INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

RESEARCH PROGRAM ON Policies, Institutions, and Markets
CGIAR
Led by IFPRI

IFPRI Discussion Paper 02051

October 2021

Public Expenditure's Role in Reducing Poverty and Improving Food and Nutrition Security

Preliminary Cross-Country Insights Based on SPEED Data

Hiroyuki Takeshima

Jenny Smart

Xinshen Diao

Development Strategy and Governance Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute (IFPRI), a CGIAR Research Center established in 1975, provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition. IFPRI's strategic research aims to foster a climate-resilient and sustainable food supply; promote healthy diets and nutrition for all; build inclusive and efficient markets, trade systems, and food industries; transform agricultural and rural economies; and strengthen institutions and governance. Gender is integrated in all the Institute's work. Partnerships, communications, capacity strengthening, and data and knowledge management are essential components to translate IFPRI's research from action to impact. The Institute's regional and country programs play a critical role in responding to demand for food policy research and in delivering holistic support for country-led development. IFPRI collaborates with partners around the world.

AUTHORS

Hiroyuki Takeshima (h.takeshima@cgiar.org) is a Senior Research Fellow in the Development Strategy and Governance Division of the International Food Policy Research Institute (IFPRI), Wshington, DC.

Jenny Smart (j.smart@cgiar.org) is a Senior Program Manager in IFPRI's Development Strategy and Governance Division, Washington, DC.

Xinshen Diao (x.diao@cgiar.org) is a Deputy Division Director in IFPRI's Development Strategy and Governance Division, Washington, DC.

Abstract

Public expenditures (PE), their sizes, and allocations across sectors, are some of the important instruments for the public sector to contribute toward sustainable development goals (SDGs). However, knowledge gaps remain as to how PEs have actually contributed to key SDG outcomes in the past, including the eradication of poverty and hunger, and the improvement in food and nutrition security in sustainable manners (SDGs 1 and 2). This study aims to partly fill this knowledge gap using the Statistics on Public Expenditures for Economic Development (SPEED data) and various country-level panel data. We find that PEs in different sectors have been significantly associated with key indicators under SDGs 1 and 2. Specifically, greater PEs for agriculture and health sectors have had relatively positive effects on total factor productivity growth in agriculture, reduced consumer food price indices, reduced poverty, reduced stunting, underweight or overweight among children under 5. A greater PE for agriculture has also been weakly associated with enhanced biodiversity. These relationships are observed for a broad class of countries, but somewhat stronger for countries that had been classified as low- or lower-middle-income in 2000. Greater PEs for education and social protection, which have been generally higher than PEs for agriculture and health, have had more mixed effects on these outcomes. While continued analyses are required to better understand the complex linkages between PE and these outcomes, the current study offers useful preliminary insights.

Keyword: public expenditures, poverty, cross-country evidence, panel data, SPEED data

Acknowledgments

We would like to thank the CGIAR Research Program on Policies, Institutions, and Markets (PIM), which is led by the International Food Policy Research Institute (IFPRI) and carried out with support from the CGIAR Trust Fund, for providing financial support to conduct this study. Authors also benefited from dialogues with Samuel Benin, Tewodaj Mogues, Bingxin Yu. Authors are responsible for any remaining errors.

1 Introduction - background

Public expenditures (PE) have been considered one of the important determinants of the public sector's capacity to contribute toward achieving various development outcomes highlighted in the Sustainable Development Goals (SDGs), including the eradication of poverty and hunger, and the improvement of food and nutrition security, through the provisions of public goods (both tangible and intangible), provisions of key public-service deliveries, in inclusive and pro-poor manners, that may be under-supplied by the private sector (Fan, Hazell, and Thorat 2000; Fan & Zhang 2008; Mogues and Benin 2012; Almanzar & Torero 2017; Anderson et al. 2017, 2018).

Knowledge gaps are still vast, however, as to how past PEs in different sectors have actually contributed to these outcomes. Such evidence is critical because the effectiveness of PEs can vary depending on: contents of support financed through Pes; institutional and governance quality (institutional capacity, the level of corruption, etc.) that affect how PEs are disbursed and spent as intended; intended beneficiaries; the extent that PEs crowd-in or crowd-out the private-sector investments and service provisions; how returns to PEs change depending on the current level of PEs and development level; as well as time-frame in which PEs' effects materialize. Where relevant evidence of PE's effects has been available, it has either been for a relatively small set of countries and regions (e.g., India by Fan et al. (2000); Uganda by Fan & Zhang (2008); Rwanda and Tanzania by Almanzar & Tolero (2017)) or PE in a single sector (e.g., certain social-sector PE including health-PE and education-PE by Martinez-Vazquez et al. (2012); Almanzar & Tolero (2017), Anderson et al. (2017); Bergh et al. (2020)), instead of offering evidence on broader contexts, or comparative perspectives across sectors, such as agriculture, health, education, and social protection.

This study aims to partly fill these knowledge gaps by addressing the aforementioned issues. Specifically, this study uses the Statistics on Public Expenditures for Economic Development (SPEED data) (IFPRI 2019) and various country-level panel data from 120 countries to gain richer insights into the cross-country associations between PEs and these outcomes. We use SPEED data because it is one of the few sources that report historical cross-country data for PE on agriculture (covering not only African countries as in the Regional Strategic Analysis and Knowledge Support System (ReSAKSS-Africa) data, but also countries outside Africa), as well as other key sectors (unlike FAOSTAT), and cover countries in broad income categories across the globe (unlike some other data that focus only on certain income levels or sub-regions). We focus on the associations between PEs and key country-level development outcomes, in particular, those associated with SDGs 1 and 2 (eradication of poverty and hunger, and realization of improved, sustainable food and nutrition security).

The remainder of the study is structured as follows. Section 2 briefly reviews the relevant literature on PEs and poverty, food and nutrition security. Section 3 describes the empirical approaches and data. Section 4 discusses the results, while section 5 concludes.

2 Relevant literature

Past literature has offered insights into the general linkages between the investments into key sectors (agriculture, health, education, and social protection) and poverty and food/nutrition security. A small subset of these studies also provide direct evidence of PE on various sectors on these outcomes.

Public expenditures on agriculture

The potentials for agricultural growth to contribute to overall economic growth and food and nutrition improvement have been highlighted in a growing body of literature. Recent literature continues to show the positive roles of agricultural productivity growth, aid into the agricultural sector, and on broader economic growth (e.g., Bustos et al. 2016; McArthur & McCord 2017; Gollin, Hansen, and Wingender 2018; Lee 2018; McArthur and Sachs 2019; Loizou et al. 2019; Baffes et al. 2019; Djoumessi et al. 2020).

PEA (Public Expenditure Allocation) can be considered effective where it provides critical public goods that are the binding constraints for production and productivity growth in agriculture (WB 2007; Fan & Zhang 2008; Benin et al. 2011; Spielman & von Grebmer 2006; Evenson & Westphal 1995). Past studies have provided direct evidence of PEs on agriculture and on agricultural growth (Headey 2010; Rohne Till 2021).

The potential for PE on agriculture to realize poverty reduction may also materialize through reduced food prices. Past and recent literature on the "food problem" continues to highlight that reduced food price that is a result of agricultural productivity growth is an important driver for overall economic growth (e.g., Lee 2018). Reduced food price has also been considered one of the most important drivers of poverty reduction worldwide (Mellor & Desai 1986; Kotwal & Ramswami 1998; Datt & Ravallion 1998; De Janvry & Sadoulet 2010; Ivanic et al. 2012; Hasan 2017).

Recent literature has also increasingly highlighted persistently strong agriculture-nutrition linkages (Ruel et al. 2018; Fan et al. 2019; Bellows et al. 2020), including demonstrating the positive effects of PE for agriculture (such as spending on input subsidies) on nutritional outcomes (for example, Harou 2018). Greater agricultural production, agricultural growth, and/or increased support for the agricultural sector (e.g., agricultural extension) has been shown to reduce stunting (Akresh et al. 2011) or other correlates of child nutrition like infant mortality (von der Goltz et al. 2020), or malaria (Pan & Singhal 2019).

The optimal investments in agriculture may also offer positive externality in access to basic services, for example, through the provision of clean water downstream (World Bank 2008, p.197), or potentially through reduced poverty and improved households' capacity to pay for these services.

Public expenditures on other social sectors (health, education, social protection)

The evidence of the potential roles of investments in other sectors, including health, education, and social protection, on poverty reduction, food, and nutrition security improvements, has been highlighted in the literature.

Various studies highlight the positive roles of improved health on agricultural productivity under varying contexts (Pitt et al. 1990; Loureiro 2009; Wouterse & Badiane 2019; De La Fuente et al. 2020), suggesting indirect pathways for PE on health to generate similar contributions as PE on agriculture. In one way, health PEs may improve health conditions of household members, which can raise their on-farm productivity. Similarly, improved health conditions of household members could lead to reduced health-related expenses by the household, which can release more resources to purchase inputs or services for the household's farm production. Growing studies have also provided evidence of the direct effects of PE or public aid on the health sector. Development assistance for the health sector in 96 countries has been shown to reduce mortality (Wilson 2011), which is often associated with reduced poverty and improved child nutrition. Similarly, cash transfers conditioned on healthcare utilization in Nigeria reduced child mortality (Okeke & Abubakar 2020). Public-sector health services

continue to be effective in India, where private-sector service providers are emerging but often provide unnecessary treatments (Das et al., 2016). Public support toward maternal and child health programs has also been a viable option for addressing not only undernutrition but also mitigating overweight, particularly in SSA countries (Haggblade et al., 2016).

