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The (Evolving) Role of Agriculture in Poverty Reduction

An Empirical Perspective

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Abstract

The role of agriculture in development remains much debated. This paper takes an empirical perspective and focuses on poverty, as opposed to growth alone. The contribution of a sector to poverty reduction is shown to depend on its own growth performance, its indirect impact on growth in other sectors, the extent to which poor people participate in the sector, and the size of the sector in the overall economy. Bringing together these different effects using cross-country econometric evidence indicates that agriculture is significantly more effective than non-agriculture in reducing poverty among the poorest of the poor (as reflected in the $1-day squared poverty gap). It is also up to 3.2 times better at reducing $1-day headcount poverty in low-income and resource-rich countries (including those in sub-Saharan Africa), at least when societies are not fundamentally unequal. However, when it comes to the better-off poor (reflected in the $2-day measure), non-agriculture has the edge. These results are driven by the much larger participation of poorer households in growth from agriculture and the lower poverty-reducing effect of non-agriculture in the presence of extractive industries.

Keywords: agriculture, economic growth, poverty, sub-Saharan Africa

JEL classification: D3, O1

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Acronyms

GDP	gross domestic product
GMM	Generalized Method of Moments
MDGs	Millennium Development Goals
SSA	sub-Saharan Africa
TFP	total factor productivity

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1 The longstanding debate of agriculture and development

While world attention has shifted back to agriculture out of concerns about how to feed its nine billion people by 2050, the precise role of agriculture in economic development remains very much debated. The dual economy models inspired by Lewis (1954) and popular in development economics in the 1960s and 1970s typically viewed agriculture as a backward unproductive subsistence sector, from which labour and resources were to be drawn to encourage development of the dynamic productive industrial sector. Much of the early development economics literature was thus interpreted as supporting an industrialization strategy. This led to an urban bias in development planning (Lipton 1977), and fiscal and trade systems that systematically over-taxed agriculture (Krueger, Schiff and Valdes 1988).

But an alternative view of agriculture as a leading sector (especially during the early stages of development) also emerged. This followed the seminal contributions by Johnston and Mellor (1961) and Schultz (1964). They emphasized the critical contributions of agriculture to growth in other sectors, implying that investments and policy reforms in agriculture might actually yield faster overall economic growth, even though agriculture itself might grow at a slower pace than non-agriculture. Several authors have since documented the existence of substantial multiplier effects from agriculture to non-agriculture, especially in Asia, but also in sub-Saharan Africa (SSA) (Haggblade, Hazell and Dorosh 2007).

The experience of the green revolution in Asia during the 1970s and 1980s, where traditional agriculture was rapidly transformed into a fast growing modern sector through the adoption of science-based technology, provided further confidence in agriculture as an engine of growth. Nonetheless, this belief in the potential of the sector eroded gradually thereafter, especially in SSA, following the poor performance of many agricultural development projects (World Bank 2007a), the secular decline in the world price of food and other primary commodities, and the rising appeal of East Asia's export-led manufacturing growth miracle.

The adoption of the Millennium Development Goals (MDGs) by the UN member states at the turn of the millennium added a new dimension to the debate. It shifted the focus in development from fostering economic growth per se to encouraging poverty reduction. Since the latter does not depend only on the rate of overall economic growth, but also on the ability of poor people to participate in that growth, this rekindled interest in the specific role of agriculture in the development process. The majority of poor people in the developing world depend on agriculture for their livelihood, and it was argued that the poor stood to gain much more from GDP growth originating in agriculture than from an equal amount of GDP growth generated outside the sector. Achieving 'pro-poor' or 'shared' growth, i.e., growth with a maximum pay-off in terms of poverty reduction (Ravallion and Chen 2003; Kraay 2006), would call for policies and investments that support the development of agriculture.

Both the contribution of each sector to economic growth and the participation of poor people in it, continue to be debated. On the growth side, the view of agriculture as an engine of growth in agriculturally based economies has attracted political traction, partially mediated by the World Bank's 2008 *World Development Report Agriculture for Development*, and reinforced by the 2007-08 spike in world food prices. Others maintain that the classical intersectoral linkages no longer apply with the same force, given increasingly interconnected markets, and that a pro-agriculture strategy will often not deliver the overall growth necessary for rapid poverty reduction, especially in Africa (Ellis 2005; Dercon 2009).

On the participation side, the sheer weight of numbers, with the majority of poor people living in rural areas, depending on agriculture (World Bank 2007b), would suggest that they will benefit more from growth originating in agriculture. But it is also argued that agricultural development will not involve the majority of poor smallholder farmers, and that it can succeed only among larger farmers, again, particularly in Africa (Reardon and Berdegue 2002; Maxwell 2004; Collier and Dercon 2009). The extent to which poor people would gain from a pro-agriculture strategy is questionable in this view. But they may also benefit indirectly through the labour market and employment expansion in non-traditional agro export sectors (Anriquez and Lopez 2007; Maertens and Swinnen 2009).

To further this longstanding debate an empirical perspective is needed. This must focus on four questions:

1) Do investments and policy reforms in agriculture enhance overall growth more than investments and policy reform outside non-agriculture?
2) Is participation by poor people in agricultural growth on average higher than their participation in non-agricultural growth, and if so, under what conditions and for whom among the poor?
3) If a focus on agriculture would tend to yield slower overall growth, but larger participation by the poor, compared with a focus on non-agriculture, which strategy would tend to have the largest pay-off in terms of poverty reduction, and under which circumstances?
4) Does the response differ depending on the poor groups being considered (for example $1-day versus $2-day poverty)?

Most studies so far have focused either on the first (growth)[1] or second (participation)[2] question. Rarely have they adopted a sufficiently uniform framework to assess simultaneously potential trade-offs.[3] Neither have they differentiated these trade-offs across country settings (question 3), nor taken into account the extent of poverty (question 4). This paper seeks to advance both the ‘growth’ and ‘participation’ debate and brings a synthesizing perspective. It starts from a simple organizing framework in which the effects of agriculture and non-agriculture on poverty are decomposed into three principal sources: a growth, a participation, and a size effect. In examining the growth effect, it considers both a direct (sectoral) and an indirect (cross-sectoral) contribution, yielding four components in total. Cross-country analysis is used to compare each of these effects empirically across sectors and settings (including the SSA context), drawing on national accounts evidence on sectoral growth and household survey data on poverty.

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1 Tiffin and Irz (2006); Haggblade, Hazell and Dorosh (2007).

2 Ravallion and Datt (1996); Loayza and Raddatz (2006); Ravalllion and Chen (2007); Ligon and Sadoulet (2007); Christiaensen and Demery (2007); Suryahadi, Suryadarma, and Sumarto (2009).

