 65 in the low-income median in 2024 (Figure 8). A whole generation of telephone infrastructure was skipped, and the speed of the shift came from a combination of falling handset costs, prepaid billing, competition between operators and towers that could be built without a rail or road network (Aker and Mbiti, 2010).

Figure 8 Mobile phones bypassed landlines: fixed-line telephony never reached more than a few lines per 100 people in poorer economies

Mobile subscriptions and landlines per 100 people, 1990–2024, lower-middle-income and low-income medians



Source: World Bank WDI (World Bank, 2026); H Heuristics calculations. Median economy within each income group; mobile subscriptions can exceed 100 per 100 people because of multiple SIM cards.

The internet followed. Between 2000 and 2024, internet use rose by at least 40 percentage points in 76% of 116 developing economies, and by a median of 65 points Weighted by population, the share of people online in 2024 was 93% in high-income economies, 86% in upper-middle-income, 59% in lower-middle-income and 20% in low-income economies. Globally about 6 billion people were online in 2025 and 2.2 billion were not, of whom 96% lived in low- and middle-income countries; internet use was 94% in high-income and 23% in low-income countries (ITU, 2025). Fast adoption did happen. The next section asks what it has meant for production.

SECTION 06

The Ladder from Access to Use

Having a phone is the first rung. Productive use needs reliable power, fast connections, skills and systems. On those higher rungs the gap between rich and poor economies is still very large.

IN BRIEF

- Lower-middle-income economies are at 77% of the high-income level in mobile subscriptions, 6% in fixed broadband and 10% in electricity use per person.
- Firms in low-income countries are as likely to licence foreign technology (14%) as rich-country firms (14%), yet far less likely to have a website (26% vs 68%).
- 56% of firms in low-income countries run a generator; 47% say electricity is a major obstacle.

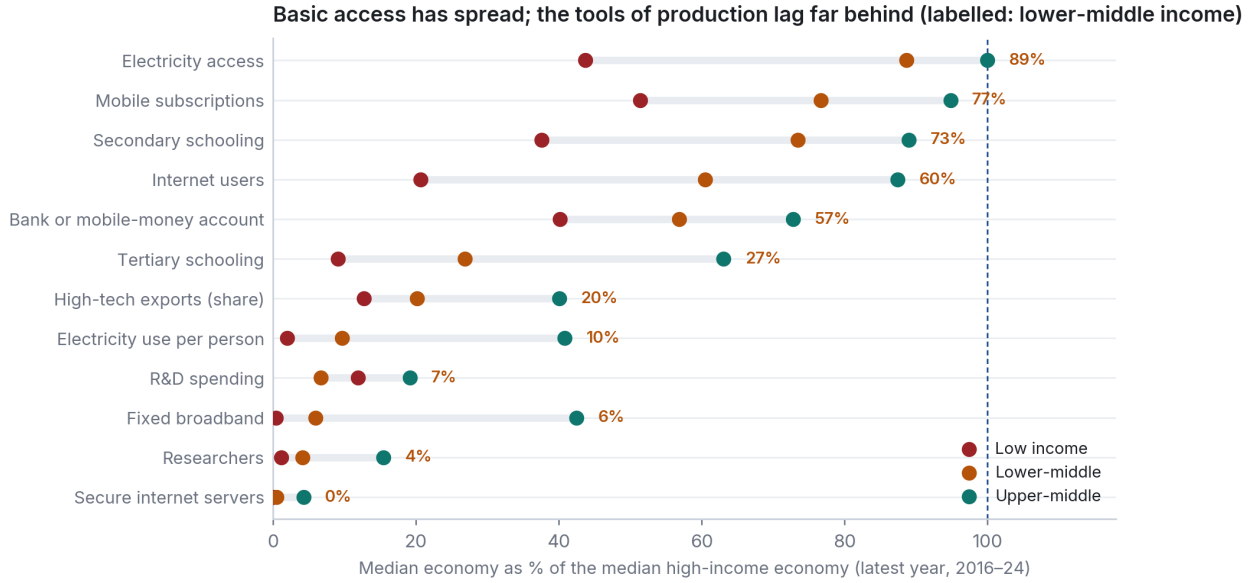
6.1 From first access to productive use

Think of technology adoption as a ladder. The bottom rungs are basic access: a mobile subscription, an electricity connection, an account. The middle rungs are the services that need networks and reliability: fixed broadband, steady power, schooling to the secondary level. The top rungs are the capabilities of an advanced economy: secure data systems, researchers, research spending and high-technology exports. Everything above the bottom rungs is about depth of use, which is the intensive margin of Section 4.

Figure Figure 9 places the median economy in each group on this ladder as a share of the high-income median. The pattern is clear. In lower-middle-income economies the basics are mostly in place: 89% of the high-income level for electricity access, 77% for mobile subscriptions, 73% for secondary schooling and 60% for internet use. Further up the ladder the ratio collapses: 27% for tertiary schooling, 10% for electricity use per person (the typical lower-middle-income economy uses about 615 kilowatt-hours per person a year, against 6,386 in high-income ones), 6% for fixed broadband, 4% for researchers and 0.5% for secure internet servers. In low-income economies the picture is the same, only lower on every rung.

Figure 9 **Basic access has spread, but the tools of production are far behind**

Median developing economy as % of the median high-income economy, by indicator, from basic to advanced



Source: World Bank WDI and Global Findex (World Bank, 2026; World Bank, 2025); H Heuristics calculations. Latest value 2016–24 per economy; median by income group as % of the median high-income economy (68–215 economies per indicator).

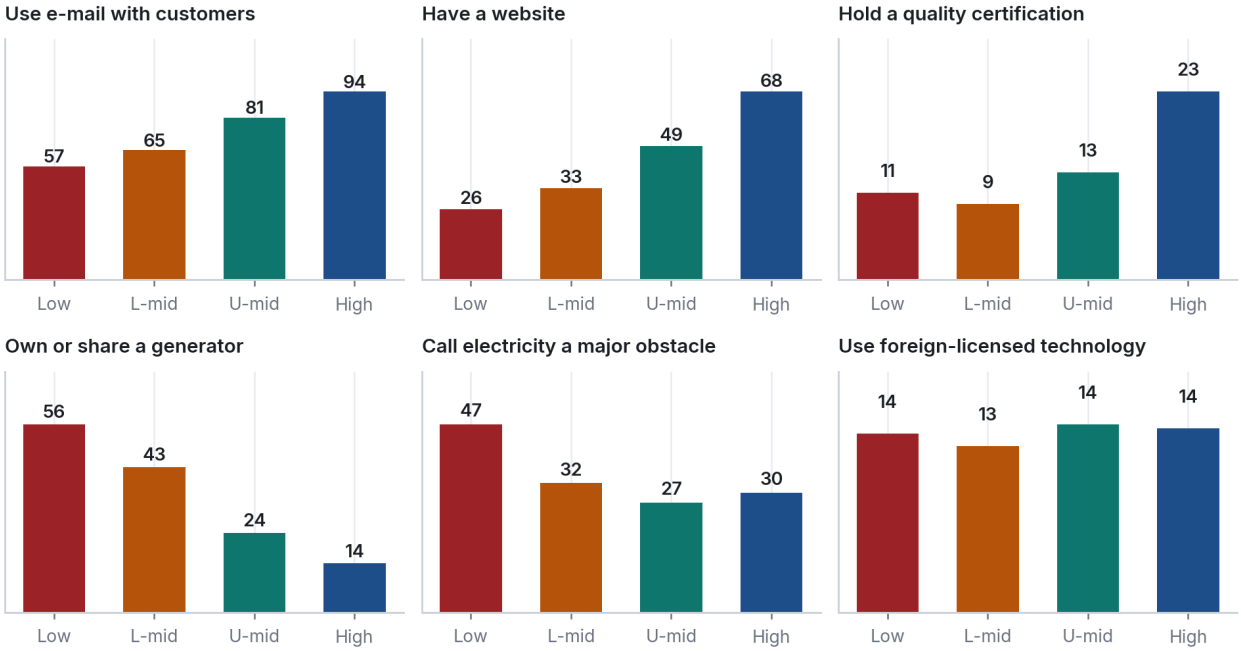
6.2 Firms: using a tool is not the same as using it well