The potentials for PE on education and social protection for achieving poverty reduction and food/nutrition security improvement have also been put forth in the literature, although a significant body of literature has also provided counter-evidence. The potential effects of PE on education have long been advocated by the positive associations between human capital investment and economic growth (Barro 1991; Mankiw et al. 1992; Easterly & Rebelo 1993). PE on education, health, and general social welfare have also been found to significantly reduce income inequality across countries (e.g., Martinez-Vazquez et al. 2012). However, other studies have found generally limited effects of social-sector PE, including education, on mitigating within-country inequality and reducing poverty (Anderson et al., 2017, 2018; Bergh et al., 2020). Studies also highlight challenges in providing quality education services, particularly in rural areas (Williams 2005) where qualified teachers are scarce and cannot be trained in the short-term (Muralidharan & Prakash 2017), reflected in insufficient instructional time (Abadzi 2009), leading to lower education achievements given the number of years of schooling (e.g., Antoninis 2014). These challenges can limit translating education-PE into effective outcomes, especially poverty and hunger reduction or food and nutrition security improvement. Similarly, for social protection, studies have highlighted the challenges of beneficiary targeting (e.g., Golan et al. 2017; Cameron & Shah 2014), crowding-out of private transfers (Bahal et al. 2018; Nikolov & Bonci 2020), and reduced labor-market participation (Almanzar & Tolero 2017). Some argue that social-sector PEs have been captured by the high- or middle-income class in urban areas rather than the lower-income class (Alesina 1998; Castro-Leal et al. 1999; Davoodi et al. 2010; Anderson et al. 2017), posing challenges to achieving more pro-poor, inclusive outcomes like poverty reduction and food/nutrition security improvements.

Absolute size vs. Relative size (share) of PE[1]

Literature has also suggested important distinctions between the absolute size of PEs and the relative sizes of PEs (e.g., the share of PEs allocated to each sector). When the focus is on the absolute size of PEs in each sector, decisions on PEs also involve broader resource reallocations between the public and the private sector. Greater overall size of PEs can be justified if the public sector's overall comparative advantages are significant, including economies of scale in generating public goods such as infrastructure, or there is significant complementarity between PEs in different sectors. On the other hand, when the focus is on the share of PEs, the relative returns across sectors may be more important determinants of the PE on each sector. The share of PEs may be more important also when the Ricardian Equivalence (Barro 1976) holds, i.e., effects of the size of PEs have no effects if taxation that finances PEs perfectly offsets the outcomes of PEs. The literature has, however, offered generally limited evidence of Ricardian Equivalence (Masson et al. 1998; Grigoli et al. 2018; Haug 2020). A higher discount factor, particularly common in developing countries (Binswanger & Deininger 1997), can also affect the social returns from PEs relative to the social costs incurred through taxation. In such a case, the

[1]Note that the formal analyses of distinctions between the absolute size and the relative size of PEs often require examinations of broader set of theories and empirical models, which are beyond the scope of this study. Discussions and literature in this paragraph may capture only a limited aspect of relevant theories and evidence. In our study, therefore, we simply assess if there are different patterns between absolute size of PEs and relative size of PEs on their associations with various outcome variables.

absolute size of PEs may have significant effects on outcomes that differ from the effects of the share of PEs.

3 Estimation methods

Our empirical approach is a simple panel-data that account for unobserved country-specific fixed effects. Specifically, we estimate

$$Y_{it} = \alpha + \sum_{s} \beta_s \cdot X_{s,it} + \gamma \cdot Z_{it} + c_i + \varepsilon_{it} \quad (1)$$

where various outcome variables for country i in year t (Y_{it}) are regressed on a set of relevant PE variables in each sector s ($X_{s,it}$), and a vector of exogenous time-variant variables (Z_{it}) that are also expected to affect the outcome variables. Parameter c_i denotes the estimated country-fixed effects. Parameter β denotes the estimated coefficients capturing the effects of PEs on respective outcomes. Parameter γ is the set of other estimated coefficients, while α and ε_{it} are intercept and idiosyncratic shocks.

Specification (1) can lead to spurious regression when Y_{it} and / or X_{it}, Z_{it} are nonstationary. As is discussed in the later section, where first-differencing leads to stationary series, we estimate first-differenced model:

$$\Delta Y_{it} = \alpha + \sum_{s} \beta_s \cdot \Delta X_{s,it} + \gamma \Delta Z_{it} + \varepsilon_{it} \quad (2)$$

which is less efficient because it requires dropping the first period, but avoids spurious regressions.

Sectors of PEs

We include five sectors, namely, agriculture, health, education, social protection, and defense.[2] These sectors are selected as PEs are most commonly reported for these sectors, including our primary data (described in the data section).

Absolute size vs. relative size (share) of PEs

Separate models are also estimated using either the absolute size of PEs or the relative size of PEs (measured as the share of PEs for the sector to total PEs).

Current and past PEs

For each outcome, we estimate (1) or (2) using two versions of $X_{s,it}$. In one version (Model A), $X_{s,it}$ only includes PE in the same year t when outcomes were also measured. In the other version (Model B), $X_{s,it}$ is the average of PE during the five-years leading up to year t. The first version aims to capture more immediate effects of PEs on Y_{it}, while the other version aims to capture more medium-term effects of PEs on Y_{it}. The latter version also mitigates the biases that may arise due to potential endogeneity in PEs whereby Y_{it} affects government's decisions on PEs.

[2]PE on defense is not our primary interest. However, PE on defense is included as one of PE sectors since it is reported with sufficient frequency, and its inclusion can control for particular factors that affect outcomes of our interests, separate from PEs for agriculture, health, education, and social protection.

Results from both models, however, should still be interpreted as "associations", rather than evidence of "causality". This is because, even when past PEs (instead of current PEs) are used for $X_{s,it}$ as in Model B, two-way causality may still exist. For example, governments' decisions on PEs may partly depend on the future projections of relevant outcomes. While hypothetical, governments may determine current PE levels for each sector, based on the expected level of, for example, poverty five years later.

Using panel data based on period-averages for outcome variables with gaps

As is described in the later sections, certain outcome variables are reported over long time periods but contain significant gaps. These variables may reflect more the average conditions during particular periods rather than the conditions in particular years. In these cases, we estimate model (1) by transforming all variables into 5-year averages (when observations are missing in a particular year, averages are calculated using only non-missing values).

Estimations for all countries, and low- / lower-middle-income countries

As the effects of PEs can be different depending on the initial income level of the country, we estimate the above models using all sample countries, as well as using only countries that were classified low- or lower-middle incomes in 2000.

3.1 Variables and data

3.1.1 Outcome variables (Y_{it})

Outcome variables are selected focusing on key indicators listed under SDGs 1 and 2 (United Nations 2021), and selected indicators with sufficient number of observations. Table 1 summarizes these outcome indicators. Where suitable substitutes were available from other sources, for example, FAOSTAT and IFPRI (2021), those indicators were used to proxy SDG indicators. These outcome variables consist of the prevalence of poverty under various international poverty lines, prevalence of undernutrition, prevalence of stunting, underweight and overweight among children under 5, total factor productivity (TFP) growth rate in agriculture, indicators of biodiversity proxied by the number of plant breeds for which sufficient genetic resources are stored and the proportion of local breeds facing extinction risk, and consumer food price indices.

3.1.2 Expenditure variables ($X_{s,it}$)

Expenditure variables are taken from SPEED data (IFPRI 2019). SPEED is a publicly available dataset containing PE data for 164 countries from 1980 to 2017 for 10 sectors, including agriculture, health, education, social protection, and defense, as the most frequently reported sectors. SPEED data report both the absolute sizes of PEs (measured in constant Purchasing Power Parity (PPP) dollars per capita) in various sectors and relative sizes (shares to total PEs). SPEED data are based on information on PE compiled from the International Monetary Fund, the World Bank, national governments, among others, and adjusted through extensive data checks and procedures to remove effects of exchange-rate fluctuations and currency denomination changes (for detailed definitions of PEs for each sector, as well as data checks and verification procedures, see Yu et al. 2015).

Among the 10 sectors covered in SPEED, we focus on the aforementioned five sectors. Other sectors covered in SPEED, including communication, fuel and energy, transport, mining, and a combination of communication of transportation, are less frequently reported, and thus not

included. Future studies, however, should extend SPEED data to cover these additional sectors and expand the analyses.

3.1.3 Other explanatory variables ($\boldsymbol{Z_{it}}$)

Table 2 lists the other explanatory variables ($\boldsymbol{Z_{it}}$) selected, and their data sources. Since we focus on panel-data analyses, $\boldsymbol{Z_{it}}$ only include key time-variant variables that are expected to commonly affect the set of outcome variables.

The share of urban population to total population is included. The urbanization process is often driven by broader macro-economic factors and often reflects the level of infrastructure and public services accessible by the general population. Generally it is considered to affect the economic and food/nutrition security outcomes in addition to the direct effects through PEs.

Variables capturing the incidence of two types of major disasters from CRED (2021) are also included to control for the effects of these disasters on various outcomes. CRED (2021) is used as they provide information comparable across countries and over time. These are dummy variables indicating whether the country experienced any major disasters defined by CRED (2021) in a particular year. Natural disasters include biological, climatological, geophysical, hydrological, and meteorological disasters, while technological disasters include any major industrial or transport accidents (CRED 2021).

Trade-openness, which is proxied by the proportion of the sum of imports and exports to GDP, is used to control for various effects arising through international trade rather than domestic market conditions, which has been used by various studies investigating the effects of public expenditures on economic growth (e.g., Bose et al. 2007; Acosta-Ormaechea & Morozumi; 2013; Gnangoin et al. 2019).

Six indicators measuring various dimensions of governance quality are taken from Worldwide Governance Indicators (Kaufmann et al., 2009). These indicators have been widely used in similar past studies as important determinants of the effectiveness of public-sector programs on various development outcomes (e.g., Lio & Hu 2009).

The share of natural resource rent to GDP relates to natural resource commodity prices and is often associated with corruption, weak institutions, etc. (Castañeda & Rodríguez 2018). In countries relying on natural-resource rents, these rents can flow to certain segments of the population, separate from PEs.

Dependency, which captures the ratio of the population older than 65 to the population between 15 and 64, is included to capture inherent levels of the vulnerability of the population, which can affect the tendency to fall into poverty and suffer from food and nutrition insecurity, independent of the levels of PEs.

Lastly, the interaction terms between year and regions are included to capture the region-specific trends that are external to the linkages between PEs and aforementioned outcomes.

3.3 Descriptive statistics

Table 3 summarizes the descriptive statistics of the outcome variables and explanatory variables described above. As is presented in the results section, outcome variables are generally available for narrower ranges of periods than explanatory variables. Table 3 therefore summarizes the statistics for respective periods for outcome variables, and 1991-2019 for explanatory variables.

Generally speaking, the descriptive statistics suggest considerable overall variations in the outcome variables. Countries that were classified as low-income or lower-middle-income countries in 2000 generally show worse conditions in terms of poverty, malnutrition, and children's anthropometrics, as well as access to basic drinking and sanitation services. However, considerable variations are observed even among low- and lower-middle-income countries, which generally suggest that there is significant scope for improvements in these outcomes through various development resources, including the optimal use of PEs.