3 Perry et al. (2005) provide an important step in this direction for Latin America.

The results suggest that agriculture is significantly more effective in reducing poverty among the poorest of the poor (as reflected in the $1-day squared poverty gap). When societies are not fundamentally unequal, it is also up to 3.2 times better at reducing $1-day headcount poverty in low-income and resource-rich countries (including those in SSA). However, when it comes to the better-off poor (reflected in the $2-day measure) non-agriculture has the edge. These results are driven by the much larger participation of poorer households in growth from agriculture which more than compensates for the slower growth of the sector. They are also influenced by the presence of extractive industries which undermines the poverty-reducing effect of non-agriculture. The indirect growth effects from agriculture are found to be somewhat larger in Sub Saharan Africa than the reverse linkage effects, an advantage that disappears as countries develop.

The paper proceeds by developing the conceptual framework in section 2. It then examines the direct and indirect growth effects in sections 3 and 4, followed by an assessment of potential differences in the participation effects in section 5. Section 6 synthesizes how these different effects are expected to play out in terms of poverty reduction across country settings, using different measures of poverty. Section 7 concludes.

2 The growth and participation components of change in poverty

Let P_i be any (decomposable) measure of poverty and Y_i be gross domestic product (GDP) per capita (that is, per person in the total population, not per worker) in country *i*. The proportionate change in poverty in a country can then be seen to be equal to the GDP elasticity of poverty (defined as the proportionate change in poverty divided by the proportionate change in per capita GDP)[4] times the proportionate change in per capita GDP, $\frac{dP_i}{P_i} = \left(\frac{dP_i}{P_i}\frac{Y_i}{dY_i}\right)\frac{dY_i}{Y_i}$, or, approximating for small changes:

$$\mathrm{d}lnP_i = \varepsilon_i \mathrm{d}lnY_i \qquad (1)$$

We refer to the GDP elasticity of poverty (ε_i) in (1) as the *participation* component and $\mathrm{d}lnY_i$ as the *growth* component of poverty change in country *i.*

Not all growth processes generate an equal amount of overall growth or an equal amount of poverty reduction (World Bank 2000). The growth and participation components may differ substantially across sectors. Noting that the growth in Y_i can be approximated by the sum of the share-weighted growth rates of the sectors, Equation (1) is rewritten as a share weighted sum of the contributions to poverty reduction of both the agricultural (*a*) and the non-agricultural (*n*) sectors:

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4 By using GDP per capita growth rather than changes in per capita household income as is common in this sort of equation (Ravallion 2001; Adams 2004), the paper very much focuses on the overall growth process. The elasticity concept used here reflects the impact of growth on both the average incomes of households and how those incomes are distributed. This is commonly referred to as the 'growth elasticity of poverty', though technically speaking, this is the elasticity of poverty with respect to GDP or the 'GDP elasticity of poverty'.

$$\mathrm{d}lnP_i = \varepsilon_{ia}s_{ia}\,\mathrm{d}lnY_{ia} + \varepsilon_{in}s_{in}\,\mathrm{d}lnY_{in} \qquad (2)$$

with s_{ij} denoting the share of sector j (= a, n) in total GDP in country i. Both participation and growth components are more complex in this two-sector economy.

Obviously there are now two GDP elasticity terms ($\varepsilon_{ia}s_{ia}$ *and* $\varepsilon_{in}s_{in}$), and each of these has two elements: a share component (s_{ij}) and what can be called the sector's participation component (ε_{ij}). The sectoral participation components (ε_{ij}) measure the response of overall poverty to (aggregate) GDP originating in that sector ($s_{ij}\,\mathrm{d}Y_{ij}/Y_{ij}=\mathrm{d}Y_{ij}/Y_i$), that is, the response of overall poverty to growth in a sector controlling for its size. It indicates the extent to which *all* the poor participate in overall growth generated in that sector. Note that when $\varepsilon_{in}=\varepsilon_{ia}$, Equation (2) collapses to equation (1), and the source of growth no longer matters in determining the poverty effect of growth. Following Ravallion and Datt (1996), this property of Equation (2) is exploited later in developing an empirical test to assess whether the responsiveness of poverty to growth differs across sectors.

The poverty-reducing effect of growth in a particular sector ($\mathrm{d}lnY_{ij}$) may thus differ for two reasons. First, the sector may be bigger (e.g., $s_{in} \geq s_{ia}$). Second, even if both sectors are of equal size, the marginal effect on overall poverty of an additional percentage point of overall GDP growth originating in one sector may still be larger than the marginal effect of an additional percentage point of overall GDP growth originating in the other sector if $\varepsilon_{ia} \neq \varepsilon_{in}$, for example if one sector employs more of the poor. Whether an acceleration in the pace of per capita agricultural growth ($\mathrm{d}lnY_{ia}$) will have a more marked effect on poverty than an identical increase in the rate of non-agricultural growth ($\mathrm{d}lnY_{in}$) thus depends on whether $\varepsilon_{in}s_{in} < \varepsilon_{ia}s_{ia}$..

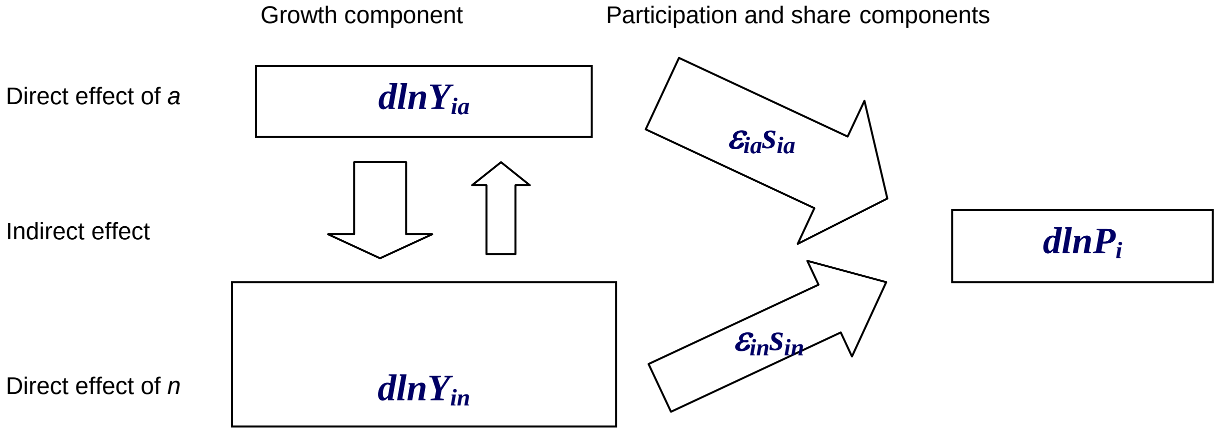
The growth component of poverty reduction is also more complex in this two sector world. The obvious point is that there are now two growth components—one for each sector. But analysing the sectoral growth effects is complicated further by the spillover effects of growth in one sector on another. A large literature exists showing that accelerating agricultural growth will induce changes in other sectors, resulting in higher non-agriculture growth. While the reverse interaction also holds, the literature suggests that these effects are smaller (Haggblade, Hazell and Dorosh 2007). The growth effect of sector j therefore will have two components: the *direct* contribution (or the size of $\mathrm{d}lnY_{ij}$) and an *indirect* contribution, this being additional changes in poverty resulting from the induced change in the growth performance of the other sectors (the effects of $\mathrm{d}lnY_{ia}$ on $\mathrm{d}lnY_{in}$ and vice versa).