The World Bank's Enterprise Surveys ask thousands of firms in 144 economies about their technology and operating conditions (World Bank, 2026). The results fit the ladder. In the median low-income economy 57% of firms use e-mail with customers and suppliers and 26% have their own website, against 94% and 68% in high-income economies. The share of firms with an internationally recognised quality certification is 11% in low-income and 23% in high-income economies, a sign of the gap in the processes that let a firm sell to demanding buyers. The surveys do not show a gap everywhere. About 14% of firms in low-income economies use foreign-licensed technology, the same as in high-income economies (14%), and firms in poor countries report as much process innovation as rich-country firms. These self-reported measures capture whether something is new to the firm, not whether it is new to the world or whether it is used at scale. They show that firms in poor economies are trying to adopt, which is encouraging, while the measured outcomes show how far apart the results are.

The most telling numbers are about infrastructure. 56% of firms in the median low-income economy own or share a generator, against 14% in high-income economies, and 47% of them call electricity a major obstacle (Figure 10). A firm that has to generate its own power spends money on fuel and equipment that a rich-country competitor does not, and a firm that loses power cannot run computers, cooling or machines reliably. Across the 113 developing economies with data, the share of firms with a website is lower where more firms need a generator (correlation -0.33). This is the complementarity problem of Section 4 in a concrete form.

Figure 10 Poorer economies' firms lag in digital tools and quality systems, carry the cost of unreliable power, and licence foreign technology as often as rich ones

Share of firms (%) by income group: digital tools, quality, power and technology licensing



Source: World Bank Enterprise Surveys (World Bank, 2026); H Heuristics calculations. Median across economies of the latest survey since 2008 (144 economies; 18–49 per group and measure). Survey years differ across economies.

6.3 The intensive margin and the gap that remains

These data are consistent with the finding of Comin and Mestieri that the extensive margin has converged and the intensive margin has not (Comin and Mestieri, 2018). A typical lower-middle-income economy has most of the tools that rich economies have, in the sense that the technologies exist and some people use them, but it uses them at lower intensity: fewer firms use them, fewer workers have devices and fast connections, and fewer processes run on reliable power. The World Bank's work on digital development makes the same point: digital technologies bring 'dividends' to growth, jobs and services only where the analogue complements of regulation, skills and institutions are in place, and these complements are scarce where the need is greatest (World Bank, 2016; Cirera and Maloney, 2017).

This changes the strategic question. If access were the whole problem, the solution would be cheaper phones and more towers, and the market is already doing that. The remaining problem is intensity of use: reliable power, affordable fast connectivity, systems that firms can build on, skills to run them and finance to buy them. The next section asks how much these things matter for productivity growth.

SECTION 07

Does Adoption Raise Productivity?

Trials and case studies show large gains where a technology solves a specific problem. Across countries the link is positive but modest, and it does not appear automatically.

IN BRIEF

- Careful studies find real productivity gains from mobile phones, digital payments, management practices and fertiliser, each in particular conditions.
- Across 153 economies, each extra point a year of internet adoption goes with 0.37 points a year of extra productivity growth in developing economies.
- Raw country comparisons are noisy: only 26 of 50 fast adopters were also fast growers.

7.1 What careful studies show

The most convincing evidence on adoption comes from studies that compare similar people or firms with and without a technology, usually through randomised trials or natural experiments. They show that technology can raise productivity, and that it does so when it addresses a particular binding problem.

- **Information.** When mobile phones reached the fishing villages of Kerala in India in the late 1990s, fishermen could check prices at several ports before landing their catch. Price differences between markets nearly vanished, waste fell and both fishermen and consumers gained (Jensen, 2007). A review of mobile phones in Africa found similar effects on price information, market search and the coordination of trade (Aker and Mbiti, 2010).
- **Connectivity.** When submarine cables brought faster internet to African cities, employment rose in the connected areas, and firms became more productive and entered new markets, with gains for workers at several skill levels (Hjort and Poulsen, 2019).
- **Finance.** Kenya's mobile-money system M-Pesa let households receive money from relatives after a shock, and one study estimated that access to it raised per-capita consumption and moved about 2% of Kenyan households out of extreme poverty, mainly by shifting women into business and retail work (Suri and Jack, 2016; Jack and Suri, 2014).
- **Management.** Free consulting that taught basic record-keeping and quality practices raised productivity in Indian textile plants by about 17% in the first year (Bloom et al., 2013).
- **Farming.** Small, well-timed interventions, such as offering fertiliser at harvest time when farmers have cash, raised fertiliser use and returns in Kenya, and matching hybrid seeds to farmers who gain most from them improved yields (Duflo et al., 2011; Suri, 2011).
- **Electricity.** Rural electrification in South Africa raised employment, especially among women (Dinkelman, 2011). A randomised trial of grid connections in rural Kenya found only small short-run effects on income and assets, a reminder that a connection does not guarantee productive use (Lee et al., 2020).

Two lessons come from this evidence. First, effects are large when the technology removes a specific obstacle and is paired with what makes it usable: a price, a payment, a skill, a market. Sec-

ond, effects shrink or disappear when a technology arrives without those complements. Economists studying the arrival of general-purpose technologies such as computers and electricity in rich economies find that productivity can stay flat for years while firms invest in the organisation, skills and processes that make the technology pay, a pattern called the productivity J-curve (Brynjolfsson et al., 2021). A similar lag should be expected, and more so in economies where the complements are scarce.

7.2 What the cross-country data show

To see whether adoption and productivity growth move together across countries, the analysis splits 2000–2019 into four five-year windows and, for every economy with more than a million people, compares productivity growth in each window with the rise in internet use in the same window. It holds constant the starting level of productivity, to allow for catch-up, and allows for differences between windows. For developing economies the result is positive: an extra percentage point a year of internet adoption goes with 0.37 percentage points of extra annual productivity growth (standard error 0.10, 405 observations from 153 economies in all groups). Controlling for each economy's own earlier productivity growth, which guards against the reverse story that fast-growing economies simply go online faster, the estimate is 0.30 (0.09). For high-income economies it is -0.09 (0.08), which cannot be distinguished from zero. The average developing economy added 2.3 points of internet use a year, so the estimate implies that adoption was associated with about 0.9 points of its 2.2% annual growth in output per worker. This is an association, not proof of cause, and internet use is only a proxy for a wider wave of technology that arrived together.

The positive estimate sits alongside a lot of noise. Among 100 developing economies, a simple comparison of the rise in internet use between 2000 and 2019 with productivity growth shows almost no relationship (correlation 0.10). Sorting economies into those above and below the median on each measure gives four groups of nearly equal size: 26 above on both, 24 fast adopters with slow growth, 24 slow adopters with fast growth and 26 below on both (Figure 11). Of the 53 economies that raised internet use by 40 points or more, 13 saw productivity grow by less than 1% a year, including Libya, Gabon and Jamaica, while 19 grew by more than 3% a year, including China, Armenia, Georgia and Azerbaijan. Going online mattered less than what else was happening.