Among explanatory variables, both the absolute sizes of PEs and relative sizes (shares) of PEs vary across countries and periods. Generally, PE for agriculture is typically the smallest, followed by PE on health, while PEs for education and social protection are relatively larger. In terms of shares, PEs for agriculture and health are about 4.6% and 8.8% on average, respectively (6.5% and 7.4% in low- and lower-income countries, respectively), while PEs for education and social protection are about 13.6% and 18.7% on average, respectively (14.3% and 11.5% on average, respectively). In terms of absolute size, PE for agriculture is about 100 per capita (constant 2010 purchasing power parity (PPP) dollars) on average, and about 150 in low- and lower-income countries, lower than other social-sector PEs and PEs on defense.

As for other explanatory variables, on average, the shares of the urban population are around 50%, the number of major natural disasters and technology-related disasters is about 0.3 ~ 0.6 per year, trade openness measured as the proportion of the sum of import and export to GDP is around 0.8, natural resource rent is around 8% of GDP, and dependency of around 0.7, albeit with considerable variations across countries and periods.

Lastly, Table 3 shows the distributions of regions for which PE variables are reported for all of agriculture, health, education, social protection and defense. The sample shows considerable regional distributions, indicating the global relevance of our analyses.

3.4 Panel unit root test

When both outcome and explanatory variables contain unit-roots and thus are nonstationary, our model (1) can lead to spurious regression. We, therefore, test the stationarity of variables in level, and if nonstationarity is detected in level, test the stationarity of first-differenced forms. We use Fisher-type, Phillips-Perron unit-root tests, which can accommodate panel data that are unbalanced and contain gaps, like ours.[3] Table 4 summarizes the results of panel unit root tests for each variable.[4]

First, for outcome variables with considerable gaps between data points, we use five-year averages as the unit of data, and resulting panel data consist of 4 or 5 rounds at maximum, where

[3]We used STATA command `xtunitroot`, conducted multiple tests, with 0 lag, 1 lag, 2 lags and 3 lags, with and without trends. The null hypothesis is that all panels contain unit root, while the alternative hypothesis is that at least one panel is stationary. Fisher-type tests combine the p-values using the four methods proposed by Choi (2001). If the null hypothesis is rejected by all 4-methods, we conclude that the variable can be treated as stationary.
[4]Detailed results are available from authors upon request.

unit-root tests are unreliable to distinguish stationary and nonstationary series (these variables include TFP growth, poverty prevalence, the prevalence of stunting, underweight and overweight) (Karlsson & Löthgren 2000; Baltagi 2008).

For other outcome variables, consumer food price indices and prevalence of malnutrition were found nonstationary in levels, but stationary when transformed in first-differenced values. Other remaining outcome variables are all found stationery in levels. All explanatory variables, including PE variables, are found stationary in both levels and in first-differences.

Based on the unit-root test results, we estimate all regressions (1) using both outcome variables and explanatory variables in levels, except when outcomes are consumer food price indices or the prevalence of malnutrition. For the latter two outcomes, we estimate (2).

4 Results

Table 5 through Table 9 show the effects of PE in key sectors (agriculture, health, education, social protection, and defense), on key outcome indicators in SDGs 1 and 2 described above. Table 5, Table 7 and Table 9 show the results for all countries included, while Table 6, Table 8 (and again Table 9) show the results for countries that were classified as either "low-income" or "lower-middle-income" in 2000 by the World Bank (Table 10 in Appendix lists countries falling under this classification). Each table shows two sets of results regarding the public expenditure variables; shares of PE in each sector to total PE, and the size of PE in each sector measured as PPP-adjusted per capita values. We also show both the (a) associations between various outcome variables and public expenditures in the same year, as well as (b) associations with average public expenditures of the previous 5 years. Model (a) assumes that the effects of public expenditures exclusively are mostly short-term, while model (b) assumes that the effects materialize in the relatively more medium term.

Food security and poverty

Table 5 and Table 6 summarize the effects on TFP growth in agriculture, consumer food price index, shares of the population living below various international poverty lines, and prevalence of malnutrition. The results broadly suggest that PE in the certain sector have been relatively effective in improving these outcomes. In particular, generally speaking, PE in agriculture and PE in health have been more associated with higher TFP growth in agriculture, reduced food price, reduced poverty, and reduced prevalence of malnutrition. These results are consistent with the hypothesis that PE on agriculture contributes to technological improvements in agricultural production, which then lower food price and reduce poverty through reduced food prices as well as increased incomes of poor households that rely more on agriculture as a major income source. These results also are consistent with the hypothesis that PE on health also improves agricultural productivity, contributing to similar effects on food price and poverty as PE on agriculture.

In contrast, PE for other sectors, including education, social protection, and defense, have had relatively mixed effects on these outcomes. The causes of these relatively weak associations should be investigated more formally in future studies. However, they are consistent with hypotheses briefly described in the literature section on factors preventing PE on education and social protection from translating into effective services on the ground. For education, these include, among others, the challenges in improving quality for education in rural areas (Williams 2005; Abadzi 2009; Antoninis 2014; Muralidharan & Prakash 2017). In Uganda, education has been found not to affect poverty due to similar quality issues, as well as the failure to achieve pro-poorness of education services (Datzberger 2018). For PE on social protection, the relatively

weak effects on poverty reduction and food security observed may in part reflect the challenges associated with appropriate targeting (Cameron & Shah 2014; Golan et al. 2017; Nikolov & Bonci 2020), as well as potential crowding-out effects on labor-market participation (Almanzar & Tolero 2017).

In terms of differences between the share of public expenditures and the size of public expenditures, results suggest that, in both low-income or lower-middle-income countries and other countries, the size of public expenditures, rather than the share of public expenditures, have generally greater effects on these outcomes. While more formal investigations are required (and they are beyond the scope of this study), based on the discussions in earlier sections, the results are more consistent with the hypothesis that Ricardian Equivalence is relatively weak for these relationships.

Nutrition and health

Table 7 and Table 8 summarize the associations between PE on key sectors and various nutritional and health outcomes, including stunting, underweight and overweight among children, as well as access to basic drinking water and sanitation services.

Overall patterns suggest that, similar to the associations with agricultural productivity, food price, and poverty in Table ***5*** and Table 6, PEs on agriculture and health are generally more associated with improved nutritional and health status.

The greater size of PE on agriculture seems to have consistent effects on reduced stunting or underweight among children under 5 in the same year or in future years, in both low- and lower-middle-income countries and other countries. These are consistent with hypotheses on significant agriculture-nutrition linkages put forth by earlier studies in the literature review section, that domestic and household level agricultural production is still an important source of food and macro- and micro-nutrients for children. Stunting is also reduced through poverty reduction (e.g., Akram et al. 2018), which may be another indirect pathway that PE on agriculture contributes to reduced stunting. The roles of health PE on reduced stunting and underweight among children are also consistent with the aforementioned literature highlighting the positive effects of health sector aid (Wilson 2011) and healthcare services (Okeke Abubakar 2020; Das et al. 2016). Unlike agriculture-PE, health-PE is also often associated with reduced overweight among children, which is also consistent with the aforementioned literature discussing the roles of maternal and child health programs on reducing overweight in SSA (Haggblade et al. 2016).

PE on agriculture also is found to be associated with greater access to drinking water and sanitation (related to SDG 1.4.1 on access to basic services) in both low- and lower-middle-income countries, as well as in other countries. These associations are consistent with the hypothesis that increased incomes and poverty reduction, enabled by PE on agriculture (**Table *5*** and Table 6), leads to a greater ability for households to pay for drinking water and sanitation services. However, as was mentioned, the exact roles of agriculture-PE on various basic services like drinking water and sanitation have not been widely studied, and require more in-depth investigation in future studies.

Contrary to agriculture- or health-PE, the associations with PEs in other sectors are less clear. In particular, greater education-PE is sometimes found to be associated with higher stunting or overweight among children. While more detailed investigations should be conducted in future studies, these associations may in part reflect the challenges in translating education-PE into quality education services, especially in rural areas (e.g., Williams 2005; Abadzi 2009; Antoninis 2014; Muralidharan & Prakash 2017).

Biodiversity

Table 9 summarizes the effects of PE on two sustainability indicators related to the maintenance of genetic diversity of seeds, associated with goal 2.5 of SDG. As was described above, we included these in the set of outcome variables, as they are part of indicators in SDG 2, and information was available with sufficient samples.

Unlike the other outcomes discussed above, PEs are less clearly associated with these two genetic diversity indicators. However, in low- and lower-middle-income countries, PE on agriculture (both expenditure shares and size of expenditures) are significantly associated with reduced risk of extinction for local breeds in the same year. Associations with PE on agriculture are broadly consistent with studies highlighting the positive role of agricultural development on genetic diversity, such as the role of improved varieties (e.g., Nelson & Maredia 2007; Krishna et al. 2016) or input subsidies (Dorward 2009) on mitigating biodiversity loss. These associations, as well as seeming associations with PE on other sectors, imply that more formal investigations in future studies are potentially important.

Effects of other explanatory variables

Our primary focuses are the effects of PE variables, and the effects of other explanatory variables are of secondary focus. Table 11 through Table 13 summarize the statistically significant signs of these variables. These tables generally suggest that other explanatory variables collectively affect outcome variables separately through the effects of PEs, justifying their inclusions in the models. Generally, urbanization and improved governance are positively associated with poverty reduction and improvements in child nutrition. Incidence of disasters and higher natural resource rent is overall negatively associated with these outcomes. Greater trade openness is associated with higher poverty and stunting. These counterintuitive results may reflect the possibility of domestic market (such as labor market) imperfections whereby the poor people fail to benefit from increased trade while facing increased competition for other production resources in the short term. Overall, controlling for these factors helps us more accurately estimate the effects of PEs on the outcomes of our interest.

5 Conclusions

Public-expenditures (PE) have been considered important resources toward achieving Sustainable Development Goals (SDGs), through the provisions of public goods (both tangible and intangible), provisions of key public-service deliveries, in inclusive and pro-poor manners, that may be under-supplied by the private sector.