In sum, four key elements link poverty to sectoral growth: the direct growth component from the sector itself; the indirect growth component arising from spillover effects of growth in one sector on another; the participation component, reflecting the responsiveness of overall poverty to the sector of origin of GDP growth; and the relative size of the sector in the economy. All four components have to be taken into account when considering the relative contribution of a sector in poverty reduction.[5] In what

5 In addition to these four effects, one could also consider a population reallocation effect between the economic sectors (the 'Kuznets' process referred to by Anand and Kanbur (1985) and Ravallion and Datt (1996)). Analytically, this component can be discerned explicitly when considering GDP per worker in the decomposition in (1) as opposed to per person in the total population. Currently, this

follows, the paper quantifies each of these effects (as represented by the box and arrow size in Figure 1) across both sectors and explores the expected overall contribution of each sector to poverty reduction empirically across country settings and different degrees of poverty.

Figure 1
The relative role of agricultural and non-agricultural growth in reducing poverty



3 Growth potential across sectors—the direct growth effects

Historical sectoral growth rates across the world indicate that agricultural GDP growth has lagged non-agriculture (Table 1). The average difference amounts to 1.6 percentage points worldwide (and 1.2 percentage points in SSA). This has often been taken as evidence that *productivity* growth in agriculture is inherently inferior to productivity growth outside agriculture, a popular view that goes as far back as Adam Smith.[6] He posited that due to spatial impediments to labour division and capital accumulation in agriculture, productivity in agriculture was bound to grow at a slower pace than in spatially concentrated manufacturing. To explore this further, the sectoral GDP growth rates reported in Table 1 are decomposed into their (labour) productivity and population growth components (Table 2).[7] Contrary to common wisdom, the results suggest that since the 1960s labour productivity in agriculture has on average been *growing* faster

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effect is subsumed in the GDP growth rates. Christiaensen, Pan, and Sangui (2010) provide a first empirical application along these lines using uniquely detailed household level data on income sources and sectoral labour allocation from two provinces in rural China. In keeping with the literature, this has not been pursued here given the empirical challenge of estimating sectoral labour migration and sectoral labour productivity (or poverty by economic sector) systematically across countries and time, as rural households are often involved in both agricultural and non-agricultural activities.

6 Important dissenters include North (1959), Johnston and Mellor (1961), Hayami and Ruttan (1985), and Timmer (2009).

7 Denoting GDP and population in sector j by G_j and L_j respectively, growth in G_j can be readily decomposed through total differentiation of G_j and division by G_j as follows: $\frac{dG_j}{G_j} = \frac{d(G_j/L_j)}{(G_j/L_j)} + \frac{dL_j}{L_j}$.

than labour productivity outside agriculture. With the exception of South Asia, this holds across continents, including SSA. Overall GDP growth in agriculture has been largely driven by growth in labour productivity, and growth in the non-agricultural sector largely by population growth in non-agriculture, especially in the developing countries (except Eastern Europe and Central Asia). While admittedly crude and partial, these simple descriptive findings are nonetheless striking, and call for greater scrutiny of the view that agriculture has inherently a lower growth potential.

Excluding services, many of which tend to be more labour intensive and somewhat less conducive to capital accumulation, and focusing on manufacturing only, does not fundamentally change the picture (Szirmai 2009).[8] The trends in Table 2 may simply reflect equilibrating movements of labour out of agriculture in response to higher marginal products of labour (and thus wages) in non-agriculture ('industrial pull'). This would induce a convergence in sectoral labour productivity and explain the faster (labour) productivity growth in agriculture. Alternatively, if the observed agricultural labour productivity growth resulted from increased agricultural output following investment and technological change (yielding an increase in total factor productivity), productivity increases would free up labour in agriculture and induce it to move to the non-agricultural sector ('agricultural push'). According to this interpretation, the productivity gains in agriculture are the cause of the labour movements (and not their consequence). Without additional evidence the relative merits of the industrial pull and agricultural push perspectives cannot be ascertained—quite possibly both forces have been at work.

Table 1
Non-agricultural growth rates exceed agricultural growth rates.

Average annual growth rate (%)	1960-69		1970-79		1980-89		1990-2000		2000-03		Total	
	Agr.	Non-agri	Agr.	Non-agri	Agr.	Non-agri	Agr.	Non-agri	Agr.	Non-agri	Agr.	Non-agri
SSA	2.7	5.0	2.5	5.5	2.6	3.4	2.7	3.0	2.7	3.6	2.6	3.8
South Asia	2.9	5.7	1.7	4.7	3.6	6.4	3.2	6.2	3.0	5.9	2.9	5.8
East Asia & Pacific	4.0	7.7	3.2	7.4	3.0	4.9	1.7	5.1	0.1	5.0	2.3	5.7
East Europe & Central Asia	-1.4	7.0	1.7	7.0	1.3	3.3	-0.7	0.0	3.4	6.7	0.8	2.6
Europe, others	1.2	6.0	1.7	3.5	2.0	2.6	1.7	2.5	-0.8	2.3	1.5	2.9
Latin America & the Caribbean	2.8	5.2	2.3	5.0	1.5	1.6	1.9	3.3	2.2	2.0	2.0	3.3
Middle East & North Africa	1.3	6.1	6.0	7.3	4.8	3.0	3.9	4.2	4.4	3.7	4.4	4.7
North America	-	-	-0.3	3.7	3.2	2.7	2.7	2.7	-1.8	3.2	1.7	3.0
Total	2.7	5.7	2.6	5.3	2.5	3.2	2.0	3.1	2.1	4.0	2.3	3.9

Note: Both annual agricultural and non-agricultural growth rates are based on GDP expressed in constant 2000 US$. Non-agricultural growth is defined as the sector weighted sum of GDP growth in industry and services.