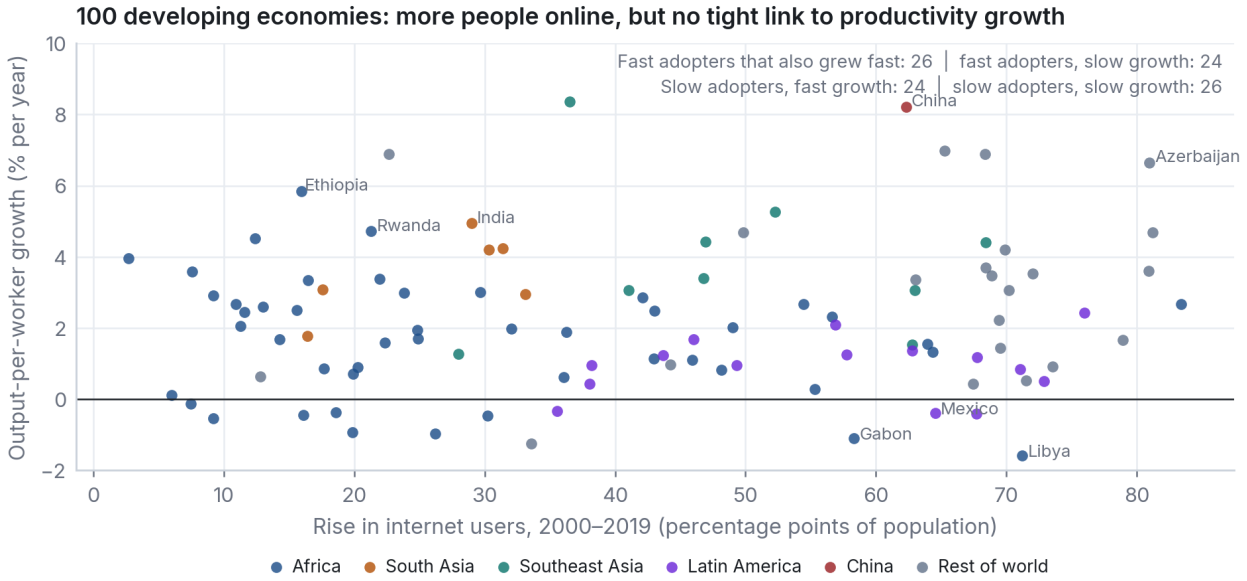
7.3 Do skills, power and governance amplify it?

A natural idea is that adoption pays more where the complements are stronger, so the analysis repeats the estimate separately for economies above and below the median on three conditions measured at the start of each window: government effectiveness, secondary-school enrolment and electricity access (80% or more of the population). The simple version of the complementarity hypothesis is not supported. The association with productivity growth is *stronger* where foundations are weaker: 0.75 (0.14) where government effectiveness is below the median against 0.07 (0.09) above it; 0.41 below the median in schooling against 0.04 above it; and little difference by electricity access (0.29 below 80% against 0.23 above) (Figure 12).

How should this be read? The most plausible reading is about diminishing returns, not about complements being unimportant. Internet use is a crude measure of access. Where connectivity starts from near zero, which describes most economies with weak foundations in 2000, the first

Figure 11 Countries that got many more people online did not reliably grow faster in productivity

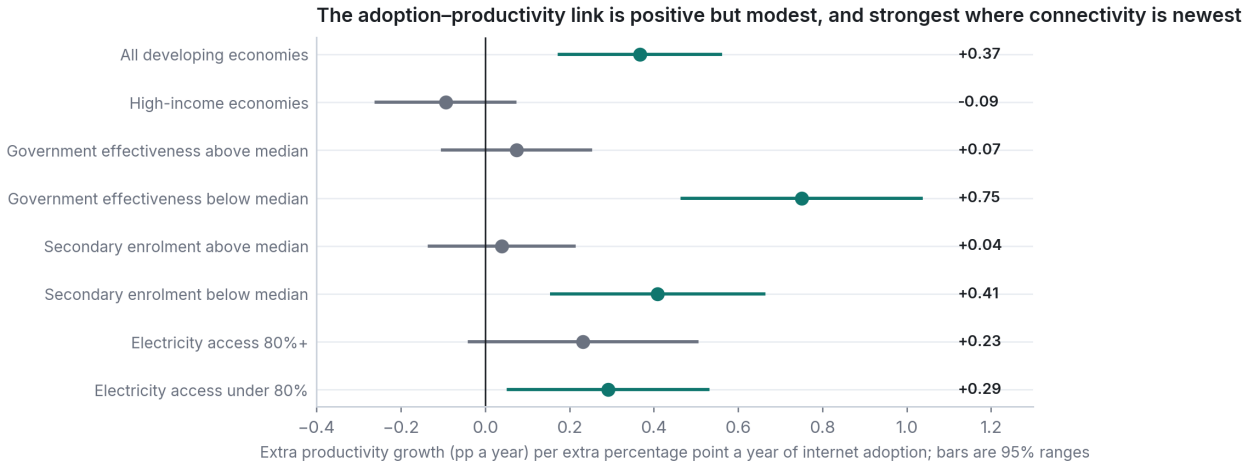
Rise in internet use 2000–2019 (x) against annual growth in output per worker (y)



Source: World Bank WDI (World Bank, 2026); H Heuristics calculations. Developing economies with more than 1 million people and data for 2000 and 2019. Productivity growth is the annualised change in log GDP per person employed.

Figure 12 The link between adoption and productivity growth is positive for developing economies and strongest where connectivity is newest

Estimated extra productivity growth (percentage points a year) per point a year of internet adoption, with 95% ranges



Source: World Bank WDI and Worldwide Governance Indicators (World Bank, 2026; World Bank, 2025a); H Heuristics calculations. Developing economies, five-year windows 2000–2019, regression of growth in log output per worker on the rise in internet use, with starting productivity and window effects; standard errors clustered by economy. Gates measured at the start of each window.

connections change production and trade by a lot, and the measured rise is large. Where a majority of people are already online, additional users add little, and what matters is how firms use the connection, which this measure cannot see. The gate results therefore say that basic access is where adoption most visibly pays, and the firm-level data in Section 6 say that the next step is depth of use. Both conclusions point in the same direction: the effects of adoption depend on what the technology is used for.

SECTION 08

Five Technology Families

Technology is not one thing. Energy, connectivity, finance, farm inputs and automation each have different costs, different barriers and different payoffs for productivity and resilience.

IN BRIEF

- Solar power and batteries have become cheap enough to bypass grids, but access is not yet reliable, productive power.
- Mobile money is the clearest case of adoption that delivered both productivity and resilience.
- Automation and artificial intelligence could widen gaps unless access is deliberately built.

8.1 Energy: cheap solar, unfinished grids

Electricity is the base on which every other technology runs, and it is the area where costs have fallen most dramatically. The global average cost of electricity from newly built solar farms fell by about 90% between 2010 and 2024 to roughly 4 US cents per kilowatt-hour, and battery storage costs fell by about 93% (IRENA, 2025). Imports of solar panels into Africa have taken off, with households and firms buying panels directly without waiting for a grid (Ember, 2025). The gap remains large all the same. In the median low-income economy only 44% of people have electricity access and electricity use per person is about 127 kilowatt-hours a year, 2% of the high-income median. 56% of firms in these economies need a generator. Adoption here means moving from a first light and phone charger to enough reliable power to run a cold store, a workshop, a clinic or a computer room, which is the step that separates a connection from a productive use.

8.2 Connectivity and digital services

Mobile telephony and mobile internet bring information, markets and services to people who are far from them, and the evidence in Section 7 shows that this has translated into real price, employment and trade gains. The weaker point is depth: fixed broadband, secure servers and the digital systems that let firms sell online, manage inventory and use cloud software are at a small fraction of rich-country levels (Section 6). The World Bank has argued that digital technologies only deliver broad 'dividends' where the analogue foundations of regulation, skills and institutions are in place (World Bank, 2016). The 2025 ITU estimate that 2.2 billion people remain offline, 96% of them in low- and middle-income countries, shows that even access is incomplete (ITU, 2025).