Knowledge gaps are still vast, however, as to how past PEs in different sectors have actually contributed to various SDG outcomes. Where evidence is available, it has been either for a relatively small set of countries and regions or PE in a single sector, instead of offering comparative perspectives across broader sectors, such as agriculture, health, education, and social protection.

This study, making use of SPEED data that have been compiled and updated by IFPRI, and a range of cross-country panel data, aimed at providing some cross-country insights into the associations between PE in key sectors and relevant outcomes related to SDGs 1 and 2, the eradication of poverty and hunger, and realization of improved, sustainable food and nutrition security.

The results generally suggest that past PEs have been associated with improvement in various indicators under SDGs 1 and 2 across countries. In particular, greater PEs on agriculture and health have generally been associated with faster growth in agricultural TFP, lower

consumer food price indices, and reduced poverty. Greater PEs on agriculture and health have also generally been associated with improved child nutrition like the lower prevalence of stunting, underweight-for-age, and overweight-for-age, and improved use of basic drinking water and sanitation services. We also find indicative evidence, albeit weak, that greater PEs on agriculture potentially contribute to enhancing sustainability through preservations of genetic diversity. These effects apply to a relatively broad set of countries, though somewhat clearer in low- and lower-income countries. Increasing absolute sizes of PEs in these sectors also have been relatively more strongly associated with these improvements than the simply increasing relative size of PEs (shares to total PEs), which is consistent with the hypothesis that social returns to overall PEs may be higher than the costs through taxation to finance these PEs, as far as SDGs 1 and 2 are concerned.

In terms of differences across sectors, we also find some indications that PEs on education or social protection have had relatively more mixed effects on SDGs 1 and 2 indicators. These are consistent with concerns expressed in the literature on education and social protection, on quality of education services, contents, institutions, as well as challenges associated with targeting issues for social protection. Whether overcoming these challenges can help realize the potentials of PEs on education and social protection to more effectively contribute to SDGs 1 and 2, should be investigated in future studies.

Lastly, while the study contributes greatly toward filling the aforementioned knowledge gaps, continued analyses in future studies are needed. Our study limits its focus on the simplest forms of econometric specifications, and results are relevant only under the assumptions that the econometric specifications correctly represent the relations between PEs and presented outcome variables. In reality, however, the linkages between PEs and these outcome variables are more complex. While our analyses focus exclusively on static aspects, there can be significant dynamic linkages between PEs and studied outcomes. PEs may have more cumulative effects on these outcomes, which materialize over a much longer-term than considered in our analyses. The pathways of the linkages between PEs and studied outcomes are also expected to be complex. Continuous analyses are required to investigate all these aspects in order to better understand the roles of PEs in the eradication of poverty and hunger and in the improvement of food and nutrition security.

References

Abadzi H. 2009. Instructional time loss in developing countries: Concepts, measurement, and implications. *World Bank Research Observer 24*(2), 267-290.

Acosta-Ormaechea MS & Morozumi, A. (2013). Can a government enhance long-run growth by changing the composition of public expenditure? (No. 13-162). International Monetary Fund.

Akram R, M Sultana, N Ali, N Sheikh & AR Sarker. 2018. Prevalence and determinants of stunting among preschool children and its urban–rural disparities in Bangladesh. *Food and Nutrition Bulletin 39*(4), 521-535.

Akresh R, P Verwiimp & T Bundervoet. 2011. Civil War, Crop Failure, and Child Stunting in Rwanda. *Econ. Dev. Cult. Change 59*(4), 777-810.

Alesina A. 1998. *The political economy of macroeconomic stabilisations and income inequality: myths and reality.* In V Tanzi & K Chu (eds), *Income Distribution and High-Quality Growth.* MIT Press, London.

Almanzar M & M Torero. 2017. Distributional Effects of Growth and Public Expenditures in Africa: Estimates for Tanzania and Rwanda. *World Development 95*, 177-195.

Anderson E, MA Jalles D'Orey, M Duvendack & L Esposito. 2017. Does Government Spending Affect Income Inequality? A Meta-regression Analysis. *Journal of Economic Surveys 31* (4): 961–987.

Anderson E, MA Jalles D'Orey, M Duvendack & L Esposito. 2018. "Does Government Spending Affect Income Poverty? A Meta-regression Analysis." *World Development 103*: 60–71.

Antoninis M. 2014. Tackling the largest global education challenge? Secular and religious education in northern Nigeria. *World Development, 59*, 82-92.

Baffes J, V Kshirsagar & D Mitchell. 2019. What Drives Local Food Prices? Evidence from the Tanzanian Maize Market. *World Bank Economic Review 33*(1):160-184.

Bahal G, M Raissi & V Tulin. 2018. Crowding-Out or Crowding-In? Public and Private Investment in India. *World Development 109*:323-333.

Baltagi, B. H. (2008). *Econometric analysis of panel data.* Chichester: John wiley & sons.

Barro RJ. 1976. Perceived Wealth in Bonds and Social Security and the Ricardian Equivalence Theorem: Reply to Feldstein and Buchanan. *Journal of Political Economy 84*(2): 343–50.

Barro RJ. 1991. Economic growth in a cross section of countries. *Quarterly Journal of Economics 106*(2):407-443.

Bellows AL, CR Canavan, MM Blakstad, D Mosha, RA Noor, P Webb, J Kinabo, H Masanja & WW Fawzi. 2020. The Relationship between Dietary Diversity among Women of Reproductive Age and Agricultural Diversity in Rural Tanzania. *Food and Nutrition Bulletin 41*(1):50-60.

Benin S, E Nkonya, G Okecho, J Randriamamonjy, E Kato, G Lubade & M Kyotalimye. 2011. Returns to spending on agricultural extension: the case of the National Agricultural Advisory Services (NAADS) program of Uganda. *Agric. Econ. 42*(2):249-267.

Bergh A, I Mirkina & T Nilsson. 2020. Can social spending cushion the inequality effect of globalization? *Economics & Politics 32*(1):104-142.

Binswanger HP & K Deininger. 1997. Explaining agricultural and agrarian policies in developing countries. *Journal of Economic Literature, 35*(4), 1958–2005.

Bose, N., Haque, M. E., & Osborn, D. R. (2007). Public expenditure and economic growth: A disaggregated analysis for developing countries. *The Manchester School, 75*(5), 533-556.

Bustos P, B Caprettini & J Ponticelli. 2016. Agricultural Productivity and Structural Transformation: Evidence from Brazil. *American Economic Review 106*(6):1320-1365.

Cameron L & M Shah. 2014. Can mistargeting destroy social capital and stimulate crime? Evidence from a cash transfer program in Indonesia. *Economic Development and Cultural Change, 62*(2), 381-415.
Castañeda Rodríguez VM. 2018. Tax determinants revisited. An unbalanced data panel analysis. *Journal of Applied Economics*, *21*(1), 1-24.
Castro-Leal F, J Dayton, L Demery & K Mehra. 1999. Public spending on health care in Africa: Do the poor benefit? *World Bank Research Observer 14*(1):49-72.
The Centre for Research on the Epidemiology of Disasters (CRED) (2021). *Emergency Events Database (EM-DAT)*. Available at http://www.emdat.be/. Accessed on September 29, 2021.
Choi I. 2001. Unit root tests for panel data. *Journal of International Money and Finance 20*: 249–272.
Das J, A Holla, A Mohpal & K Muralidharan. 2016. Quality and accountability in health care delivery: audit-study evidence from primary care in India. *American Economic Review, 106*(12), 3765-99.
Datt G & M Ravallion. 1998. Farm productivity and rural poverty in India. *Journal of Development Studies*, *34*(4), 62-85.
Datzberger S. 2018. Why education is not helping the poor. Findings from Uganda. *World Development 110*, 124-139.
Davoodi H, E Tiongson & S Asawanuchit. 2010. Benefit incidence of public education and health spending worldwide: Evidence from a new database. *Poverty and Public Policy 2*(2):5-52.
de Janvry A & E Sadoulet. 2010. Agricultural growth and poverty reduction: Additional evidence. *World Bank Research Observer 25*(1), 1–20.
De La Fuente A, HG Jacoby & KG Lawin. 2020. Impact of the West African Ebola epidemic on agricultural production and rural welfare: Evidence from Liberia. *Journal of African Economies, 29*(5), 454-474.
Djoumessi YF, CB Kamdem & L Ndeffo Nembot. 2020. Moving off agrarian societies: Agricultural productivity to facilitate economic transformations and non-agricultural employment growth in sub-Saharan Africa. *Journal of International Development 32*(3), 324-341.
Dorward A. 2009. *Rethinking agricultural input subsidy programmes in a changing world.* Paper presented for the Trade and Markets Division, Food and Agriculture Organization of the United Nations.
Easterly W & S Rebelo. 1993. Fiscal policy and economic growth: An empirical investment. *Journal of Monetary Economics 32*(3):417-458.
Evenson R & LE Westphal. 1995. *Technological Change and Technology Strategy*. In J Behrman & TN Srinivasan (Eds.), *Handbook of Development Economics*. 2209-2299. Amsterdam: Elsevier.
Fan S, P Hazell & S Thorat. 2000. "Government Spending, Agricultural Growth and Poverty in Rural India." *American Journal of Agricultural Economics 82* (4):1038–1051.
Fan S & X Zhang. 2008. "Public Expenditure, Growth and Poverty Reduction in Rural Uganda." *African Development Review 20* (3): 466–496.
Fan S, S Yosef & R Pandya-Lorch. 2019. A*griculture for Improved Nutrition: Seizing the Momentum*. Washington, DC: International Food Policy Research Institute.
Gnangoin, Y. T. B., Du, L., Assamoi, G., Edjoukou, A. J., & Kassi, D. F. (2019). Public spending, income inequality and economic growth in Asian countries: a panel GMM approach. *Economies, 7*(4), 115.