Source: Authors' calculations based on World Development Indicators.

8 Somewhat to his surprise, and unlike between 1950 and 1973 when growth in labour productivity in manufacturing typically exceeded this in agriculture, Szirmai found that between 1973 and 2005 *labour productivity* in agriculture grew faster than in manufacturing in 12 out of the 16 (Asian and Latin American) developing countries in his recently compiled sample (and in 11 out of the 18 developed countries in the sample). Incidentally, the earlier decades of this period also coincide with the occurrence of the green revolution in Asia (and to a lesser extent Latin America).

Table 2
Productivity growth drives agricultural GDP growth; migration drives non-agricultural GDP growth

Average annual growth rates (%) 1960-2003	Agriculture			Non-agriculture		
	Agric. GDP	Labour productivity	Population	Agric. GDP	Labour productivity	Population
Sub-Saharan Africa	2.6	0.9	1.7	3.8	-0.6	4.5
South Asia	2.9	1.2	1.6	5.8	2.2	3.6
East Asia & Pacific	2.3	2.9	-0.5	5.7	2.7	2.9
Eastern Europe & Central Asia	0.8	3.4	-2.5	2.6	1.4	1.2
Europe, others	1.5	4.6	-3.0	2.9	2.0	0.9
Latin America & the Caribbean	2.0	2.3	-0.24	3.3	0.5	2.8
Middle East & North Africa	4.4	4.3	0.21	4.7	0.3	4.4
North America	1.7	3.9	-2.1	3.0	1.8	1.2
Total	2.3	2.4	-0.05	3.9	0.74	3.1

Note: Figures for the total population in agriculture and non-agriculture were obtained from the FAO statistics.

Source: Authors' calculations based on World Development Indicators and FAO data.

The limited available econometric evidence does not support the view of agriculture as a sector with inherently inferior productivity.[9] Estimating rates of sectoral total factor productivity (TFP) growth for the US economy between 1948 and 1979 using a cost function approach, Jorgenson, Gollop and Fraumeni (1987; table 6.7) find that TFP growth in agriculture had been more rapid than in almost all other sectors. Lewis, Martin and Savage (1988) come to a similar conclusion in Australia using a production function approach. Based on a sample of 14 industrialized countries between the early 1970s and the late 1980s Bernard and Jones (1996) estimate average TFP growth at 2.6 per cent per year in agriculture compared with 1.2 per cent in industry and 0.7 per cent in services. There is also evidence of a more productive agriculture from the developing world. Using a production function approach applied to panel data for about 50 low- and middle-income countries over the period 1967-2002, Martin and Mitra (2001) find annual TFP growth in agriculture on average to be 0.5 to 1.5 percentage points larger than in non-agriculture, depending on the estimation technique. This difference was statistically significant and valid across the development spectrum.

The evidence reviewed here is not taken to support superiority of agriculture in TFP growth per se, but rather to refute the notion of agriculture as a backward sector, where investments and policies are automatically less effective in generating growth than outside agriculture, resulting in a limited direct growth effect on poverty reduction. This is not to suggest that globally the agricultural sector should be expected to grow faster than non-agriculture. Engel's law implies that as incomes rise, the demand for food increases at a slower rate than the demand for non-agricultural products. Slower aggregate growth for agriculture is as such the macro reflection of micro-behaviour, both nationally and globally, and is consistent with the historical migration pattern between agriculture and non-agriculture observed in the data.

9 While productivity estimates for economies as a whole or for individual sectors abound, there are very few studies that systematically compare estimates of productivity growth across agriculture and non-agriculture, especially for developing countries.

But, not all demand for agricultural produce is income inelastic, such as for high value agricultural products (meat, dairy, fruits and vegetables)[10] and industrial applications (e.g., cotton, agro-fuels). When international trading opportunities exist, even food agriculture need not face income inelastic demand, providing some countries with important growth opportunities in agriculture. For example, Brazil and Chile witnessed an agro-export boom over the past 15 years with average growth in agriculture exceeding growth outside agriculture. Similarly, several countries in sub-Saharan Africa have experienced an explosive expansion of non-traditional agricultural exports to Europe.[11]

In sum, while the direct growth effect of agriculture on poverty reduction will likely be smaller than that of non-agriculture, especially in countries where agriculture is less tradable and Engel's Law manifests itself more prominently, i.e., later in the development process, historical experience shows that agricultural productivity and growth can be substantial. For SSA, the recovery in agricultural TFP over the past decade holds some promise (Pratt and Yu 2008),[12] and higher agricultural commodity prices over the coming decade (OECD and FAO 2009), including for cereals, provide new opportunities.

4 Agriculture and the rest of the economy: the indirect growth effects

In addition to its direct sectoral contribution to overall growth, agricultural development can play an important role in fostering development in the rest of the economy, the indirect growth effect (Johnston and Mellor 1961; Schultz 1964). Three broad types of mechanism have been identified: i) *production or inter-sectoral linkages*, forward to agro-processing activities and backward to input supply sectors; ii) *consumption linkages or final demand effects* arising from an increased demand for locally produced non-traded goods and services; and iii) *wage-good effects*—by reducing the price of food, agricultural productivity growth would lower the real product wage in non agriculture, thereby raising profitability and investment in other sectors.[13]

Much of the literature has argued that the stronger links are from agriculture to non-agriculture (Mellor 1976; Tiffin and Irz 2006). In part this is because inputs into non-agriculture are more import intensive, and urban consumption patterns tend to favour imported goods (the demand for food being income inelastic). Consumption-based linkages are typically four to five times more important than production-based

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10 For example, recent estimates put the income elasticity for the demand for fruits and vegetables in Vietnam between 1.2 and 2.6 (Mergenthaler, Weinberger and Qaim 2009).

11 Examples include flowers in Kenya (Humphrey, McCulloch and Ota 2004), vegetables in Senegal (Maertens and Swinnen 2009) and fish in Uganda (Kiggundu 2006).

12 For more in-depth analysis and suggestions on how agriculture could be advanced in sub-Saharan Africa, see InterAcademy Council (2004) and *Awakening Africa's Sleeping Giant* (World Bank 2009a).