8.3 Digital finance

Digital payments are the best-documented case of adoption that served productivity and resilience at the same time. The Global Findex 2025 survey reports that 79% of adults worldwide held an account in 2024, up from 51% in 2011, and that mobile phones have been central to the gains in developing economies (World Bank, 2025). In the typical low-income economy, account ownership is 39% against 97% in high-income economies. Accounts help productivity because they lower the cost of paying, saving and borrowing, and help resilience because they let relatives and governments send money quickly after a shock: the Kenyan evidence in Section 7 is an example (Jack and Suri, 2014; Suri and Jack, 2016). Mobile money thrives on a particular combination of conditions: a dense network of cash-in agents, a regulator willing to allow non-banks to run the system, and customers who already own phones.

8.4 Farm technology

Farming is where the productivity gap is widest within countries (Section 3), and where known technologies are most under-used. Improved seeds, fertiliser, irrigation, storage and extension advice are old technologies, but cereal yields in the median low-income economy rose only 11% between 1991 and 2023 (World Bank, 2026). Trials suggest that adoption depends less on the technology than on how it is delivered: timing, credit, trust and risk. When a farmer who loses a crop cannot absorb the loss, rational farmers hold back on inputs that raise average yields but add risk. This is where resilience tools, such as weather-indexed insurance and early warnings, and productivity tools support each other (Duflo et al., 2011; Suri, 2011; Clarke and Dercon, 2016).

8.5 Automation and artificial intelligence

Manufacturing has traditionally been the escalator of development: low-skill workers move from farms to factories, productivity rises and exports grow. Automation and robotics may narrow that escalator, because the cheapest way to make many goods now requires fewer workers and more capital and skill, and the share of jobs in manufacturing at which economies peak has fallen (Rodrik, 2016; Rodrik, 2018). Artificial intelligence adds a new, still uncertain, question. Microsoft's usage telemetry estimates that 18.8% of the world's working-age population used generative AI tools in the second quarter of 2026, with 28.8% in the Global North and 16.2% in the Global South, and a gap that was widening (Microsoft, 2026). These estimates come from one company's data, and the adoption of general-purpose technologies is slow in every economy (Brynjolfsson et al., 2021). They signal the risk that a new technology wave could again open the gap before it narrows it, unless access to compute, connectivity, languages and skills is deliberately widened.

A pattern runs through the five families. The technologies with the most direct productive payoff, such as solar power, mobile money and farm inputs, depend on conditions that are physical (power, roads, agents), financial (credit, insurance) and institutional (regulation, trust). The technologies with the greatest potential reach, such as AI, depend on conditions that are the least equally distributed. That is why a strategy for adoption has to include the conditions as well as the devices, which is the subject of Section 12.

SECTION 09

From Productivity to Resilience

Productivity is not a goal in itself. It matters because it pays for the things that make societies able to prepare for shocks, survive them and recover.

IN BRIEF

- Output per worker explains 70% of the variation in countries' lack of coping capacity, but only 3% of natural-hazard exposure.
- Within countries, a 10% rise in output per worker goes with a 3.2% fall in child mortality.
- Tax revenue per worker is $676 in low-income and $18,391 in high-income countries.

9.1 Four ways productivity builds resilience

The H Heuristics framework describes Polycrisis Resilience as the capacity to anticipate, withstand, adapt to, recover from and reduce vulnerability to multiple interacting crises (Hughes, 2026a). Each of these capacities has a material base that productivity supplies. Anticipating requires data, weather services, communications and the power to run them. Withstanding requires buffers: household savings, firm reserves, food stocks and government fiscal space. Adapting requires the means to build and upgrade: resilient buildings, cooling, flood defences, new seeds, new skills. Recovering requires credit, working supply chains and a tax base to finance reconstruction.

Table 4 How higher productivity builds each resilience capacity

Capacity	What it needs	How productivity supplies it	Example of the effect
Anticipate	Data, forecasts, communications, power	A larger economy can fund weather services, sensors and networks; adopted technology (mobile, satellite) lowers their cost	Early warnings reduce disaster deaths, and coverage is lowest in the poorest countries (UNDRR and WMO, 2023; WMO, 2025)
Withstand	Savings, insurance, fiscal space, health reserves	Higher wages and profits allow saving; a larger tax base allows public buffers	Mobile-money networks spread the cost of shocks across households (Jack and Suri, 2014); pre-arranged finance pays out faster than appeals (Clarke and Dercon, 2016; CCRIF SPC, 2025)
Adapt	Skills, resilient infrastructure, technology	Productive firms and governments can afford upgrades; adoption brings better tools	Resilient infrastructure yields about $4 of benefit per $1 in low- and middle-income countries (Hallegatte et al., 2019)
Recover	Credit, supply chains, state capacity	Productive firms rebuild faster; a higher tax base funds reconstruction	Disaster losses depress income for years, and stronger economies recover faster (Hsiang and Jina, 2014; Cerra and Saxena, 2008)

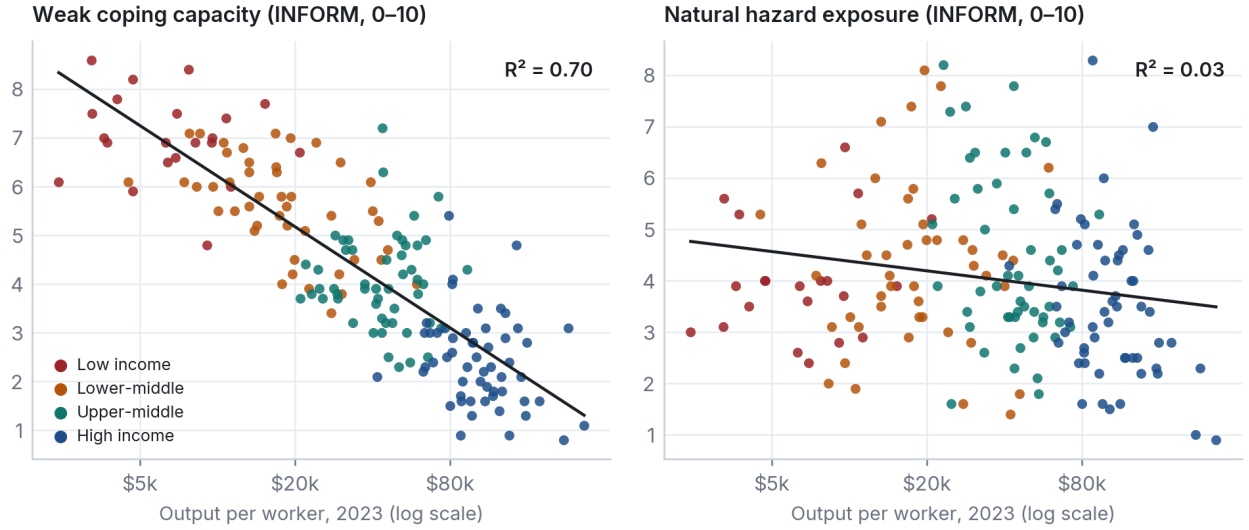
Source: H Heuristics framework (Hughes, 2026a); evidence from sources cited.