Golan J, T Sicular & N Umapathi. 2017. Unconditional cash transfers in China: who benefits from the rural minimum living standard guarantee (Dibao) program? *World Development, 93*, 316-336.
Gollin D, CW Hansen & A Wingender. 2018. *Two Blades of Grass: The Impact of the Green Revolution*. NBER Working Paper 24744. Cambridge, MA, US: National Bureau of Economic Research.
Grigoli F, A Herman & K Schmidt-Hebbel. 2018. Saving in the world. *World Development, 104*, 257-270.
Haggblade S, KG Duodu, JD Kabasa, A Minnaar, NK Ojijo & JR Taylor. 2016. Emerging early actions to bend the curve in sub-Saharan Africa's nutrition transition. *Food and Nutrition Bulletin, 37*(2), 219-241.
Harou AP. 2018. Unraveling the Effect of Targeted Input Subsidies on Dietary Diversity in Household Consumption and Child Nutrition: The Case of Malawi. *World Development 106*: 124-135.
Hasan SA. 2017. The distributional effect of a large rice price increase on welfare and poverty in Bangladesh. *Australian Journal of Agricultural and Resource Economics, 61*(1), 154-171.
Haug AA. 2019. Testing Ricardian Equivalence with the Narrative Record on Tax Changes. *Oxford Bulletin of Economics and Statistics 82*(2):387-404.
Headey D, M Alauddin & DP Rao. 2010. Explaining agricultural productivity growth: an international perspective. *Agricultural Economics 41*(1), 1-14.
International Food Policy Research Institute (IFPRI). 2019. *Statistics on Public Expenditures for Economic Development (SPEED).* Washington, DC: IFPRI [dataset]. https://doi.org/10.7910/DVN/MKX1TU. Harvard Dataverse, VERSION 1.
IFPRI. 2021. *Global Food Policy Report 2021*. Washington DC: IFPRI.
Ivanic, M., Martin, W., & Zaman, H. (2012). Estimating the short-run poverty impacts of the 2010–11 surge in food prices. *World Development 40*(11), 2302-2317.
Karlsson, S., & Löthgren, M. (2000). On the power and interpretation of panel unit root tests. *Economics Letters, 66*(3), 249-255.
Kaufmann D, A Kraay & M Mastruzzi. (2010). *The Worldwide Governance Indicators: Methodology and Analytical Issues*. The Brookings Institution.
Kotwal A & B Ramswami. (1998). Economic reforms of agriculture and rural growth. *The Journal of Policy Reform 2*(4), 369-402.
Krishna, V., Qaim, M., & Zilberman, D. (2016). Transgenic crops, production risk and agrobiodiversity. *European Review of Agricultural Economics, 43*(1), 137-164.
Lee IH. 2018. Industrial Output Fluctuations in Developing Countries: General Equilibrium Consequences of Agricultural Productivity Shocks. *European Economic Review 102*:240-279.
Lio MC & JL Hu. (2009). Governance and Agricultural Production Efficiency: A Cross-Country Aggregate Frontier Analysis. *J. Agric. Econ. 60*(1), 40-61.
Loizou E, C Karelakis, K Galanopoulos & K Mattas. 2019. The Role of Agriculture as a Development Tool for a Regional Economy. Agricultural Systems *173*:482-490.
Loureiro ML. 2009. Farmers' health and agricultural productivity. *Agricultural Economics, 40*(4), 381-388.
Mankiw G, D Romer & D Weil. 1992. A contribution to the empirics of economic growth. *Quarterly Journal of Economics 107*(2):407-437.

Martinez-Vasquez J, V Vulovic & B Moreno-Dodson. 2012. The impact of tax and expenditure policies on income distribution: evidence from a large panel of countries. *Review of Public Economics 200*(4):95-130.
Masson PR, T Bayoumi & H Samiei. 1998. International evidence on the determinants of private saving. *World Bank Economic Review 12*(3), 483-501.
Mellor J & G Desai. 1986. *Agricultural change and rural poverty variations on a theme by Dbarm Narain*, Oxford University Press.
McArthur JW & GC McCord. 2017. Fertilizing Growth: Agricultural Inputs and Their Effects in Economic Development. *Journal of Development Economics 127*:133-152.
McArthur JW & JD Sachs. 2019. Agriculture, Aid, and Economic Growth in Africa. *World Bank Economic Review 33*(1):1-20.
Mogues T & S Benin. 2012. *Public Expenditures for Agricultural and Rural Development in Africa*. Oxford, UK: Routledge.
Muralidharan K & N Prakash. 2017. Cycling to school: Increasing secondary school enrollment for girls in India. *American Economic Journal: Applied Economics, 9*(3), 321-50.
Nelson M & MK Maredia. (2007). International Agricultural Research as a Source of Environmental Impacts: Challenges and Possibilities. *Journal of Environmental Assessment Policy and Management 9*(1):103–19.
Nikolov P & M Bonci. 2020. Do public program benefits crowd out private transfers in developing countries? A critical review of recent evidence. *World Development 134*, 104967.
Okeke EN & IS Abubakar. 2020. Healthcare at the beginning of life and child survival: Evidence from a cash transfer experiment in Nigeria. *Journal of Development Economics 143*, 102426.
Pan Y & S Singhal. 2019. Agricultural extension, intra-household allocation and malaria. *Journal of Development Economics 139*, 157-170.
Pitt MM, MR Rosenzweig & MN Hassan. 1990. Productivity, health and inequality in the intrahousehold distribution of food in low-income countries, *American Economic Review 80*:1139-1156.
Rohne Till E. 2021. A green revolution in sub-Saharan Africa? The transformation of Ethiopia's agricultural sector. *Journal of International Development 33*(2), 277-315.
Ruel MT, AR Quisumbing & M Balagamwala. 2018. Nutrition-Sensitive Agriculture: What Have We Learned So Far? *Global Food Security 17*:128-153.
Skoufias E, K Vinha & R Sato. 2021. Reducing Stunting through Multisectoral Efforts in Sub-Saharan Africa. *Journal of African Economies 30*(4), 324-348.
Spielman D & K von Grebmar. 2006. Public-private partnership in international agricultural research: An analysis of constraints. *Journal of Technology Transfer 23*(3):313-331.
United Nations. 2021. *SDG Indicators.* Statistics Division, Department of Economic and Social Affairs, United Nations. Available at https://unstats.un.org/sdgs/UNSDG/
von der Goltz J, A Dar, R Fishman, ND Mueller, P Barnwal & GC McCord. 2020. Health Impacts of the Green Revolution: Evidence from 600,000 births across the Developing World. *Journal of Health Economics 74*, 102373.
Williams JH. 2005. Cross-National Variations in Rural Mathematics Achievement: A Descriptive Overview. *Journal of Research in Rural Education 20*, 1-18.
Wilson SE. 2011. Chasing success: health sector aid and mortality. *World Development 39*(11), 2032-2043.
World Bank. 2007. *World Development Report 2008: Agriculture for Development*. Washington, DC: World Bank.
World Bank. 2021. *World Development Indicators.* Washington, DC: World Bank.

World Bank. 2021b. *Worldwide Governance Indicators.* Washington, DC: World Bank.
Wouterse F & O Badiane. 2019. The role of health, experience, and educational attainment in agricultural production: Evidence from smallholders in Burkina Faso. *Agricultural Economics 50*(4), 421-434.
Yu B, E Magalhaes & S Benin. 2015. *A database user manual for SPEED: Statistics on Public Expenditures for Economic Development*. Washington, DC: IFPRI.

Tables

Table 1. Key outcome variables relevant to SDG 1 and 2 used in this study

SDG indicators and relevant SDG numbers	Definitions of outcome variables used	Source
1.1: Proportion of the population living below the international poverty line by sex, age, employment status and geographic location (urban/rural)	Proportion of population below international poverty lines (%) at 1.90, 3.20 and 5.50 (2010 International Dollar per capita per day)	World Bank (2021)
1.4: Proportion of population living in households with access to basic services	Proportion of population using basic drinking water services, by location (%)	UN (2021)
	Proportion of population using basic sanitation services, by location (%)	UN (2021)
2.1. Prevalence of undernourishment	Prevalence of undernourishment (%)	FAOSTAT
2.2.1: Prevalence of stunting among children under 5 years of age	Proportion of children under age 5 who are stunted (%)	World Bank (2021)
2.2.2: Prevalence of malnutrition among children under 5 years of age, by type (wasting and overweight)	Proportion of children under age 5 who are underweight (%)	World Bank (2021)
	Proportion of children under age 5 who are overweight (%)	World Bank (2021)
2.3.2: Average income of small-scale food producers, by sex and indigenous status	Annual growth rate in the total factor productivity (TFP) in agriculture (average between 1991-2000, 2001-2005, 2006-2010, 2011-2016)	IFPRI (2021)
2.5.1: Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities	Plant breeds for which sufficient genetic resources are stored (number)	UN (2021)
	Proportion of local breeds classified as being at risk of extension as a share of local breeds with known level of risk (%)	UN (2021)
2.c: Indicator of food price anomalies	Consumer Food Price Index (2015 = 100)	FAOSTAT

Source: Authors.

Note: Other indicators under SDGs 1 and 2 were not used due to insufficient observations.

Table 2. Other explanatory variables

Variables	Definition	Source
Urban population share (%)	Share of urban population to total population	World Bank (2021)
Natural disaster	Whether the country experienced any major natural disasters in a particular year	CRED (2021)
Technological disaster	Whether the country experienced any major technological disasters in a particular year	CRED (2021)
Trade openness		World Bank (2021)
Worldwide Governance Indicators	• Voice (voice and accountability) • Stability (Political Stability and Absence of Violence/Terrorism) • Effectiveness (Government Effectiveness) • Regulation (Regulatory Quality) • Law (Rule of Law) • Corruption (Control of Corruption)	World Bank (2021b)
Natural resource rent	The ratio of natural resource rent to GDP (%)	World Bank (2021)
Dependency	The ratio of population older than 65 to the population between 15 and 64	World Bank (2021)
Year and region dummy interaction	Interaction terms between year and regions	Region dummy defined by the World Bank

Source: Authors.