13 Lower food prices would also raise real consumption wages, and thus directly benefit poor (urban and rural) wage earners.

linkages.[14] For the consumption linkage effects to be significant, four conditions must apply (Delgado, Hopkins and Kelly 1998). First, agriculture must be a sufficiently large sector in employment terms for the income-generating effects to be significant in the aggregate. Second, the income gains from agricultural growth must be reasonably widespread, so that effective demand for locally produced goods and services is raised. Third, the consumption patterns of people in agriculture must favour locally produced non-tradable goods. Finally, the non-agricultural (non-traded) sector must have to hand underutilized resources and appropriate institutional arrangements to be able to respond to the new demand coming from agricultural growth.

Reviewing the multitude of studies calculating the agricultural multiplier effects Haggblade, Hazell and Dorosh (2007: 167, our emphasis) conclude that '*best-guess generalizations* (of the agricultural multiplier) *probably lie in the range of 1.6 to 1.8 for Asia and 1.3 to 1.5 for Africa and Latin America*'. Every dollar in direct income generated in agriculture, triggers another 30 to 80 cents in second round income gains elsewhere in the economy. Higher population density and the labour-abundant nature of the Asian economies, which facilitate a larger supply response of the non-tradable sector, are cited as important reasons for the higher agricultural multipliers in Asia compared with SSA.

The fixed price (semi) input-output models and price-endogenous CGE models underpinning most of these studies are structural in nature. This allows one to identify the nature and extent of the linkage effects—a strength—but the results also depend on the validity of the structural assumptions—a potential weakness.[15] Over time, growth in the rural non-farm economy depends more on urban-to-rural subcontracting of manufacturing, in addition to agricultural development, especially in the rapidly developing low-income countries of East Asia,[16] indicating a need for revisiting the earlier evidence. The opening up of (African) economies may further undermine the linkage effects of any expansion in rural demand (that demand possibly being increasingly met by imports), even though most of the rural non-farm linkages are mediated through growth in (non-tradable) rural services such as housing, education, health, and personal services and commerce (Haggblade, Hazell and Reardon 2007), and not through rural manufacturing growth, which is more prone to urban-based or foreign competition.

In the light of these broader economic developments and to complement the empirical insights from the structural counterfactual models, this paper revisits the causal relationship between agricultural and non-agricultural output (in the Granger [1969]

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14 As countries develop, production linkages typically gain in importance as input intensity in agriculture rises and the demand for processed foods increases.

15 For example, Dorosh and Haggblade (2003) applying both fixed price semi input-output (SIO) models as well as fully price endogenous CGE models to eight SSA countries confirm the existence of sizeable growth linkages from investments in agriculture. Fixed price (SIO) multipliers from investments in export and food crops typically exceed the manufacturing multipliers, consistent with the literature, though they also find that this is no longer the case when prices of non-tradables are endogenized (as in the CGE).

16 See Amsden (1991), Hayami, Kikuchi and Marciano (1996), and Kikuchi (1998) for case studies from Taiwan, China, and the Philippines, respectively.

sense)[17] by applying dynamic panel data estimation techniques to international cross-country data. This econometric approach does not have to make structural assumptions of supply flexibility or fixed prices in the non-tradables sector, but rather observes the 'reduced form' of the full general equilibrium outcome. It also allows for a more direct exploration of the indirect effects of growth in each sector, enabling a synthesizing perspective of the overall effect of agricultural and non-agricultural growth on poverty.

Non-agricultural GDP growth per capita ($y_{it}^{n} \approx \mathrm{d}ln Y_{it}^{n}$) in country i at time t is assumed to depend on both lagged levels of per capita non-agricultural GDP growth and lagged levels of per capita agricultural GDP growth ($y_{it-p}^{a} \approx \mathrm{d}ln Y_{it-p}^{a}$). In addition, we consider a vector X_{it} of country-specific exogenous or predetermined explanatory factors, yielding:

$$y_{it}^{n} = \chi^{0} + \sum_{p=1}^{P} y_{it-p}^{n} \chi_{p}^{1} + \sum_{q=1}^{Q} y_{it-p}^{a} \chi_{p}^{2} + \sum_{k=0}^{Ka} X_{it-k} \chi_{k}^{3} + w_{t} + h_{i} + v_{it} \tag{3}$$

where w_t represents a global time dummy, h_i reflects unobserved country specific characteristics that determine the sectoral output, and v_{it} an idiosyncratic error term.[18] Similarly, agricultural GDP growth per capita (y_{it}^{a}) is expressed as a linear function of lagged agricultural and non-agricultural GDP growth per capita as well as observed and unobserved country specific exogenous explanatory factors. A statistically significant effect of the coefficient on lagged agricultural growth in the non-agricultural growth Equation (3) is interpreted as evidence of Granger causality from agriculture to non-agriculture (and vice versa in the agricultural GDP growth regression).

In the empirical application the agricultural and non-agricultural equations are estimated separately, regressing non-agricultural GDP growth on lagged agricultural and non-agricultural GDP growth and vice versa. The GDP growth rates are predetermined in levels and the estimation therefore employs the system Generalized Method of Moments (GMM) estimator outlined in Arellano and Bover (1995) and Blundell and Bond (1998) with the finite sample correction of the two-step standard errors proposed by Windmeijer (2005).[19]

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17 The concept of Granger causality holds that a variable Y_{ai} Granger causes Y_{ni} if Y_{ni} can be better predicted using lagged values of Y_{ai} than without them. Few studies have examined Granger causality between sectoral output. Bravo-Ortega and Lederman (2005) using dynamic panel estimation techniques and Tiffin and Irz (2006) using the VAR approach are recent exceptions. This study opts for the dynamic panel data approach as it is more appropriate to capture the longer run equilibrium effects. The VAR approach is more adept at tracing the dynamic nature of the cross-sectoral growth effects, but this would again impose some structural assumptions.

18 Instead of errors being i.i.d. it is only assumed that $E(v_{it}, v_{it-1})=0$ and $E(v_{it}, v_{jt})=0$. Autocorrelation renders lagged predetermined variables invalid as instruments. Correlation in the idiosyncratic error term across countries invalidates the GMM estimation approach as well as the Arellano-Bond tests for autocorrelation of the idiosyncratic error term used below. More detail on the specification and estimation strategy used here is provided in Appendix A1. For a superb practical and intuitive exposition of the system GMM estimator, see Roodman (2009a).

19 The use of estimated parameters for the construction of the weight matrix in the GMM algorithm introduces extra variation and a difference between the finite sample variance and the usual asymptotic variance of the two-step GMM estimator. Windmeijer (2005) shows that this difference can be estimated to obtain a finite sample corrected estimate of the variance.