9.2 The gradient: productivity and vulnerability

The INFORM Risk Index, produced by the European Commission's Joint Research Centre and United Nations agencies, scores 172 countries on the three parts of risk: hazard and exposure, vulnerability, and lack of coping capacity (European Commission JRC, 2026). Matching the scores with output per worker shows a steep gradient: output per worker explains 70% of the variation in lack of coping capacity, 55% of vulnerability, 79% of the infrastructure component and 75% of the health component (Figure 13). Institutions are linked more loosely, at 39%, which suggests that they must be built deliberately. Hazard and exposure behave differently: only 3% of the variation in natural-hazard exposure is explained by output per worker, and 22% for the combined hazard score. Poor and rich countries face broadly similar physical hazards. They differ greatly in how well they can cope with them, and the coping gap is the productivity gap.

Figure 13 Output per worker tracks coping capacity closely but says almost nothing about natural-hazard exposure

Left: lack of coping capacity vs output per worker. Right: natural-hazard exposure vs output per worker (INFORM, 0–10)



Source: INFORM Risk 2026 (European Commission JRC, 2026); World Bank WDI output per worker 2023 (World Bank, 2026); H Heuristics calculations; 172 countries. Line: least-squares fit on log output per worker. Higher INFORM scores are worse.

9.3 Child survival within countries

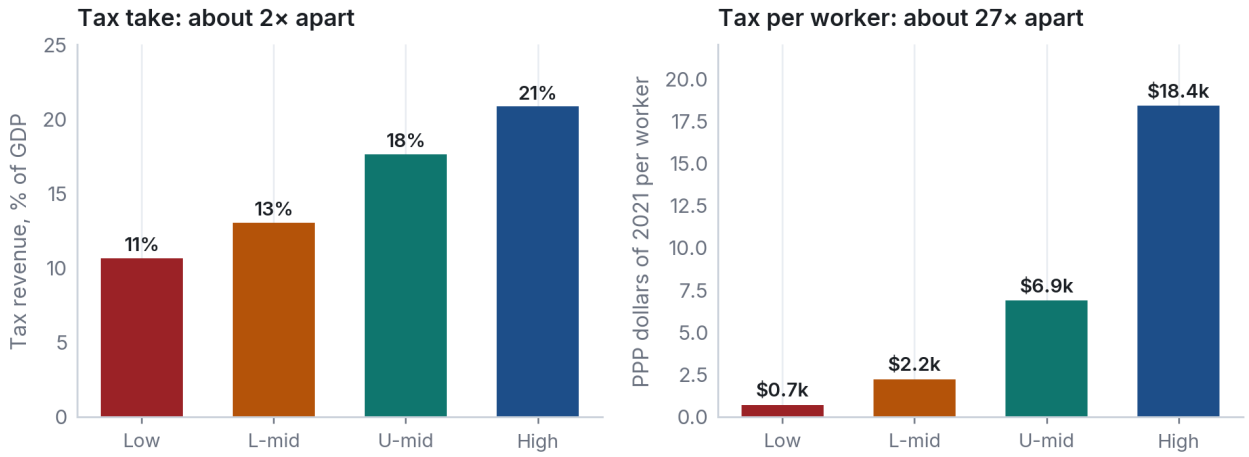
Cross-country comparisons can mislead because countries differ in geography and history. A sharper test follows the same country over time. For 151 economies with data over 1995–2023, the within-country relation between output per worker and child mortality has an elasticity of -0.32 (standard error 0.06, errors clustered by economy, year effects included): in years when a country's output per worker was 10% above its own average, its under-five mortality was about 3.2% lower. Life expectancy shows a matching pattern: it rose by about 0.16 years for each 10% rise in output per worker. These estimates describe association, and health improvements also feed back on productivity. They show that gains in output per worker travel with gains in survival, even after separating each country from the others.

9.4 The public purse

The fiscal channel is the clearest route from productivity to collective resilience. Governments finance flood defences, health systems, social protection and disaster response from taxes. In the median low-income economy, tax revenue is 11% of GDP, against 21% in high-income economies, a gap of about two to one. But taxes per worker are $676 in low-income economies and $18,391 in high-income ones, a gap of about 27 to one (Figure 14). The difference between the two ratios is output per worker. A low-income government that raised its tax-to-GDP ratio to the high-income level would collect about $1,322 per worker, which is still only 7% of what a high-income government collects. Raising the revenue ratio matters, but raising output per worker matters far more for the money available to protect people (UNCTAD, 2026).

Figure 14 Tax rates differ by about two to one; taxes per worker differ by about twenty-seven to one, because of productivity

Left: tax revenue as % of GDP. Right: tax revenue per worker, PPP dollars of 2021



Source: World Bank WDI tax revenue (% of GDP, latest 2017–23) and output per worker 2022 (World Bank, 2026); H Heuristics calculations. Median economy per group (15–50 economies).

Taken together, these results show why the productivity gap is a resilience gap. It is not only that low-productivity economies are poor: they have less to spend on every one of the functions that resilience requires, and they have little room to borrow for them. Raising productivity through adoption does not make hazards go away. It raises the capacity of households, firms and states to withstand them, which is exactly what the framework means by reducing vulnerability.

SECTION 10

Barriers and New Risks

Adoption stalls for reasons that can be named and measured. And adopting technology also creates risks of its own, which a resilience strategy has to manage.

IN BRIEF

- The main barriers are power, affordability, skills, finance, competition and institutions.
- Digital gaps also run inside countries: 85% of urban people are online against 58% of rural people.
- Technology can create new dependencies and new points of failure, so adoption must be screened for resilience.

10.1 What blocks adoption

Sections 5 to 7 point to a set of barriers that recur. The first is **unreliable power**: 44% electricity access in the median low-income economy and 56% of firms running generators. The second is **cost**: a median low-income economy has 0.2 fixed-broadband subscriptions per 100 people, against 36 in high-income economies, and high-income firms have cheap capital that low-income firms lack. The third is **skills**: median secondary enrolment is 39% in low-income economies and 103% in high-income ones, and tertiary enrolment 7% against 76%. The fourth is **finance**: only 39% of adults in the median low-income economy hold an account, which limits their ability to buy a machine or a solar system on credit. The fifth is **competition and openness**: firms adopt better methods when rivals or imports force them to, and protected markets weaken that pressure. The sixth is **institutions**: contracts, property rights, regulators and public services that work.

Barriers interact, which is the main reason that single-point fixes disappoint. A subsidy for devices does not help if the power is unreliable. A training programme does not help if firms cannot borrow to buy equipment. A broadband cable does not help if there is no local content or service. Efforts that remove several barriers in the same place and period, for example by combining power, connectivity, finance and training for a cluster of farms or small firms, are more likely to work than separate programmes.

10.2 Gaps inside countries

National averages hide large gaps within countries. The ITU estimates that 85% of people in urban areas use the internet against 58% in rural areas, and 77% of men against 71% of women (ITU, 2025). If the benefits of adoption reach urban men first, national productivity may rise while the most vulnerable households fall further behind, and the resilience gains are narrower than the headline implies. A strategy based on averages can therefore miss the people who are most at risk.

Table 5 Six barriers to adoption and what each one costs

Barrier	What it does	Evidence in this report	What changes it
Unreliable power	Raises cost, blocks equipment and connectivity	44% access in low-income median; 56% of firms use generators	Grid reliability, solar and storage, productive-use equipment
Cost and connectivity	Keeps firms offline or on slow connections	Fixed broadband at 6% of high-income level in lower-middle economies	Competition among operators, shared infrastructure, spectrum policy
Skills and management	Firms cannot use or maintain equipment	Tertiary enrolment 7% vs 76%; management trials (Bloom et al., 2013)	Schooling, vocational training, management services
Finance	Firms and farms cannot buy or insure new methods	Account ownership 39% vs 97%	Mobile credit, leasing, insurance, development finance
Competition and trade	Weak pressure to improve; imported inputs cost more	Adoption lags depend on trade and investment links (Keller, 2004)	Open, predictable trade and investment rules
Institutions	Contracts, regulation and public services unreliable	Productivity levels track social infrastructure (Hall and Jones, 1999)	Regulatory capacity, courts, data rules

Source: H Heuristics calculations from World Bank WDI and Enterprise Surveys (World Bank, 2026; World Bank, 2026); sources cited.