Table 3. Descriptive statistics

Variables	Period range	All samples			Low- / Lower-Middle income countries		
		Mean	Min	Max	Mean	Min	Max
Outcomes							
TFP growth rate (% per year)	1991-2016	0.587	-8.798	8.844	0.628	-6.874	8.844
Consumer Prices, Food Indices (2015 = 100)	2003-2017	80.431	6.538	176.712	75.085	10.631	170.817
Poverty prevalence (%, below 1.90 international dollar per day)	1995-2019	12.571	0.000	94.300	16.344	0.000	94.300
Poverty prevalence (%, below 3.20 international dollar per day)	1995-2019	23.381	0.000	98.500	30.972	0.000	98.500
Poverty prevalence (%, below 5.50 international dollar per day)	1995-2019	37.002	0.000	100.000	50.560	0.200	100.000
Malnutrition (prevalence, %)	2003-2017	10.579	2.500	67.500	14.160	2.500	67.500
Stunting (prevalence, % of children under 5)	1995-2019	27.776	0.000	73.600	31.295	2.200	73.600
Underweight (prevalence, % of children under 5)	1995-2019	14.908	0.000	61.200	17.216	0.800	61.200
Overweight (prevalence, % of children under 5)	1995-2019	6.264	0.000	30.100	5.772	0.000	30.100
Proportion of population using basic drinking water services in rural areas (%)	2000-2017	85.260	18.695	100.000	76.315	18.695	100.000
Proportion of population using basic sanitation services in rural areas (%)	2000-2017	60.910	1.190	100.000	48.912	1.190	100.000
Plant breeds with sufficient genetic resources stored (number)	2000-2017	86472	0	5428650	21969	0	405923
Proportion of local breeds classified as being at risk (%)	2000-2017	56.487	0.000	100.000	30.207	0.000	100.000
Explanatory variables							
PE share (%, agriculture)	1991-2019	4.633	0.000	45.681	6.546	0.000	45.681
PE share (%, health)	1991-2019	8.830	0.004	31.989	7.369	0.004	31.989
PE share (%, education)	1991-2019	13.603	0.001	74.146	14.320	0.001	74.146
PE share (%, social protection)	1991-2019	18.740	0.000	62.026	11.514	0.000	54.529
PE share (%, defense)	1991-2019	8.091	0.012	78.373	9.235	0.012	78.373
PE per capita (PPP $, agriculture)	1991-2019	104.504	0.001	1682.325	56.985	0.001	604.429
PE per capita (PPP $, health)	1991-2019	680.837	0.018	5196.586	153.753	0.018	2405.972
PE per capita (PPP $, education)	1991-2019	766.006	0.088	6764.604	255.470	0.088	6764.604
PE per capita (PPP $, social protection)	1991-2019	1786.855	0.001	16760.130	335.177	0.001	5572.316
PE per capita (PPP $, defense)	1991-2019	404.913	1.239	10211.670	141.082	1.239	2639.741
Urban population	1991-2019	55.912	5.491	100.000	44.201	5.491	91.203
Natural disaster	1991-2019	0.428	0.000	1.000	0.644	0.000	1.000
Technological disaster	1991-2019	0.267	0.000	1.000	0.414	0.000	1.000
Trade openness (proportion of (import + export) to GDP)	1991-2019	0.819	0.0002	8.608	0.758	0.0002	3.480
Governance indicator (Voice)	1991-2019	0.000	-2.313	1.810	-0.485	-2.313	1.256
Stability	1991-2019	0.000	-3.315	1.965	-0.470	-3.315	1.423
Effectiveness	1991-2019	0.000	-2.484	2.437	-0.598	-2.446	1.185
Regulation	1991-2019	0.000	-2.645	2.261	-0.572	-2.645	1.277

Variables	Period range	All samples			Low- / Lower-Middle income countries		
		Mean	Min	Max	Mean	Min	Max
Outcomes							
Law	1991-2019	0.000	-2.606	2.100	-0.599	-2.606	1.077
Corruption control	1991-2019	0.000	-1.869	2.470	-0.582	-1.869	1.647
Natural resource rent (% of GDP)	1991-2019	7.033	0.000	86.252	8.578	0.000	86.252
Dependency (proportion of dependents to working-age population)	1991-2019	0.641	0.157	1.175	0.725	0.308	1.175
Regions for which PEs for all five sectors are reported (1991-2019; yes = 1)							
East Asia & Pacific		0.135			0.151		
Europe & Central Asia		0.358			0.217		
Latin America & Caribbean		0.135			0.118		
Middle East & North Africa		0.116			0.098		
North America		0.018			0.000		
South Asia		0.062			0.120		
Sub-Saharan Africa		0.177			0.295		

Source: Authors' computations based on various data.

Table 4. Results of panel unit root tests for variables

Variables	Level	First difference
Outcomes		
TFP growth rate (% per year)[a]	Stationary	
Consumer Prices, Food Indices	Nonstationary	Stationary
Poverty prevalence (%, below 1.90 international dollar per day)[a]	Stationary	
Poverty prevalence (%, below 3.20 international dollar per day)[a]	Stationary	
Poverty prevalence (%, below 5.50 international dollar per day)[a]	Stationary	
Malnutrition (prevalence, %)	Nonstationary	Stationary
Stunting (prevalence, % of children under 5)[a]	Stationary	
Underweight (prevalence, % of children under 5)[a]	Stationary	
Overweight (prevalence, % of children under 5)[a]	Stationary	
Proportion of population using basic drinking water services, by location (%)	Stationary	Stationary
Proportion of population using basic sanitation services, by location (%) – rural area	Stationary	Stationary
Proportion of local breeds classified as being at risk (%)	Stationary	Stationary
Explanatory variables		
PE share (agriculture)	Stationary	Stationary
PE share (health)	Stationary	Stationary
PE share (education)	Stationary	Stationary
PE share (social protection)	Stationary	Stationary
PE share (defense)	Stationary	Stationary
PE per capita (agriculture)	Stationary	Stationary
PE per capita (health)	Stationary	Stationary
PE per capita (education)	Stationary	Stationary
PE per capita (social protection)	Stationary	Stationary
PE per capita (defense)	Stationary	Stationary
Urban population	Stationary	Stationary
Natural disaster	Stationary	Stationary
Technological disaster	Stationary	Stationary
Trade openness	Stationary	Stationary
Voice	Stationary	Stationary
Stability	Stationary	Stationary
Effectiveness	Stationary	Stationary
Regulation	Stationary	Stationary
Law	Stationary	Stationary
Corruption control	Stationary	Stationary
Natural resource rent	Stationary	Stationary
Dependency	Stationary	Stationary

Source: Authors' estimation.

[a]These variables use 5-year averages and thus panel is too short for unit root tests.

Table 5. Effects of public expenditures in different sectors on agricultural productivity, food price, poverty and undernutrition

Variables		TFP growth / year (percentage point)	Reduction in consumer food price indices (2015=100)		Reduction in poverty below 1.90 international dollar per day (percentage point)		Reduction in poverty below 3.20 international dollar per day (percentage point)		Reduction in poverty below 5.50 international dollar per day (percentage point)		Reduction in undernutrition (percentage point)	
Unit of sample		5-year average	Annual		5-year average		5-year average		5-year average		Annual	
First difference or not		Level	First difference		Level		Level		Level		First difference	
Models		A	A	B	A	B	A	B	A	B	A	B
Share (%) of PE for the sector to total PE	Agriculture	– 0.096	0.207*	0.152	0.049	0.081	0.560	0.220	1.199**	0.451*	– 0.024	– 0.149
		(0.651)	(0.116)	(0.115)	(0.533)	(0.230)	(0.456)	(0.194)	(0.498)	(0.267)	(0.035)	(0.125)
	Health	0.419†	– 0.002	– 0.011	0.439**	0.213	0.336	0.236†	0.076	0.211	0.029*	0.020
		(0.288)	(0.049)	(0.152)	(0.202)	(0.158)	(0.240)	(0.148)	(0.265)	(0.192)	(0.017)	(0.061)
	Education	– 0.394†	0.024	– 0.018	– 0.314*	– 0.215	– 0.042	– 0.171	0.293	0.096	– 0.030†	– 0.040
		(0.237)	(0.046)	(0.171)	(0.170)	(0.113)	(0.161)	(0.147)	(0.183)	(0.128)	(0.019)	(0.061)
	Social protection	– 0.078	0.046†	0.119	– 0.128*	– 0.114	– 0.111	– 0.146*	– 0.094	– 0.220**	0.004	– 0.007
		(0.111)	(0.030)	(0.148)	(0.071)	(0.081)	(0.075)	(0.083)	(0.117)	(0.094)	(0.004)	(0.023)
	Defense	0.038	– 0.064	– 0.215	0.220	0.003	– 0.045	0.148	– 0.212	0.013	0.013	– 0.022
		(0.297)	(0.051)	(0.180)	(0.215)	(0.188)	(0.191)	(0.142)	(0.235)	(0.125)	(0.013)	(0.069)
Size of PE for each sector (natural log)	Agriculture	0.020	0.611**	2.013**	1.274	1.057†	2.311**	1.560**	3.427***	3.567***	0.070	– 0.066
		(0.016)	(0.282)	(0.977)	(0.921)	(0.711)	(0.949)	(0.743)	(1.240)	(0.932)	(0.072)	(0.235)
	Health	0.013*	0.164	– 0.080	3.293***	2.034**	2.747*	1.918**	1.231	1.258	0.291*	0.099
		(0.008)	(0.323)	(1.017)	(1.143)	(0.098)	(1.480)	(0.968)	(1.775)	(1.141)	(0.155)	(0.408)
	Education	– 0.006*	0.998*	1.965	–2.536**	–2.736**	– 0.724	–2.508†	2.458	1.030	– 0.321	– 0.021
		(0.003)	(0.533)	(1.439)	(1.264)	(1.322)	(1.695)	(1.581)	(2.471)	(1.575)	(0.287)	(0.638)
	Social protection	– 0.001	0.186	0.217	0.692	– 0.577	0.127	–1.347**	– 0.121	–1.567**	– 0.014	– 0.020
		(0.002)	(0.150)	(0.417)	(0.616)	(0.670)	(0.644)	(0.592)	(0.606)	(0.651)	(0.055)	(0.209)
	Defense	0.003	0.176	–3.586**	1.925	0.609	1.684	1.639	1.388	0.964	0.165*	– 0.028
		(0.002)	(0.291)	(1.463)	(1.257)	(1.382)	(1.420)	(1.250)	(2.112)	(1.245)	(0.086)	(0.435)
Sample size		185	1289	1622	376	340	376	340	376	340	1174	1461
Number of countries		71	118	120	111	113	111	113	111	113	104	106
Average rounds		2.6	10.9	13.5	3.4	3.0	3.4	3.0	3.4	3.0	11.3	13.8
Beginning period		1991-2000	2003		1995-1999		1995-1999		1995-1999		2003	
Ending period		2011-2016	2017		2015-2019		2015-2019		2015-2019		2017	

Source: Authors. ***1% **5% *10% †15%.

Note: Numbers in figures show estimated standard errors that are robust against unknown forms of heteroskedasticity or serial correlations.
A = using only the PEs in the same year; B = using averages of PEs from the past 5 years.