Both regressions include a time indicator to capture period-specific shocks common to all countries (e.g., global economic up- or down-turns, or sudden shifts in the agricultural terms of trade as during the 2007-08 food crisis).[20] The percentage change in the 3-year average rainfall in each country[21] acts as another exogenous variable in the agricultural regression, while the twice-lagged share of mining (and quarrying) in non-agricultural value added enters as a predetermined explanatory factor in the non-agricultural equation. The latter allows for a possible resource curse for countries rich in natural resources (Sachs and Warner 2001).[22] The (lagged) precipitation and share of mining variables provide external instruments in the non-agricultural and agricultural growth regressions respectively, reducing risks associated with weak instrumentation.[23]

To focus on the longer run, the analysis uses growth rates based on 3-year averages of log per capita GDP over the period 1960-2005, in effect calculating 3-year growth rates. This also reduces the number of observations per country from 45 to 15. OECD-countries and countries from Eastern Europe and Central Asia (as well as very small countries) are further excluded,[24] yielding a sample of 100 countries and 1,497 observations. Missing observations on the sectoral GDP figures, the share of mining and precipitation, as well as the use of lagged dependent variables in the regressions (and as instruments) lead to further reductions in the actual regression sample sizes.[25] Sub-Saharan Africa is comparably well represented with slightly over one third of all observations in the sample.

Tables 3 and 4 report the findings of the regressions with non-agricultural GDP growth and agricultural GDP growth as the dependent variables, respectively. Non-rejection of

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20 This also protects against correlation in v_{it} across countries.

21 The meteorological data are based on a comprehensive set of high-resolution grid data of monthly climate indicators 1901-2000 (version TYN CY 1.1), constructed by Dr T.D. Mitchell, previously at the Tyndall Centre for Climate Change Research, see Mitchell et al. (2004) and www.cru.uea.ac.uk/~timm/cty/obs/TYN_CY_1_1.html. Change in 3-year averages of rainfall is used to match the growth variables which are also based on 3-year averages.

22 We thank an anonymous referee for this suggestion. The resource curse could also affect agricultural growth through a reduction in domestic prices of agricultural tradables following Dutch disease type appreciation of the real exchange rate. Inclusion of the (twice lagged) share of mining proved not to affect agricultural growth in a statistically significant fashion and was subsequently dropped to yield an additional (external) instrument.

23 Bravo-Ortega and Lederman (2005) and Tiffin and Irz (2006), for example, rely on internal instruments only (i.e., instruments based on lagged values of the explanatory variables).

24 The former countries have typically already passed through the structural transformation and the economic systems of the latter have undergone dramatic structural change over the past 20 years, rendering their historical experience atypical of the remaining sample. Half a million inhabitants on average during the period under study was taken as threshold to define very small countries (many of them small island economies). Similar results were found taking one million as the threshold.

25 To overcome the reduction in the sample size and the imbalance in the panel introduced by the missing observations, and to maximize the sample size, forward orthogonal deviations have been used instead of the first difference transformation, when applying the system GMM. Under the former technique, the average of all future available observations of a variable is subtracted from the contemporaneous one, instead of the previous observation, as done in the more common first difference transformation (Roodman 2009a).

Table 3
Growth linkages from agriculture to non-agriculture largely limited to low-income SSA countries

Non-agricultural growth per capita	Full sample (1)	Middle income (2)	Middle income (3)	Low income (4)	Low income (5)
Non-agr. GDP growth $_{t-1}$	0.40	0.42	0.40	0.31	0.37
	0.00	*0.00*	*0.00*	*0.00*	*0.00*
Agr. GDP growth $_{t-1}$	0.09	0.11	0.11	0.15	0.07
	0.20	*0.27*	*0.30*	*0.11*	*0.71*
Agr. GDP growth$_{t-1}$*SSA			-0.10		0.12
			0.82		*0.58*
Mining share $_{t-2}$	-0.02	-0.09	-0.13	-0.19	-0.12
	0.94	*0.69*	*0.62*	*0.20*	*0.30*
p-value Ag growth$_{t-1}$+ Ag growth$_{t-1}$*SSA = 0			*0.98*		*0.09*
Observations	588	232	232	356	356
No. of countries	85	30	30	55	55
No. of instruments	22	22	25	22	25
Arellano-Bond test for AR(1) p-value	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR(2) p-value	0.27	0.42	0.35	0.25	0.24
Hansen test of joint validity of instruments (p-value)	0.32	0.22	0.13	0.24	0.14

Note: Growth rates expressed in logs. Period-specific time dummies jointly significant, but not reported. Lagged growth rates and mining shares are instrumented by further lags and levels. Time indicators and precipitation (defined as per cent change from the previous 3-year period provide exogenous variation for the lagged growth rates). P-values are reported under the coefficients.

Source: Authors' calculations.

Table 4
No linkage effects from non-agriculture to agriculture in SSA,
but noticeable reverse linkage effects in other low-income countries

Non-agricultural growth per capita	Full sample (1)	Middle income (2)	Middle income (3)	Low income (4)	Low income (5)
Non-agr. GDP growth $_{t-1}$	0.07	-0.07	-0.02	0.15	0.18
	0.33	*0.52*	*0.84*	*0.03*	*0.01*
Non-agr GDP growth$_{t-1}$*D_{SSA}			-0.47		-0.09
			0.00		*0.40*
Agr. GDP growth$_{t-1}$	0.21	0.29	0.30	0.12	0.11
	0.01	*0.05*	*0.02*	*0.10*	*0.17*
Change in precipitation	0.05	0.01	-0.01	0.08	0.09
	0.05	*0.81*	*0.66*	*0.07*	*0.04*
p-value Non-ag growth$_{t-1}$+ Non-ag growth$_{t-1}$*SSA =0			0.00		0.34
Observations	608	240	240	368	368
No. of countries	87	31	31	56	56
No. of instruments	22	22	23	22	25
Arellano-Bond test for AR(1) p-value	0.00	0.08	0.06	0.00	0.00
Arellano-Bond test for AR(2) p-value	0.89	0.97	0.99	0.93	0.95
Hansen test of joint validity of instruments (p-value)	0.44	0.25	0.59	0.78	0.66

Note: Growth rates expressed in logs. Period-specific time dummies jointly significant, but not reported. Lagged growth rates instrumented by further lags and levels. Time indicators, precipitation (defined as per cent change from the previous 3-year period) and appropriately lagged mining shares provide exogenous variation for the lagged growth rates. P-values are reported under the coefficients.