10.3 New risks from technology itself

Adoption brings new risks, and a resilience framework cannot ignore them. The table lists five.

Table 6 New vulnerabilities created by technology adoption, and how to manage them

Risk	How it arises	Management
Dependency	Reliance on imported platforms, cloud services, spare parts and software controlled elsewhere	Open standards, local capability to maintain and adapt, diversified suppliers
Single points of failure	A fault or outage in a shared system (payment network, cloud provider, power grid) spreads widely	Redundancy, offline fall-backs, independent audits
Fossil lock-in	Adopting technology that locks in fossil-fuel use or stranded assets	Prefer clean options with dual benefits; screen for climate exposure
Displacement	Automation reduces demand for the kinds of jobs that move workers out of farming (Rodrik, 2018)	Skills, social protection, support for service and agri-processing jobs
Exclusion	Women, rural people and the poor are left behind (ITU, 2025)	Affordable access, local languages, targeted programmes

Source: H Heuristics synthesis; evidence from sources cited.

Geopolitics adds another layer. The World Economic Forum's Global Risks Report 2026 ranks geoeconomic confrontation among the top risks, a reminder that access to technology, components and markets can be restricted by trade barriers and export controls (World Economic Forum, 2026). Debt adds another: interest payments squeeze the public investment that adoption requires (UNCTAD, 2026). And middle-income economies face the risk of getting stuck: the World Bank has counted 108 economies where progress toward high-income status has slowed (World Bank, 2024).

SECTION 11

Three Pathways to 2100

What would the productivity gap look like if adoption does not turn into catch-up, if the recent pace continues, or if adoption is backed by the conditions that make it pay? The answer shows what is at stake in the choice.

IN BRIEF

- Developing economies' output per worker, as % of the high-income level, goes from 27% today to 20%, 39% or 54% by 2100.
- Cumulative child deaths in 2025–2100: 285, 187 or 150 million.
- These are conditional illustrations from a simple model, not forecasts.

11.1 How the model works

The model covers 169 economies, 97% of the world's people. Each economy starts at its 2024 output per worker. The high-income frontier grows at 1% a year, a little below the 1.1% observed for high-income economies in 2000–2019. Every other economy grows at the frontier rate plus a *catch-up speed* times its gap to the frontier, which is the same idea as the convergence regressions of Section 2: the farther behind, the faster the growth. Growth is capped at 6% a year. Child survival, life expectancy, coping capacity and vulnerability are then predicted from output per worker using the cross-country relationships of Section 9, with each country keeping its own distance from the line. Population and births come from the UN's medium projection (United Nations, 2024).

The pathways differ in one parameter, the catch-up speed, which stands for how much of the adoption that takes place turns into productivity. **Adoption without absorption** sets the speed to zero, consistent with the estimate for 2019–2024, so that technology spreads but the ratio of productivity does not change. **Diffusion at the 2000–19 pace** uses the estimated speed of that period, 0.86% of the gap a year. **Enabled diffusion** uses 1.6% a year, the 90th percentile of the speeds implied by the experience of 81 developing economies in 2000–2019, which stands for adoption backed by the power, skills, finance, competition and institutions that make it pay. It is a demanding benchmark: it assumes the typical economy matches what the top tenth achieved.

11.2 Results

The table summarises the three pathways. Each row is produced by the same model with a different catch-up speed, so differences between columns show the effect of converting adoption into productivity and nothing else.

The differences are large. Without any conversion of adoption into catch-up, developing economies fall from 27% to 25% of the high-income level by 2050 and to 20% by 2100 (Figure 15), because the high-income frontier keeps growing. At the 2000–19 pace the ratio rises to 31% in 2050 and 39% in 2100. In the enabled pathway it reaches 37% and 54%. Low-income economies remain far behind in 2050 in all cases, at 5%, 9% and 13% of the high-income level, because they

Table 7 Three pathways: results for 2050 and 2100

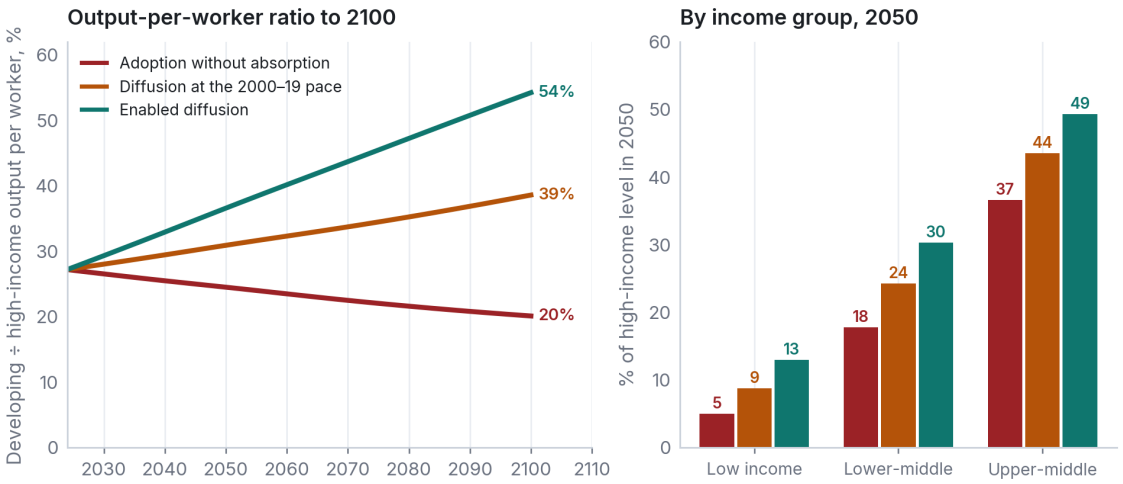
Outcome	Adoption without absorption	Diffusion at 2000–19 pace	Enabled diffusion
Catch-up speed assumed (% of gap a year)	0.0	0.86	1.6
Average growth, developing economies, 2024–50 (% a year)	0.7	1.6	2.3
Developing output per worker, % of high income, 2050	25%	31%	37%
Developing output per worker, % of high income, 2100	20%	39%	54%
Low-income output per worker, % of high income, 2100	5%	19%	37%
Lower-middle-income output per worker, % of high income, 2100	17%	36%	53%
World output in 2050 (trillion PPP dollars of 2021)	234	271	305
Extra world output 2025–2050 vs. no catch-up (trillion)	–	452	851
Under-five mortality in 2050 (per 1,000 births)	24	17	14
Under-five deaths 2025–2100 (million)	285	187	150
People in weak-coping countries, 2100 (billion)	4.0	1.6	0.2

Source: H Heuristics model (169 economies); World Bank WDI (World Bank, 2026); UN WPP 2024 (United Nations, 2024); INFORM 2026 (European Commission JRC, 2026). Conditional illustrations, not forecasts; 2021 PPP dollars; weak coping = predicted INFORM lack-of-coping score above 4.

start so low and a gradual process leaves them behind for a long time. The first group to reach half of the high-income level is the upper-middle-income group: in 2052 in the enabled pathway and 2079 at the 2000–19 pace.

Figure 15 The enabled pathway lifts the productivity ratio to above half by 2100; without conversion of adoption into catch-up, it keeps falling

Left: developing economies' output per worker as % of high-income, 2024–2100. Right: income-group ratios in 2050



Source: H Heuristics model (see methods). Ratios use employment-weighted output per worker, 169 economies; frontier growth 1% a year; growth capped at 6% a year.