Table 6. Results for countries classified as low- or lower-middle-income in 2000

Variables		TFP growth / year (percentage point)	Reduction in consumer food price indices (2015=100)		Reduction in poverty below 1.90 international dollar per day (percentage point)		Reduction in poverty below 3.20 international dollar per day (percentage point)		Reduction in poverty below 5.50 international dollar per day (percentage point)		Reduction in undernutrition (percentage point)	
Unit of sample		5-year average	Annual		5-year average		5-year average		5-year average		Annual	
First difference or not		Level	First difference		Level		Level		Level		First difference	
Models		A	A	B	A	B	A	B	A	B	A	B
Share (%) of PE for the sector to total PE	Agriculture	-0.083	0.202*	0.041	0.063	0.099	0.729	0.273	0.241**	0.455†	– 0.030	– 0.168
		(0.687)	(0.123)	(0.081)	(0.643)	(0.306)	(0.536)	(0.239)	(0.583)	(0.290)	(0.042)	(0.150)
	Health	0.149	0.050	– 0.102	0.656	0.365	0.495	0.356	0.387	0.261	0.030	0.060
		(0.365)	(0.070)	(0.157)	(0.435)	(0.359)	(0.460)	(0.289)	(0.447)	(0.335)	(0.023)	(0.079)
	Education	-0.340	0.031	– 0.059	– 0.541**	– 0.336	– 0.189	– 0.382†	0.037	– 0.065	– 0.032	– 0.056
		(0.261)	(0.061)	(0.193)	(0.265)	(0.240)	(0.236)	(0.242)	(0.237)	(0.246)	(0.027)	(0.083)
	Social protection	-0.134	0.042	0.003	– 0.213*	– 0.309**	– 0.195	– 0.398***	– 0.186	– 0.565***	0.004	– 0.040
		(0.141)	(0.051)	(0.262)	(0.107)	(0.140)	(0.114)	(0.144)	(0.172)	(0.146)	(0.008)	(0.038)
	Defense	-0.306	– 0.074	– 0.494**	– 0.020	– 0.192	– 0.092	– 0.051	– 0.256	– 0.134	0.007	0.007
		(0.355)	(0.068)	(0.235)	(0.252)	(0.292)	(0.216)	(0.206)	(0.253)	(0.194)	(0.018)	(0.093)
Size of PE for each sector (natural log)	Agriculture	0.049*	0.612†	2.482*	2.051*	1.834	3.268**	2.942**	3.861**	4.782***	0.106	– 0.017
		(0.029)	(0.387)	(1.399)	(1.149)	(1.478)	(1.274)	(1.353)	(1.672)	(1.592)	(0.113)	(0.422)
	Health	0.031***	0.500	0.277	4.939**	4.246*	3.751	3.504†	3.293	2.006	0.407*	0.312
		(0.008)	(0.490)	(1.518)	(2.335)	(2.553)	(2.678)	(2.336)	(2.875)	(3.063)	(0.240)	(0.650)
	Education	-0.019*	0.792	2.403	–3.871*	–4.558*	–1.581	–4.810*	0.024	– 0.574	– 0.460	– 0.097
		(0.010)	(0.600)	(1.748)	(2.079)	(2.452)	(2.212)	(2.521)	(2.538)	(2.259)	(0.388)	(0.843)
	Social protection	0.003	0.108	0.103	0.881	– 0.818	0.158	–1.934***	– 0.208	–2.670***	– 0.016	– 0.141
		(0.005)	(0.171)	(0.379)	(0.707)	(0.818)	(0.737)	(0.665)	(0.717)	(0.659)	(0.063)	(0.201)
	Defense	-0.006*	0.071	–5.150**	1.484	– 0.672	1.237	0.820	1.169	1.023	0.172†	– 0.271
		(0.003)	(0.321)	(1.930)	(1.959)	(2.286)	(1.825)	(1.936)	(2.861)	(2.194)	(0.108)	(0.599)
Sample size		133	630	824	196	177	196	177	196	177	564	728
Number of countries		53	63	65	63	66	63	66	63	66	54	56
Average rounds		2.5	10.0	12.7	3.1	2.7	3.1	2.7	3.1	2.7	10.4	13.0
Beginning period		1991-2000	2003		1995-1999		1995-1999		1995-1999		2003	
Ending period		2011-2016	2017		2015-2019		2015-2019		2015-2019		2017	

Source: Authors. ***1% **5% *10% †15%

Note: Numbers in figures show estimated standard errors that are robust against unknown forms of heteroskedasticity or serial correlations.
A = using only the PEs in the same year; B = using averages of PEs from the past 5 years.

Table 7. Effects of public expenditures in different sectors on nutrition and health and basic services

Variables		Reduced stunting (percentage point)		Reduced underweight (percentage point)		Reduced overweight (percentage point)		Proportion of population using basic drinking water services in rural area (percentage point)		Proportion of population using basic sanitation services in rural area (percentage point)	
Unit of sample		5-year average		5-year average		5-year average		Annual		Annual	
First difference or not		Level		Level		Level		Level		Level	
Models		A	B	A	B	A	B	A	B	A	B
Share (%) of PE for the sector to total PE	Agriculture	0.123	– 0.025	0.212	– 0.002	– 0.019	– 0.021	0.189	– 0.013	– 0.399*	– 0.045
		(0.202)	(0.040)	(0.186)	(0.028)	(0.175)	(0.027)	(0.195)	(0.060)	(0.233)	(0.067)
	Health	0.141	0.135	0.110	0.137	0.079	0.084	– 0.069	– 0.007	– 0.033	– 0.051
		(0.141)	(0.194)	(0.094)	(0.109)	(0.127)	(0.113)	(0.059)	(0.098)	(0.077)	(0.139)
	Education	– 0.144	– 0.080	– 0.059	– 0.032	– 0.033	– 0.024	0.080†	– 0.017	– 0.030	– 0.059
		(0.099)	(0.103)	(0.069)	(0.059)	(0.064)	(0.074)	(0.049)	(0.078)	(0.090)	(0.134)
	Social protection	0.054	0.047	0.021	0.007	– 0.006	– 0.002	– 0.004	0.034	– 0.017	– 0.030
		(0.044)	(0.055)	(0.024)	(0.029)	(0.051)	(0.057)	(0.032)	(0.058)	(0.035)	(0.072)
	Defense	0.132	0.209†	– 0.028	– 0.011	– 0.205**	– 0.205**	0.088	0.096	0.119	0.011
		(0.121)	(0.139)	(0.084)	(0.101)	(0.096)	(0.083)	(0.071)	(0.137)	(0.091)	(0.163)
Size of PE for each sector (natural log)	Agriculture	1.040**	0.944***	0.625***	0.452**	– 0.126	– 0.303	– 0.543*	– 0.887**	– 0.745†	– 0.834†
		(0.384)	(0.327)	(0.235)	(0.219)	(0.222)	(0.224)	(0.281)	(0.414)	(0.459)	(0.552)
	Health	1.144	0.831	0.995	0.932†	1.315†	0.937	– 0.392	0.151	– 0.185	– 0.028
		(1.051)	(0.903)	(0.777)	(0.615)	(0.908)	(0.830)	(0.427)	(0.697)	(0.527)	(0.831)
	Education	–2.087†	–1.936†	– 0.785	– 0.392	–1.159	– 0.820	– 0.022	–1.350	– 0.575	– 0.865
		(1.325)	(1.274)	(0.906)	(0.845)	(0.848)	(1.068)	(0.531)	(0.940)	(0.764)	(1.160)
	Social protection	0.211	0.025	– 0.007	– 0.023	0.144	0.054	– 0.328	– 0.192	0.212	– 0.041
		(0.279)	(0.255)	(0.183)	(0.140)	(0.207)	(0.186)	(0.232)	(0.339)	(0.383)	(0.492)
	Defense	0.504	0.705	– 0.916	– 0.955	– 0.878	–1.042	0.221	0.446	1.005**	1.190
		(1.027)	(1.127)	(0.697)	(0.692)	(0.655)	(0.686)	(0.539)	(0.848)	(0.502)	(0.804)
Sample size		240	281	236	276	232	271	1364	1609	1350	1595
Number of countries		89	94	87	92	86	93	107	113	106	112
Average rounds		2.7	3.0	2.7	3.0	2.7	2.9	12.7	14.2	12.7	14.2
Beginning period		1995-1999		1995-1999		1995-1999		2000		2000	
Ending period		2015-2019		2015-2019		2015-2019		2017		2017	

Source: Authors. ***1% **5% *10% †15%

Note: Numbers in figures show estimated standard errors that are robust against unknown forms of heteroskedasticity or serial correlations.
A = using only the PEs in the same year; B = using averages of PEs from the past 5 years.