Source: Authors' calculations.

the 2nd-order autocorrelation tests[26] and non-rejection of the Hansen-tests provides confidence in the instruments used.[27] To explore whether the linkage effects differ depending on the stage of structural transformation, results are presented for the full sample (column 1) as well as for middle- and low-income countries separately (columns 2 and 4, respectively). An SSA-indicator variable is subsequently introduced to examine whether linkages in SSA differ from those observed in other low- and middle-income countries (columns 3 and 5, respectively).

For the sample as a whole the results suggest a small positive effect of agriculture on non-agriculture, though it is imprecisely estimated (Table 3, column (1)). No effect is found in the middle-income countries (columns 2 and 3), nor in African middle-income countries. There is a positive effect of lagged agricultural growth on the rest of the economy for the group of low-income countries, with an estimated 11 per cent chance that the effect is not different from zero (column (4)). When adding an interaction term with SSA the linkage effects are especially strong (and also more significant). An increase in annual per capita growth in the SSA agricultural sector by 1 percentage point raises the per capita annual growth rate outside agriculture three years later by 0.19 percentage points (0.19=0.07+0.12 from column 5). Replication using only the SSA subsample or without correction for the unbalanced panel yields a similar result—positive but slightly imprecisely estimated effects of lagged agriculture in the low-income countries as a whole, and larger and more precisely estimated effects for the SSA subsample. While the negative sign on most of the coefficients of the mining share in non-agricultural GDP is consistent with the existence of a resource curse, none of the coefficients is estimated with much precision.

Looking at the reverse effects of lagged growth outside agriculture on growth in agriculture (Table 4) the signs on the coefficients are negative in the group of middle-income countries—consistent with a rapid release of labour out of agriculture, though these effects are not statistically significant (except in the few SSA middle-income countries in the sample). The results further suggest a positive (and strongly significant) reverse effect from non-agriculture to agriculture in the low-income countries (Table 4, column 4) which is similar in size to the (somewhat imprecise) effect of agriculture on non-agriculture. There is no sign of a reverse effect in SSA (Table 4, column 5; p-value for the sum of coefficients on lagged non-agricultural growth and its interaction with SSA dummy is 0.34). Changes in rainfall patterns do not seem to affect agricultural growth rates in middle-income countries, but they do in the low-income subsample. The latter result is largely driven by SSA, where rainfed staple crop production still dominates.

Given the declining share of agriculture in the overall economy (even though not in absolute terms) and the increasing linkage and spillover effects within non-agriculture

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26 The autocorrelation test is performed for an estimation in first-differences (Roodman 2009a), and 1st-order autocorrelation is therefore expected, while 2nd-order autocorrelation would be a sign of serial correlation in the levels, invalidating the use of once-lagged dependent variables as instruments.

27 Mindful of the danger of overfitting, the number of instruments (i.e., the number of lagged variables included as instruments) has been kept well below the number of countries. Instrument sets yielding high p-values of the Hansen J-statistic were revisited for robustness to exclusion of deeper lags as instruments (Roodman 2009b). The reported results are based on only two lags, which were further collapsed into a single moment condition. They proved robust.

in richer countries, the absence of a spillover effect from growth in agriculture to non-agriculture is no surprise (and consistent with the findings in Bravo-Ortega and Lederman (2005) and Tiffin and Irz (2006)). The negative effects from non-agricultural growth on agriculture, even though not statistically significant, are also consistent with a more rapid release of labour out of agriculture when economies are further advanced in their structural transformation richer and their labour force becomes better prepared for and adept in transitioning out of agriculture. These processes would slow down growth in agriculture—not to be equated with a slowdown in *productivity* growth in agriculture, or a decline in overall agricultural GDP.

On the other hand, there is clear evidence of larger linkage effects from agriculture to non-agriculture in low-income SSA, consistent with the longstanding agricultural multiplier literature and the econometric findings of Tiffin and Irz (2006). Using an innovative measure of non-agricultural activity (light intensity), Henderson, Storeygard and Weil (2009) also find that exogenous agricultural productivity shocks (high rainfall years) have substantial[28] effects on local urban economic activities in SSA (as measured by light intensity). They do not estimate the reverse effects, but report that these effects are smaller for bigger, more industrialized cities and political centres.

The latter refinement helps understand why the agricultural linkage effects no longer exceed the reverse effects in the other (richer) low-income countries of the sample (or the middle-income African countries). As countries grow, the role of agriculture as a generator of overall growth declines, and new drivers emerge both in the rural non-farm economy (urban-to-rural subcontracting) as well as the urban economy (e.g., manufactured exports), a phenomenon widely observed over the past decades in the Asian economies. With rapid (urban) income growth comes a significant diversification of diets into higher value agricultural products such as meat, dairy, fruits and vegetables, providing an additional demand boost for agriculture and thus larger reverse linkage effects.[29]

The empirical results of the linkage effects in this study thus suggest an evolving relation of agriculture to the rest of the economy, from encouraging growth elsewhere in the economy at low levels of development (still the case in many SSA countries), developing into a more mutually beneficial relationship as countries grow, to eventually ending up in a stage where growth outside agriculture drives growth (potentially even at the expense of agriculture). There will be important variations in the exact magnitude of these linkages across countries and their evolution over time, depending on the countries' agro-ecological conditions, their institutions, and their agrarian structures, but these are the broad trends that emerge from these data.[30] How the poorer populations participate in this (direct and indirect) growth is the topic of the next section.

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28 A one standard deviation increase in rainfall in the current or either of the two prior years is estimated to increase light intensity by 14 per cent, corresponding to a 4 per cent increase in GDP for a city.

29 Per capita caloric consumption of meat and horticultural products in developing countries almost doubled between 1980 and 2002, while per capital caloric consumption from cereals remained constant. Meat consumption, for example, increased especially in low-income countries in East Asia (by 7.3 per cent per year between 1969 and 1999) (World Bank 2007b).

30 Close inspection of the Tiffin/Irz sample reveals a similarly evolving relationship. When their sample countries are classified according to the 3-way typology suggested by the World Bank (2007b), 50 per cent (12 out of 24) of the countries classified as agriculture-based display Granger causality from

5 Benefiting from growth – the participation effects

There are three main reasons why the impact on poverty of growth might differ across sectors. First, connecting to the growth process might be easier for poor people if it occurs where they are located. It is often argued that poor people stand to benefit much more from agricultural growth than from non-agricultural growth because they live mostly in rural areas and earn their living in agriculture or related activities (Byerlee, Diao and Jackson 2005). It goes without saying that the sectoral concentration of poverty does not necessitate a sectoral policy response by itself (the 'non sequitur' highlighted by Collier and Dercon 2009). Rather, the proposition follows from two observations: first, that the poor typically face major obstacles in connecting to growth elsewhere in the economy due to factor- (including labour) and product-market failures (emphasized by Dercon 2009); and second, that the political economic constellation typically does not favour redistribution of income across sectors and locations (i.e., from the people employed in industry or services to those in agriculture).[31]

Second, given that the major asset of poor people is usually their (unskilled) labour, differences in (unskilled) labour intensity across sectors might generate sectoral differences in poverty reduction from growth. The evidence in Loayza and Raddatz (2006) suggests that the (unskilled) labour intensity of a sector is important in determining its poverty-reducing effects. They find that growth in agriculture (which is highly labour intensive) is the most poverty reducing, followed by manufacturing and construction, with growth in services, mining, and utilities being least poverty reducing (and also the least labour intensive, especially mining and utilities).