11.3 What it means for people

Higher productivity feeds through to human outcomes in the model by way of the observed relationships in Section 9. Under-five mortality in 2050 is 24 per 1,000 births in the no-catch-up pathway, 17 at the 2000–19 pace and 14 in the enabled pathway. Cumulative child deaths from 2025 to 2100 are 285, 187 and 150 million respectively, so the enabled pathway avoids about 135 million deaths and the 2000–19 pace about 98 million relative to no catch-up. World output in 2050 is $234 trillion in the first pathway and $305 trillion in the third, and the enabled pathway adds about $851 trillion of output over 2025–2050. For public finances, the median low-income economy would collect about $831 per worker in 2050 at today's tax ratio in the first pathway and $2,221 in the third, a difference of about 2.7 times in the money available to protect people.

11.4 How sensitive are the results?

The three pathways are three points on a continuous scale. The table below shows the results for a wider range of catch-up speeds, from zero to three per cent of the gap a year.

Table 8 Sensitivity of results to the catch-up speed

Catch-up speed (% of gap a year)	Developing ratio 2050	Developing ratio 2100	Low-income ratio 2100	Child deaths 2025–2100 (m)
0.0	25%	20%	5%	285
0.5	28%	31%	12%	217
0.86	31%	39%	19%	187
1.2	34%	46%	27%	167
1.6	37%	54%	37%	150
2.0	40%	61%	45%	138
3.0	46%	73%	60%	123

Source: H Heuristics model. Frontier growth 1% a year; growth capped at 6%.

Results move strongly with the catch-up speed and hardly at all with the frontier growth rate: setting frontier growth to 0.5% or 1.5% changes the enabled-pathway 2100 ratio by less than one point (54% and 54% against 54%). The model leaves out shocks, climate impacts, demographic effects on productivity, the feedback from health and schooling to output and the possibility that new technologies change the rules of convergence. It is a tool for showing how much depends on the one thing that policy and investment can influence, the conversion of adoption into catch-up.

SECTION 12

A Strategy for Closing the Gap

If adoption pays where the conditions are right, the strategy is to build the conditions: six enablers, applied in an order that depends on where an economy stands.

IN BRIEF

- Six enablers turn adoption into productivity: power and connectivity, skills and management, finance, competition and openness, institutions and local capability.
- Priorities differ by income tier: basics first in low-income economies, depth in lower-middle-income ones, frontier-adjacent capability in upper-middle-income ones.
- Every technology should pass three filters: productivity, absorbability and resilience.

12.1 Six enablers

The evidence of Sections 5 to 10 can be summarised in six enablers. Each is both a condition for adoption to raise productivity and a part of resilience in its own right, which is the sense in which the strategy is a proactive one.

Table 9 Six enablers of productive adoption: actions and indicators

Enabler	Priority actions	Indicator and current gap
1. Reliable power and connectivity	Grid reliability, distributed solar with storage, productive-use equipment, shared digital infrastructure and competition among operators	Electricity use per person: 10% of high-income in lower-middle economies; fixed broadband 6%
2. Skills and management	Basic and technical schooling, vocational training, management extension for small firms and farms	Tertiary enrolment 7% in low-income vs 76% in high-income economies
3. Finance for adoption	Mobile credit and leasing for equipment, insurance for farmers, development finance for infrastructure and technology upgrading	Account ownership 39% vs 97%
4. Competition and openness	Open trade and investment, competition among suppliers and operators, supplier-development programmes that link firms to leaders	Firms with a website: 26% vs 68%
5. Capable institutions	Predictable regulation, contract enforcement, data and standards rules, public-sector use of digital tools	Coping-capacity gap tracks output per worker (R^2 0.70)
6. Local ability to adapt and repair	Repair and maintenance skills, local content, open standards, research and technology centres	Share of firms using foreign technology the same across groups; depth of use differs

Source: H Heuristics synthesis; indicators from World Bank WDI and Enterprise Surveys (World Bank, 2026; World Bank, 2026).

12.2 Sequencing by stage of development

The right order depends on where an economy stands. In **low-income economies**, where electricity access is 44% and only 19% of people use the internet, the priority is reliable basic power, mobile access, mobile money, farm inputs and schooling, since these have the clearest evidence of productivity and resilience gains. In **lower-middle-income economies**, where basics are mostly in place, the priority shifts to depth: fixed and mobile broadband quality, dependable power for firms, finance for small firms, skills, and the management of adoption by firms. In **upper-middle-income economies**, which are 6 years behind on the internet and closer on most measures, the priority is to move up the ladder: research and development, standards, advanced manufacturing and services, and avoiding the middle-income trap (World Bank, 2024).

12.3 Three filters for choosing technologies

Not every technology that is available should be adopted. Three questions, in the spirit of earlier H Heuristics work on screening technologies for dual benefits, help decide which ones to back (H Heuristics, 2026). The first is *productivity*: does it raise output per worker in the sectors where most people work? The second is *absorbability*: can local firms and institutions use, maintain and adapt it with the skills, power and finance they have, or can that be built quickly? The third is *resilience*: does it reduce vulnerability to shocks, such as heat, floods, price swings, outages and supply cut-offs, or does it create a new dependency? Technologies that pass all three, such as distributed solar with storage, mobile money, quality seed with insurance, and digital early-warning systems, are the best candidates for early scale-up.

ROLES

Who does what

Governments. Provide the enabling environment: reliable power, competitive connectivity, open trade, rules that allow new business models, schooling, and public services that use the technology.

Firms and farmers. Adopt in stages, invest in skills and management, share what works, and build supplier links with leading firms.

Development partners. Finance infrastructure and technology upgrading on terms that do not add to debt stress, support local capability and open standards, and fund the evidence on what works.

Researchers and statistical offices. Measure depth of use, not only access: firm-level technology use, power reliability and productivity by sector.

A final point concerns evidence. Most adoption data measure access, such as subscriptions and connections, because access is easy to count. Depth of use, power reliability, firm technology and sector productivity are measured less often and less consistently. A strategy for closing the productivity gap should invest in measurement so that it can tell which adoption is turning into productivity and which is not.

SECTION 13

Conclusion: Signs of Success

Technology diffusion can become a principal route by which global economic convergence strengthens Polycrisis Resilience, but only if adoption is converted into productivity. Eight indicators will show whether it is.

IN BRIEF

- The case for adoption is strong, and the conversion of adoption into productivity is the part that cannot be assumed.
- Eight indicators can be tracked each year to see whether the conversion is happening.
- The stakes by 2100 are a world in which developing economies produce about 20% or more than 50% of what rich economies do per worker.

13.1 The argument in brief

The global productivity gap is large: a worker in a low-income economy produces about one-twentieth of what a worker in a high-income economy produces, and the ratio has not improved since 1991. It is mainly a gap in productivity, meaning technology, organisation and the efficiency of the system, not in machines or the number of jobs. Technologies are spreading faster than ever, and mobile phones and mobile money show that developing economies can skip steps. But access has spread much faster than depth of use, the lag is longest for the technologies that matter most for production, and across countries the link between more connectivity and faster productivity growth is modest and noisy. Productivity matters for resilience because it pays for the buffers, infrastructure, services and public finances that decide how much harm a shock does. If adoption turns into catch-up at the pace of the best-performing tenth of developing economies, output per worker in developing economies could reach about 54% of the high-income level by 2100 and avoid about 135 million child deaths; if it does not, the ratio could fall toward 20%.

CONCLUSION

The central argument, revisited

Technology diffusion can become one of the principal mechanisms through which global economic convergence contributes to Polycrisis Resilience.