Table 8. Results for countries classified as low- or lower-middle-income in 2000

Variables		Reduced stunting (percentage point)		Reduced underweight (percentage point)		Reduced overweight (percentage point)		Proportion of population using basic drinking water services in rural area (percentage point)		Proportion of population using basic sanitation services in rural area (percentage point)	
Unit of sample		5-year average		5-year average		5-year average		Annual		Annual	
First difference or not		Level		Level		Level		Level		Level	
Models		A	B	A	B	A	B	A	B	A	B
Share (%) of PE for the sector to total PE	Agriculture	– 0.033	– 0.036	0.145	– 0.005	– 0.112	– 0.027	0.219	– 0.008	– 0.340	– 0.043
		(0.237)	(0.040)	(0.237)	(0.029)	(0.187)	(0.030)	(0.194)	(0.051)	(0.242)	(0.065)
	Health	0.295*	0.108	0.261**	0.150	0.190	0.158	– 0.031	0.116	0.108	0.287
		(0.160)	(0.268)	(0.130)	(0.166)	(0.162)	(0.171)	(0.066)	(0.126)	(0.075)	(0.198)
	Education	– 0.274**	– 0.120	– 0.140†	– 0.049	– 0.098	– 0.071	0.075	– 0.048	– 0.037	– 0.073
		(0.112)	(0.127)	(0.087)	(0.072)	(0.077)	(0.093)	(0.055)	(0.100)	(0.097)	(0.163)
	Social protection	0.090†	0.064	0.038	0.017	0.095†	0.097	0.005	0.053	0.011	0.018
		(0.061)	(0.095)	(0.043)	(0.048)	(0.058)	(0.080)	(0.034)	(0.082)	(0.043)	(0.100)
	Defense	0.206	0.224	– 0.005	– 0.030	– 0.184**	– 0.160*	0.084	0.145	0.131	0.041
		(0.184)	(0.203)	(0.126)	(0.142)	(0.091)	(0.090)	(0.072)	(0.156)	(0.099)	(0.208)
Size of PE for each sector (natural log)	Agriculture	0.993**	0.915**	0.640**	0.431*	– 0.137	– 0.247	– 0.446	–1.074**	– 0.387	– 0.902†
		(0.433)	(0.371)	(0.265)	(0.237)	(0.276)	(0.262)	(0.404)	(0.492)	(0.536)	(0.588)
	Health	1.724	0.429	1.789†	0.945	2.453**	1.832*	– 0.075	1.121	0.411	1.820
		(1.467)	(1.315)	(1.235)	(0.880)	(0.955)	(1.049)	(0.606)	(1.180)	(0.615)	(1.306)
	Education	–2.722*	–1.983	–1.277	– 0.368	–2.500**	–1.898	– 0.306	–2.287**	– 0.657	–1.698
		(1.500)	(1.549)	(1.083)	(0.994)	(1.094)	(1.347)	(0.582)	(1.143)	(0.776)	(1.373)
	Social protection	0.289	0.230	0.023	0.057	0.344*	0.156	– 0.317†	– 0.253	0.156	– 0.082
		(0.323)	(0.296)	(0.213)	(0.151)	(0.196)	(0.192)	(0.216)	(0.363)	(0.378)	(0.513)
	Defense	0.535	0.383	– 0.977	–1.159	–1.132*	– 0.906	0.401	0.736	1.302**	1.406
		(1.180)	(1.334)	(0.811)	(0.812)	(0.637)	(0.697)	(0.585)	(0.998)	(0.622)	(1.045)
Sample size		177	213	175	210	169	203	751	931	750	930
Number of countries		61	65	60	64	58	65	64	70	64	70
Average rounds		2.9	3.3	2.9	3.3	2.9	3.1	11.7	13.3	11.7	13.3
Beginning period		1995-1999		1995-1999		1995-1999		2000		2000	
Ending period		2015-2019		2015-2019		2015-2019		2017		2017	

Source: Authors. ***1% **5% *10% †15%

Note: Numbers in figures show estimated standard errors that are robust against unknown forms of heteroskedasticity or serial correlations.
A = using only the PEs in the same year; B = using averages of PEs from the past 5 years.

Table 9. Effects of public expenditures in different sectors on biodiversity

Variables		Reduced proportion of local breeds classified as being at risk (percentage point)				Plant breeds for which sufficient genetic resources are stored (number, natural log)			
Sample of countries		All countries		Low / Lower middle-income countries		All countries		Low / Lower middle-income countries	
Unit of sample		Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual
First difference or not		Level	Level	Level	Level	Level	Level	Level	Level
Models		A	B	A	B	A	B	A	B
Share (%) of PE for the sector to total PE	Agriculture	– 0.269	– 0.194	2.406**	–1.414	0.082	– 0.015	0.094	– 0.036
		(1.676)	(1.219)	(0.938)	(1.903)	(0.073)	(0.058)	(0.086)	(0.062)
	Health	0.161	0.050	– 0.554	1.555	– 0.010	0.016	– 0.022	– 0.002
		(0.433)	(0.758)	(1.320)	(3.005)	(0.023)	(0.025)	(0.052)	(0.050)
	Education	0.237	0.787	– 0.072	– 0.472	0.047*	0.017	0.095**	0.045
		(0.371)	(0.551)	(0.848)	(1.115)	(0.028)	(0.029)	(0.042)	(0.041)
	Social protection	0.052	0.172	– 0.158	– 0.334	– 0.013	0.001	– 0.035*	– 0.007
		(0.220)	(0.344)	(0.273)	(0.598)	(0.011)	(0.014)	(0.019)	(0.031)
	Defense	– 0.041	0.608	–1.332*	0.498	– 0.067	– 0.039	– 0.095†	– 0.074
		(0.669)	(0.870)	(0.753)	(1.363)	(0.040)	(0.027)	(0.059)	(0.045)
Size of PE for each sector (natural log)	Agriculture	0.424	–2.362	7.358**	1.317	– 0.054	– 0.134	– 0.090	– 0.166
		(2.952)	(3.073)	(3.238)	(6.536)	(0.149)	(0.130)	(0.222)	(0.165)
	Health	4.856	0.660	7.218	18.876*	0.127	0.158	0.180	0.323
		(3.581)	(2.952)	(8.974)	(9.835)	(0.128)	(0.181)	(0.296)	(0.388)
	Education	0.559	4.963	–3.932	–4.025	0.150	0.164	0.109	0.238
		(5.467)	(5.043)	(11.327)	(9.275)	(0.218)	(0.342)	(0.346)	(0.557)
	Social protection	2.499	4.504	1.225	–4.478	– 0.263*	– 0.116	– 0.232†	– 0.183
		(2.429)	(3.679)	(3.433)	(4.165)	(0.143)	(0.139)	(0.151)	(0.206)
	Defense	2.877	4.920	–1.774	18.219**	– 0.025	– 0.042	– 0.181	– 0.364*
		(3.599)	(6.129)	(4.874)	(8.523)	(0.157)	(0.188)	(0.233)	(0.218)
Sample size		767	924	236	300	415	562	188	264
Number of countries		64	67	24	26	83	84	42	43
Average rounds		12.0	13.8	9.8	11.5	5.0	6.7	4.5	6.1
Beginning period		2000	2000	2000	2000	2000	2000	2000	2000
Ending period		2017	2018	2017	2018	2017	2018	2017	2018

Source: Authors. ***1% **5% *10% †15%

Note: Numbers in figures show estimated standard errors that are robust against unknown forms of heteroskedasticity or serial correlations.
A = using only the PEs in the same year; B = using averages of PEs from the past 5 years.

Appendix: Full results

Table 10. List of low and lower-middle income countries in 2000

Low income		Lower-middle income	
Afghanistan	Liberia	Albania	Marshall Islands
Angola	Madagascar	Algeria	Micronesia
Armenia	Malawi	Belarus	Morocco
Azerbaijan	Mali	Belize	Namibia
Bangladesh	Mauritania	Bolivia	North Macedonia
Benin	Moldova	Bosnia and Herzegovina	Papua New Guinea
Bhutan	Mongolia	Bulgaria	Paraguay
Burkina Faso	Mozambique	Cabo Verde	Peru
Burundi	Myanmar	Colombia	Philippines
Cambodia	Nepal	Costa Rica	Romania
Cameroon	Nicaragua	Cuba	Russia
Central African Republic	Niger	Djibouti	Saint Vincent and the Grenadines
Chad	Nigeria	Dominica	Samoa
China	Pakistan	Dominican Republic	South Africa
Comoros	Republic of Congo	Ecuador	Sri Lanka
Côte d'Ivoire	Rwanda	Egypt	Suriname
Democratic Republic of the Congo	Sao Tome and Principe	El Salvador	Syria
Eritrea	Senegal	El Salvador	Thailand
Ethiopia	Sierra Leone	Equatorial Guinea	Tonga
Gambia	Solomon Islands	Eswatini	Tunisia
Ghana	Somalia	Fiji	Ukraine
Guinea	Sudan	Georgia	Uzbekistan
Guinea-Bissau	Tajikistan	Guatemala	Vanuatu
Haiti	Tanzania	Guyana	West Bank and Gaza
Honduras	Togo	Iran	
India	Turkmenistan	Iraq	
Indonesia	Uganda	Jamaica	
Kenya	Vietnam	Jordan	
Korea, DPR	Yemen	Kazakhstan	
Kyrgyzstan	Zambia	Kiribati	
Lao PDR	Zimbabwe	Lithuania	
Lesotho		Maldives	

Source: Authors compilation.

Table 11. Statistically significant signs of other explanatory variables for results in Table 6

Variables	TFP growth rate		Lower consumer food prices		Reduced poverty (1.90 international dollar per day)		Reduced poverty (3.20 international dollar per day)		Reduced poverty (5.50 international dollar per day)		Reduced malnutrition	
	A	B	A	B	A	B	A	B	A	B	A	B
Urban population												
Natural disaster		–			–	–	–	–		–		
Technological disaster												
Trade openness							–	–	–	–		
Voice	+				+	+						
Stability					+	+	+	+				
Effectiveness												
Regulation												
Law												
Corruption control									–	–		
Natural resource rent					–	–		–			–	–
Dependency	+	+			–	–					+	+

Source: Authors. A = models with the relative size (share) of PEs; B = models with the absolute size of PEs.

Table 12. Statistically significant signs of other explanatory variables for results in Table *8*

Variables	Reduced stunting		Reduced underweight		Reduced overweight		Access to drinking water services		Access to sanitation services	
	A	B	A	B	A	B	A	B	A	B
Urban population	+	+	+	+			–	–		
Natural disaster	+	+	+		+	+				
Technological disaster	–	–	–	–			+			
Trade openness	–	–								
Voice										
Stability									–	–
Effectiveness										
Regulation		–							+	+
Law										
Corruption control										
Natural resource rent										
Dependency			–	–	+	+			+	+

Source: Authors. A = models with the relative size (share) of PEs; B = models with the absolute size of PEs.

Table 13. Statistically significant signs of other explanatory variables for results in Table 9 (for low- / lower-middle income countries)

Variables	Lower proportion of local breeds classified as being at risk as a share of local breeds		Plant breeds for which sufficient genetic resources are stored	
	A	B	A	B
Urban population				
Natural disaster	+			
Technological disaster	–	–		
Trade openness				
Voice	+			
Stability				
Effectiveness	–			
Regulation				
Law				
Corruption control				
Natural resource rent	–	–		+
Dependency				

Source: Authors. A = models with the relative size (share) of PEs; B = models with the absolute size of PEs.

ALL IFPRI DISCUSSION PAPERS

All discussion papers are available here

They can be downloaded free of charge

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
www.ifpri.org

IFPRI HEADQUARTERS
1201 Eye Street, NW
Washington, DC 20005 USA
Tel.: +1-202-862-5600
Fax: +1-202-862-5606
Email: ifpri@cgiar.org