Policy Priorities to Promote Healthy, Equitable, Resilient, and Sustainable Agri-Food Systems Transformation

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Abstract

The world faces multiple interrelated economic, environmental, equity, health, and security challenges arising from slowed productivity growth and widespread government and market failures in agri-food systems around the world. Preventing these challenges from becoming outright crises requires concerted, multinational efforts spanning multiple policy domains to transform today’s agri-food systems into healthy, equitable, resilient, and sustainable ones. This policy paper outlines the evidence and logic for a prioritized set of policy responses to meet these challenges.
Introduction

Steady global agricultural productivity growth and declining undernourishment over the half century from 1960 to 2010 have stalled. As a result, the world faces global food crises along multiple dimensions: health, equity, resilience, and sustainability. This matters because food is the only economic sector that touches every human everyday. Everyone eats and nearly half the world’s population relies on work in food production or distribution (Davis et al. 2023). Food insecurity and the number of undernourished people worldwide have risen since 2014, especially since 2020 (Figure 1). Meanwhile, nearly half of all adults globally are overweight or obese (Shekar and Popkin 2020) and most women and children suffer dietary mineral and vitamin deficiencies (Beal et al. 2017; Stevens et al. 2022). These conditions drive health care costs up and labor productivity and economic growth down. This “triple burden of malnutrition” afflicts poor populations in high-income countries (HICs) but mainly harms the low- and middle-income countries (LMICs), where food insecurity inequality is also the greatest (Wesselbaum et al. 2023). The resilience of agri-food systems (AFS)1 has been tested by extreme weather events, pandemics, and war, helping fuel food price inflation (Barrett et al. 2021). AFSs contribute 20%–30% of global greenhouse gas (GHG) emissions, although AFSs could be carbon sinks mitigating climate change (Clark et al. 2020). In addition, agricultural development accounts for a large share of new infectious diseases among humans, especially zoonoses, diseases transmitted from animals to humans (Rohr et al. 2019). Add it all up, and global and local AFSs urgently need transformation to remedy these various crises.

History shows that policy plays a central role in AFS transformation. Past episodes of concerted policy efforts sparked impactful AFS transformation. The 1910s–1940s rise of public agricultural research and extension in today’s HICs developed, diffused, and adapted improved seeds, agrochemicals, machinery, and soil and water conservation that led to historically unprecedented productivity growth after decades of stagnation (Fogel 2004; Gardner 2009). The 1960s–1980s Green Revolution in Asia and Latin America—in which agricultural technological innovations were combined with rural infrastructure and markets development as well as social protection programs to build healthy, educated workforces—ignited accelerated economic growth, improved health and nutrition outcomes, and reduced deforestation (Evenson and Gollin 2003; Gollin et al. 2021). Those efforts consistently bundled new technological (mechanical, genetic, biochemical, etc.) advances with supportive policy and institutional efforts, reflecting a doubly-progressive commitment to foster scientific progress and to protect those who might otherwise lose out in the creative destruction intrinsic to change (Barrett 2021).

We can overcome today’s global food crises. But it will take concerted, multinational efforts spanning multiple policy domains to transform today’s AFSs into healthy, equitable, resilient, and sustainable (HERS) ones, thereby steering the world away from prospective humanitarian, economic, and environmental disasters (Barrett 2022a; Barrett et al. 2022a). The core policy tasks are to accelerate and expand knowledge-driven innovation to produce more HERS food per capita with less adverse impacts, and to tailor bundles of social and technological innovations to specific contexts to create transition pathways from our present, unsustainable trajectory to HERS AFSs.