What the evidence adds. Diffusion is the right mechanism, and access is the easy part. The mechanism works when adoption is deep, reliable and productive, which depends on power, skills, finance, competition, institutions and local capability. Where those are absent, adoption produces devices rather than productivity.

What it means for resilience. Productivity does not remove hazards. It raises the capacity of households, firms and states to anticipate, withstand, adapt to and recover from them.

13.2 Indicators to watch

The following eight indicators are drawn from this report. They can be tracked every year from public sources and together show whether adoption is converting into productivity or stopping at access.

Table 10 Eight indicators of whether adoption is turning into productivity

Indicator	Latest value	Sign that adoption is converting into catch-up
Developing-economy output per worker, % of high-income	27% (without China and India 24%)	Rising for the group without China and India
Low-income output per worker, % of high-income	5%	Sustained rise above 6%
Share of developing economies growing faster than the US	28% in 2019–24	Back above 50%
Fixed broadband per 100, lower-middle-income median	2.1 (high income 36)	A steady rise toward the upper-middle level
Electricity use per person, low-income median (kWh)	127	Doubling within a decade
Firms with their own website, low-income median	26% (high income 68%)	A rise toward the lower-middle level
Internet use, low-income median	19%	First low-income economies passing 50%
Tax revenue per worker, low-income median	$676	Rising faster than the high-income level

Source: H Heuristics calculations from World Bank WDI and Enterprise Surveys (World Bank, 2026; World Bank, 2026). The signs are H Heuristics suggestions, not official targets.

None of these indicators is a forecast. They are things that can be looked up each year and that together answer a simple question: is the world's ability to produce, and therefore to protect itself, becoming less unequal? The data in this report suggest that the opportunity is real and that it is not being fully used. The most important finding may be the plainest one: technology is not scarce, and conditions for using it are. Closing the global productivity gap through technology adoption is a feasible and proactive way of reducing vulnerability to the polycrisis, and it depends less on inventing new tools than on building the foundations that let existing ones do their work.

METHODS NOTE

Methods and Data

How the figures were calculated, and what to check before reusing them.

IN BRIEF

- All data are public; the calculations can be reproduced from the sources cited.
- Scenario results are conditional on the parameters stated here.

Data

Productivity and income use the World Bank's World Development Indicators, retrieved in November 2026 (World Bank, 2026): GDP per person employed (SL.GDP.PCAP.EM.KD) and GDP per capita (NY.GDP.PCAP.PP.KD), both in constant 2021 international dollars; employment is implied as total output divided by output per worker. **Technology indicators** are WDI series for internet users, mobile and fixed telephone subscriptions, fixed broadband, secure internet servers, electricity access and use, researchers, R&D; spending, high-technology exports, schooling and account ownership (Global Findex) (World Bank, 2025). **Firm-level indicators** are from the World Bank Enterprise Surveys (World Bank, 2026), taking the latest survey since 2008 per economy. **Development accounting** uses the Penn World Table 11.0 (Groningen Growth and Development Centre, 2025) with capital share 1/3. **US adoption history** is the Comin–Hobijn series via Our World in Data (Comin and Hobijn, 2004). **Risk components** are INFORM Risk 2026 (European Commission JRC, 2026); **governance** is the Worldwide Governance Indicators (World Bank, 2025a); **population** is the UN medium projection (United Nations, 2024). Groups are the World Bank's current classes (World Bank, 2025b). Missing years were filled by interpolation inside each series and by carrying values forward by at most one to three years.

Calculations

Group productivity is total output divided by total employment for economies with data. **Catchup regressions** regress annualised growth of log output per worker on its starting log level for economies with more than a million people, with robust standard errors. **Development accounting** writes output per worker as (capital ÷ output)^(α/(1−α)) × human capital × TFP, with α = 1/3, and reports differences in the average of logs across economies, so that the three parts add up; results are reported for equal-weighted and population-weighted groups and for α of 0.25 and 0.4. **Adoption lags** are the years since the median high-income economy reached the level a group's median economy has today (series start in 1990, so some lags are lower bounds). **The adoption–productivity estimate** stacks four five-year windows (2000–05 to 2015–19) and regresses growth in log output per worker on the rise in internet use, controlling for starting log output per worker and window effects, with standard errors clustered by economy; gates are splits at the median (or at 80% electricity access) of conditions measured at the start of each window. **Within-country elasticities** demean log variables by country and year. **Gradients** are least-squares fits of INFORM scores on log output per worker.

Table 11 Main data series and identifiers

Series	Source and identifier	Years used
Output per worker; GDP per capita (2021 PPP $)	World Bank WDI, SL.GDP.PCAP.EM.KD; NY.GDP.PCAP.PP.KD	1991–2024
Internet users; mobile; fixed telephone; broadband	World Bank WDI, IT.NET.USER.ZS; IT.CEL.SETS.P2; IT.MLT.MAIN.P2; IT.NET.BBND.P2	1990–2024
Secure servers; researchers; R&D; high-tech exports	World Bank WDI, IT.NET.SECR.P6; SP.POP.SCIE.RD.P6; GB.XPD.RSDV.GD.ZS; TX.VAL.TECH.MF.ZS	Latest 2016–24
Electricity access; use per person	World Bank WDI, EG.ELC.ACCS.ZS; EG.USE.ELEC.KH.PC	1990–2024
Schooling; account ownership	World Bank WDI, SE.SEC.ENRR; SE.TER.ENRR; FX.OWN.TOTL.ZS (Findex)	Latest 2016–24
Farm employment and value added; cereal yield; fertiliser	World Bank WDI, SL.AGR.EMPL.ZS; NV.AGR.TOTL.ZS; AG.YLD.CREL.KG; AG.CON.FERT.ZS	1991–2024
Firm technology and infrastructure	World Bank Enterprise Surveys, IC.FRM.INNOV.T1/T4/T5/T6; IC.FRM.INFRA.IN9/IN12	Latest since 2008
Tax revenue	World Bank WDI, GC.TAX.TOTL.GD.ZS	Latest 2017–23
Capital, human capital, employment, output	Penn World Table 11.0 (rgdpo, cgdpo, cn, hc, emp)	1990–2023
Hazard, vulnerability, coping capacity	INFORM Risk 2026 (JRC / IASC)	2026 release
Population, births, projections	UN World Population Prospects 2024, medium variant	1950–2100

Source: as listed (World Bank, 2026; Groningen Growth and Development Centre, 2025; World Bank, 2026; European Commission JRC, 2026; World Bank, 2025a; United Nations, 2024; Comin and Hobijn, 2004).

Scenario model and limits

For each of 169 economies, log output per worker grows at the frontier rate of 1% a year plus the catch-up speed times the gap to the frontier (the high-income employment-weighted level), capped at 6% a year. Employment is population times each economy's 2024 employment ratio, held constant. Outcomes are predicted from log output per worker with the cross-sectional 2023 fit for each outcome (log for child mortality, linear for life expectancy and INFORM scores), and each country keeps its own residual. Child deaths are births times modelled mortality, with a floor of 2 per 1,000. The catch-up speeds are 0, the 2000–19 regression estimate (0.86) and the 90th percentile of country-level implied speeds (1.6); the median country-level implied speed was 0.42, lower than the regression estimate because the regression gives weight to fast movers, so the middle pathway should not be read as pessimistic.

The analysis has limits. Income groups are today's World Bank classes. Internet use is a measure of access, not depth. The adoption–productivity estimates show associations and cannot separate the effect of adoption from other changes that arrive with it. Enterprise Survey data are for different years in different economies, and innovation questions are self-reported. Development-accounting residuals include measurement error, institutions and the quality of capital as well as technology. The scenarios use cross-sectional relationships and ignore shocks, climate impacts, demographic effects on productivity and the feedback of health and schooling on output.

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