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1 Agri-food systems span not just farms and fisheries, but also post-harvest storage and transport, food manufacturing, processing, retailing, and food service. The suite of activities and agents in the whole process, starting in agricultural production and ending in consumable food, is known as the agri-food system (AFS).
The downside of failure to respond adequately to the global food crises is significant multilateral security risk for the Group of Seven (G7) and partners (e.g., the Group of Twenty, G20). Global food price spikes are growing more frequent and dangerous. The 2021–2022 spike was the third in a dozen years, after 2007–2009 and 2011–2012; the last one was in 1973–1974. Food price spikes and episodes of mass food insecurity cause increased sociopolitical unrest and violence (Barrett 2013; Bellemare 2015). Unhealthy diets also create a human labor challenge, sapping worker productivity and driving up health care costs (Cawley 2015) at a time when aging and shrinking G7 populations make healthy working age adults more valuable, including for militaries increasingly struggling to recruit young adults who are not overweight or obese (Cawley and Maclean 2012; Reyes-Guzman et al. 2015). Insufficient AFS resilience also emboldens hostile actors—like the Russian Federation—that can and will project military force when the global community is preoccupied coping with other crises and when excessively concentrated dependence on a few suppliers of key commodities—e.g., wheat, fertilizer, and natural gas—hampers the global community’s ability to coalesce to respond to unprovoked aggression. AFS’ considerable contributions to climate change (Pörntner et al. 2022) and to zoonoses (Rohr et al. 2019) pose serious, direct national security risks (US GAO 2022). HERS AFS transformation is central to multilateral security strategy, not just a matter of agricultural, environmental, health, or social protection policy.

**Why Global Food Crises?**

We face global food crises due to simple economics: food demand growth has outpaced supply growth since the 1990s. This has led to real food price inflation and greater food price volatility since the turn of the millennium (Figure 2). Average inflation-adjusted food prices in the first 3 years of this decade were 18% higher in inflation-adjusted terms than in the 2010s, more than 47% above the 2000s average, and 56% higher than in the 1990s. Price volatility likewise grew sharply, more than doubling in 2020–2022 relative to even the prior food price spike periods of the 2000s and 2010s and more than tripling as compared to the 1990s.
Food demand’s long-run drivers—population growth and income growth—are not easily altered. Food demand grows at slightly less than the rate of population growth for the simple reason that poorer women who consume less food have higher fertility rates than the global average, thus most children are born into households that consume less food than average. Although improving women’s access to reproductive health care can reduce unwanted pregnancies and has intrinsic merit in promoting women’s empowerment, population policy has little aggregate impact on food demand.

Income growth is a high policy priority that fuels (not slows) food demand growth, especially when incomes grow among the poor, who diversify and upgrade their diets as they can afford to, leading in particular to sharp growth in demand for animal-source foods, fruit, vegetables, processed foods, and food consumed away from home (Barrett et al. 2022b; Masters, Finaret, and Block 2022). Some of these foods are rich in essential bioavailable micronutrients, but also have an especially large GHG footprint and are relatively water- and agrochemicals-intensive. Further, food processing and food service often add unhealthy fats, salt, and sugar to increase foods’ sensory appeal to consumers. The higher prices induced by added demand from rising incomes create incentives to clear more land for cultivation and pasture, aggravating AFS’ biodiversity, climate, and environmental footprint if technological advances do not keep pace. Food demand growth unmatched by adaptation and expansion of food production thus lies at the heart of today’s global food crises.
Demand-side Policy Priorities for HERS AFS Transformation

Policy tools must try to slow demand growth. But while dietary change is necessary (Willett et al. 2019), we cannot rely on dietary behavioral change interventions that have at best mixed results in small-scale studies and no evidence of impacts at scale (O’Riordan and Stoll-Kleeman 2015). Food consumer behaviors are driven mainly by proximal factors like income, price, and sensory appeal—how foods look, smell, and taste—far more than by distal factors such as a food’s environmental footprint or long-run health concerns.

While demand-side interventions alone cannot overcome the demographic and (especially) income effects that drive food demand growth, two main demand-side policy levers exist. The first shifts relative prices to internalize some of the many externalities associated with food and thereby induce healthier, more sustainable food purchasing behaviors. The past 2 decades have brought significant experimentation with “sin taxes” and “virtue subsidies” to incentivize healthier dietary choices, in particular to reduce the intake of sugar, salt, and unhealthy fats and to increase consumption of fruit, vegetables, and whole grains. The evidence on sugar-sweetened beverage taxes—the most widespread such policy globally—consistently finds that higher taxes reduce purchases and consumption of these beverages (Allcott, Lockwood, and Taubinsky 2019; Cawley and Frisvold 2023; Caputo and Just 2022). The effects are greatest for policies at national, rather than municipal, scale for the simple reason that shoppers will travel short distances to avoid taxes. But the impacts of food tax and subsidy policies remain modest.

A potentially more impactful approach broadens the lessons of sin taxes on unhealthy foods to promote true cost pricing in public procurement to address the broader range of externalities present in most foods, not just a few health externalities. The best, albeit imprecise and coarse, current estimates are that contemporary food production systems’ negative environmental, health, and social justice externalities amount to $8 to $52 trillion annually, likely at least triple the $9 trillion currently spent on total global food consumption (Hendriks et al. 2022). Governments ultimately bear significant fiscal costs from these large spillovers. Developing scientifically sound, easily implementable systems for public procurement based on foods’ true and full life cycle cost can not only improve government finances but also induce private producers, processors, and vendors to develop and adopt improved processes and products.

Sin taxes or true cost procurement will on average raise food prices, however, adversely affecting the more than 3 billion people who already cannot afford a healthy diet (Hirvonen et al. 2020; Bai et al. 2021). So, policies to internalize AFS externalities in food prices must be linked to expanded food assistance programs well-targeted to the poor. One otherwise merely trades off environmental or health concerns (among the better-off) for social justice concerns.

Food assistance programs’ design and financing also require rethinking. Many governments rely excessively on consumer food subsidies that accrue mainly to better-off consumers who purchase more food—and thus receive more subsidies—rather than to the poor. The challenge is enabling every family to enjoy a healthy diet, even in the face of high prices, macroeconomic downturns, and disasters. Layered national and global safety nets work, especially when underpinned by
public–private partnerships enacted through financial instruments that contractually trigger cash or in-kind food assistance to the needy in response to major shocks (Barrett and Maxwell 2005; Lentz et al. 2013). Public–private partnerships and financial contracts are needed because HIC governments and philanthropies typically fill only half or so of humanitarian food assistance appeals. Market mechanisms offering assistance targeted effectively to the poor and disaster-affected can help fill the gap and accelerate relief delivery.

The second policy tool to reduce food demand is to roll back biofuel mandates. Biofuel mandates create competing demand for cereals and oilseeds, diverting commodities from food and feed supply chains, especially when oil prices jump and blending rates rise in response to processors’ profit incentives (De Gorter, Drabik, and Just 2015). Because they limit liquid fuels price hikes, biofuel mandates also dampen incentives to use electric vehicles, public transit, and renewable energy generation, resulting in little or no measurable improvements in GHG emissions, which grow with transportation demand arising from population and income growth (Mat Aron et al. 2020). Ultimately, biofuel mandates mainly fuel food price increases and incentives to clear more land to cultivate feedstocks. Dropping biofuel mandates is the single fastest step governments can take to reduce food price pressures and their associated ills.

**Supply-side Policy Priorities for HERS AFS Transformation**

Even if relative price adjustments can reduce some adverse AFS externalities, few policy levers can meaningfully slow aggregate food demand growth that arises mainly from income and population growth. Policies to boost accelerate supply growth are therefore essential.

The longer-run focus must be on accelerating total factor productivity (TFP) growth in agriculture and in producing foods in nonagricultural systems that require little land, water, or agrochemicals and rely on renewable energy. The world has scant available land or water to bring into new agricultural production. Virtually all future supply growth must therefore come from increased output from the same land and water footprint—i.e., TFP growth—a considerable share of which will likely emerge from nontraditional, nonfarm sources like controlled environment agriculture, novel (e.g., insect-based) foods and feeds, and alternative, more sustainable, and healthier protein-rich foods produced in factories rather than on farms.

TFP growth and product and process innovation require substantially increased public and private investment. Public investment in AFS research and development (R&D) has waned over the past 30 years. Shrinking real R&D investment is a major reason why supply growth has slowed behind demand growth, driving up food prices. While government support to agriculture has grown, it mostly flows to individual producers—$611 billion of $817 billion total annually in 2019–2021—and in ways that distort global markets (OECD 2022). These subsidies often incentivize inefficient and environmentally-damaging patterns of input (especially agrochemicals and land) use and discourage crop diversification, contributing to the massive externalities that necessitate true cost pricing and procurement policies. The HICs, the People’s Republic of China, and Brazil are the biggest offenders.
A decreasing share of public spending on AFS goes to research or extension to develop, diffuse, and adapt innovations to promote HERS AFS. As distortionary agricultural support payments to individual growers have grown, HICs’ public investment in AFS R&D has fallen even though the returns to agricultural R&D far exceed most other public expenditures. Across 2,242 studies, the mean (median) benefit-cost ratio is 27.9 (8.1) for public agricultural R&D (Alston and Pardey 2021). Yet in the United States, public agricultural R&D has fallen by one-third over the past 2 decades (Nelson and Fuglie 2022). The People’s Republic of China has overtaken all other countries; soon Brazil’s and India’s agricultural R&D will likewise surpass the United States and the European Union (Nelson and Fuglie 2022). Moreover, public R&D remains heavily concentrated in refining traditional crops and methods, which exhibit diminishing rates of return (Bloom et al. 2020). Reallocating 15%–20% of current transfers to producers could enable a budget-neutral 50% expansion in public AFS R&D with a focus on healthier, more resilient, and sustainable products and methods.

The private sector has stepped in aggressively in search of those high returns, sharply expanding investments in AFS R&D since the late 2000s global food price spike (Fuglie 2016; Alston and Pardey 2021). But private investment responds to near-term, distorted market incentives more than to long-term, societal needs. This results in private investment patterns that, like government agricultural support, largely miss the AFS transformation target. For example, a plurality of 2021’s record $52 billion in global venture capital agri-food tech funding went to e-groceries, not to innovations to reduce food insecurity, GHG emissions, biodiversity loss, water stress, or excessive use of agrochemicals and antimicrobials (AgFunder 2022). Far more private funding goes to developing meat substitutes for wealthy consumers than to genetic improvements in livestock or improved feeds that more directly and immediately help poor herders in Africa and Asia.

Any of several policy or institutional innovations could significantly increase private incentives to invest in HERS AFS transformation. True cost pricing and public procurement policies, advance market commitments, or benevolent patent extensions would boost the relative returns to HERS AFS R&D (Barrett 2022b; Kremer, Levin, and Snyder 2022). Such public policies can crowd in considerable private investment in innovations needed to accelerate HERS AFS transformation.2

One focus of R&D, policy and institutional innovations should be novel products and processes that, once cost competitive with existing technologies, can accelerate AFS transformation toward HERS foods (Barrett et al. 2022a). High-priority domains include circular systems that can recycle waste products into fertilizers and livestock feed (Van Zanten, Van Ittersum, and De Boer 2019; Muscat et al. 2021; Green et al. 2022; Hazarika and Kalita 2023), controlled environment agriculture that can reduce land and water use and crop loss to pests and pathogens (Benke and Tomkins 2017; Beachem, Vickers, and Monaghan 2019), and novel protein-rich foods that replicate the animal-source foods we presently consume and the feeds given to fish and livestock.

But much of what is needed is not novel food products or processes but rather crop and livestock genetic improvements to existing AFSs’ dominant crops and breeds to cope with climate change and the shifting abiotic and biotic stresses it brings. Genetic advances have historically been

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2 The scale of private investment required is relatively small. By way of comparison, the entire annual budget of the CGIAR—the international agricultural research system—is roughly 0.05% of the $2 trillion in cash reserves held by the Standard & Poor’s 500 firms alone.
central to most agricultural TFP growth, generating spillover benefits in economic growth, poverty reduction and slowed rates of deforestation (Evenson and Gollin 2003; Gollin, Hansen, and Wingender 2021; Pelletier et al. 2020). Of all the various sustainable agricultural intensification strategies rigorously evaluated in the past generation, crop genetic improvement has consistently been the most impactful (Jain et al. 2023).

New scientific tools can dramatically accelerate progress from idea to an innovation implementable at scale. Advances in gene editing and sequencing, synthetic biology, combinatorial chemistry, nanotechnology, artificial intelligence, etc., enable more rapid, purposeful alteration of organisms than was ever feasible with slow, random natural selection or traditional plant and livestock breeding methods. Our expanding ability to develop new crop varieties and livestock breeds—and to identify desirable traits in indigenous ones—as well as novel, HERS food products and production methods, necessitates parallel progress in biosafety, food safety, intellectual property, and other regulations. Adaptive regulatory processes guard against the adverse, unintended consequences intrinsic to all innovation (Herrero et al. 2021) and build consumer, investor, and policy-maker confidence in emergent technologies. Proper oversight is essential. But policymakers must heed credible evidence and permit responsible, monitored use of expanding scientific toolkits, not saddled AFSs with unscientific regulatory restrictions that impede HERS AFS transformation (Barrett et al. 2022a; Paarlberg 2022). We must learn the lessons of transgenic organisms, where overreaction and distrust of science impeded advance at high cost with no discernible environmental or public health gain.

Some innovation perhaps especially increasingly affordable robotics, sensors, and artificial intelligence—can boost AFS TFP, resolve growing agricultural labor shortages in the G7 nations where working age populations are falling, and improve water, soil, pest, and agrichemicals management through more precise inputs management. But without concerted efforts to promote credit and insurance options, broadband access, and agricultural extension support for small-scale farmers these innovations will be slow to reach the LMICs where advances are most urgently needed. Such policy interventions can help level the playing field, much as digital machinery rental markets have boosted productivity-boosting equipment access for small farmers in the LMICs.

The geography of food demand growth will also necessitate increased attention to aid, trade, and technology transfer policies. Expected population and income growth patterns imply that virtually all future global food demand growth will occur in Asian and African LMICs, where AFS TFP lags the rest of the world (Fukase and Martin 2020; Barrett et al. 2022a). Imports and improved trade finance will be important, but AFS TFP growth in Asian and African LMICs is essential to meet looming demand expansion. Aid and technology transfer policies must aim for technological and institutional leapfrogging in Africa and Asia akin to that seen in communications and banking systems that largely skipped landlines and retail branch networks to quickly scale mobile phones and digital financial services. Sub-Saharan Africa especially needs increased AFS investment, as it not only hosts the youngest population on Earth, it is also the only world region where the rural population continues to grow, despite rapid urbanization (UN DESA 2021). Nonfarm food production growth must account for a large share of Africa’s food supply growth if we are to avert environmental and humanitarian disasters.

Governments must also revisit trade agreements to extend disciplines to export restrictions that were neglected in the late 20th century negotiations, which occurred during a period of steadily falling real food prices and thus focused on import restrictions. International trade accounts for
Policy reforms outside AFSs are crucial to accelerating food supply growth. For example, immigration policies that respond to labor market signals can obviate the labor constraints that increasingly limit food supply growth throughout value chains. Likewise, energy, environmental, and transportation policies that reduce GHG emissions and air and water pollution can significantly boost agricultural productivity (Ortiz-Bobea et al. 2021; Lobell et al. 2022). Advances in renewable energy technologies can also significantly reduce AFS production costs, especially for novel processes and products—like vertical farming and cultured meats—that are on the cusp of the commercial viability necessary for them to generate climate, environmental, food safety, or other impacts at scale. Modest intellectual property law reforms can likewise crowd in considerable private investment into African and Asian AFSs (Barrett 2022b).

Socio-technical Innovation Bundles

One can readily identify a menu of candidate policies needed to help accelerate transformation toward HERS AFSs and away from global food crises. Table 1 summarizes the top AFS policy priorities, distinguishing between those that require concerted international actions (in italics) and those that national (or even subnational) governments can usefully pursue unilaterally. The world would benefit from an intergovernmental science-policy platform3 to synthesize the rapidly evolving science of AFSs, draw out policy implications for participating governments and society, and help inform and facilitate actions that require international coordination.

But just as a good diet requires multiple ingredients that suit the season and taste, so does good food policy requiring strategically combining multiple menu items. No single policy or technology suffices because no one-size-fits-all solutions exist. Successful innovation requires bundling multiple technological (biochemical, digital, genetic, mechanical, etc.) advances with institutional and policy reforms both to promote adaptation and diffusion of innovations and to safeguard communities from the unintended consequences that inevitably follow technological change (Barrett et al. 2020; Herrero et al. 2020; Herrero et al. 2021; Barrett et al. 2022a).

Policy reforms are central to AFS transformation because the challenges and opportunities we face originate in the food-related decisions made by every person on Earth as they pursue their own objectives as a consumer, investor, producer, regulator, or worker. Effective policy helps direct and coordinate the decentralized decisions AFS stakeholders make every day, especially those that have important economic, environmental, health, and social repercussions for others. The specific combinations of policies and innovations appropriate to a given setting must be strategically designed and deployed in authentically participatory processes at varying, field-to-regional scales to match local conditions (Barrett et al. 2020, 2022a). Authentic engagement of

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3 Models include the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). The IPCC and the IPBES were created in the late 1980s and the early 2010s, respectively, to address the scientific and policy challenges the world faces due to climate change and biodiversity and ecosystem services losses, respectively. Similar AFS challenges merit similar effort.
local populations in the innovation cycle is both a democratic imperative as well as a high-value quality control mechanism.

Policy makers have a range of instruments at their disposal to induce impactful innovations and demand- and supply-side responses that can help steer the world away from the myriad food crises we face today and toward healthy, equitable, resilient, and sustainable (HERS) AFSs. Urgent action is needed, as institutional and technological changes take time, and the world cannot afford for food demand growth to continue to outpace supply growth.

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<tr>
<th><strong>Table 1: Top Agri-food Systems Policy Priorities</strong></th>
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<td><strong>Demand side</strong></td>
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<tr>
<td>1. True cost public food procurement and sin taxes and virtue subsidies combined with targeted food assistance safety nets underpinned by PPPs</td>
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<td>2. Drop biofuel mandates</td>
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<td><strong>Supply side</strong></td>
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<td>3. Sharply (≥50%) increase in public AFS R&amp;D, including in the CGIAR, through reallocation of some (about 15%–20%) direct payments to producers and broadened scope of products and/or processes beyond traditional staple cereals, roots, and tubers</td>
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<td>4. Align private AFS R&amp;D incentives with societal goals more than distorted markets (AMCs, BPEs, PPPs)</td>
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<td>5. Science-based, adaptive biosafety, food safety, and IP regulatory oversight</td>
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<td>6. Aid, trade, and technology transfer policies to accelerate AFS TFP growth in LMICs</td>
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<td>7. Trade disciplines on export restrictions</td>
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<td><strong>Non-AFS complements</strong></td>
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<td>8. Immigration policies that respond to labor market conditions</td>
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<td>9. Transportation, environmental, energy policies to reduce GHGs, air and water pollution</td>
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<td>10. Promote advances in more cost-effective renewable energy technologies</td>
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<tr>
<td>11. Create an intergovernmental science-policy platform for AFS transformation</td>
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AFS = agri-food system, AMC = advance market commitments, BPE = benevolent patent extensions, GHG = greenhouse gases, IP = intellectual property, LMICs = low- and middle-income countries, PPP = public-private partnership, R&D = research and development, TFP = total factor productivity.

Notes: Menu items require selection(s) from the supply side, with demand side measures highly recommended. Italics indicates measures requiring international (e.g., the G7) coordination.

Source: Created by author.
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