Third, sectoral variations in the poverty-reducing effects of growth are likely to arise from differences in asset inequality, particularly the distribution of land. Bourguignon and Morrison (1998) find that the larger the share of land cultivated by small and medium farmers, the lower the observed income inequality, and thus the greater the impact of growth on poverty. Emerging evidence from country studies supports this. In China, characterized by rather equal land distribution, growth in agriculture has been estimated to be up to four times more poverty reducing than growth in industry and services (Ravallion and Chen 2007). In India, on the other hand, where land inequality and landlessness are pervasive, growth originating in agriculture and services was found to be equally poverty reducing (Ravallion and Datt 1996).[32] Similarly, Dorosh, Niaza and Nazli (2003) find no decline in rural poverty rates in Pakistan in the 1990s despite substantial growth in agricultural GDP, a finding they related to the highly skewed distribution of land.

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agricultural labour productivity to GDP. This reduces to 38 per cent (5 out of 13) among those classified in the transition group and 20 per cent (2 out of 10) in the urbanizing group.

31 Rising spatial and sectoral inequality as countries develop is even posited as the historical norm with convergence in living standards only arising much later in the development process (World Bank 2009b). This is often aided by a shift in policies from taxing to subsidizing and protecting agriculture as a politically motivated response to the social tensions associated with the growing rural-urban divide (Hayami 2007; Timmer 2009).

32 Growth in industry did not reduce poverty. In a follow-up study, Ravallion and Datt (2002) also report that the poverty-reducing effects from non-agricultural growth were larger in states with higher initial farm productivity.

To assess the empirical validity of these propositions, the study turns to cross-country data. Building on Ravallion and Datt (1996) an appropriate empirical specification to test whether the source of growth matters for poverty reduction can be derived from Equation (2) as follows:

$$\Delta \ln P_{it} = \pi_0 + \pi_{at} s_{ait-1} \Delta \ln Y_{ait} + \pi_{nt} s_{nit-1} \Delta \ln Y_{nit} + c_i + u_{it} \quad (4)$$

where c_i are time invariant (unobserved) country characteristics, u_{it} is a white-noise error term, π_0 a common intercept and π_{jt} (j = a, n) the sectoral participation effects to be estimated. If $\pi_{iat}= \pi_{int}$, Equation (4) collapses to an estimation of the GDP elasticity of growth on poverty, and the composition of growth does not matter for poverty reduction.

Bias may arise if omitted (unobserved) country characteristics are correlated with the sectoral growth rates, while also affecting the rate of poverty reduction independently. For example, if the existence of a large extractive industry in a country would increase the rate of non-agricultural growth and reduce the rate of agricultural growth (e.g., through Dutch disease type appreciation of the real exchange rate), while also independently reducing the rate of poverty reduction (controlling for growth), the effect of non-agricultural (agricultural) growth would be underestimated (overestimated) leading to a more likely (and potentially misleading) acceptance of superiority of agriculture over non-agricultural. To control for such bias Equation (4) is estimated using a country fixed effects estimator. This forces identification of the coefficients from the within country variation, strengthening any results because of the much lower signal-to-noise ratio.

While country fixed effects help protect against *bias* from country heterogeneity, the sectoral participation effects may also depend on the particular country characteristics (X_{it}) themselves. The literature reviewed above points to initial asset inequality and the structure of the non-agricultural economy, especially the presence of an extractive industry. To explore how these characteristics affect sectoral participation effects, interaction terms with the Gini coefficient of income/consumption (GN_{it-1})[33] and the share of the extractive industry in GDP (M_{it-1}) at $t-1$ will be included in the empirical specification.

The size of the sectoral participation effects (π_{jt}) critically depends on the position of the poverty line with respect to the mean of the income distribution, as well as the shape of this distribution (Bourguignon 2003; Klasen and Misselhorn 2006). This varies substantially depending on the country's level of development. It also evolves over time in any given country—an important reason for the posited time varying nature of $\pi_{jt.}$

One approach would be to explore how sectoral growth affects income among the bottom (quantile) of the population in each country. This approach followed by Bravo-Ortega and Lederman (2005) and Ligon and Sadoulet (2007) assumes in effect a different (absolute) poverty line for each country, rendering the concept of poverty fully country specific (and relative) and masking potential differences in the sectoral participation effects of growth depending on the level of development. Preferring the

33 Gini coefficients of income/consumption typically correlate well with measures of asset/land inequality, which are not systematically available.

concept of absolute poverty, which also enhances comparability across countries, the route taken by Christiaensen and Demery (2007) is adopted here.

They augment (4) with interaction terms between the sectoral GDP growth variables and the ratio of the poverty line (z) to each country's average household income/expenditures ($\bar{e}_{it-1}$). An important part of the time varying nature of the elasticities is thereby controlled for, and π_{jt} and π_{jxt} are subsequently assumed constant over the (short) time periods considered ($\pi_{jt=}$ π_j and $\pi_{jxt=}$ π_{jx}):

$$\Delta \ln P_{it} = \pi_0 + [\pi_a + \pi_{ax} X_{it'-1}] s_{ait-1} \Delta \ln Y_{ait} + [\pi_n + \pi_{nx} X_{it-1}] s_{nit-1} \Delta \ln Y_{nit} + c_i + u_{it} \quad (5)$$

where $X_{it-1}=GN_{it-1}$, M_{it-1} and $\frac{z}{\bar{e}_{it-1}}$. Testing whether the sectoral composition of growth matters for poverty reduction, then boils down to testing whether

$$\left\{ \pi_a + \pi_{a\,gn} GN_{it-1} + \pi_{a\,m} M_{it-1} + \pi_{ae} \left(\frac{z}{\bar{e}_{it-1}}\right) \right\} = \left\{ \pi_n + \pi_{n\,gn} GN_{it-1} + \pi_{n\,m} M_{it-1} + \pi_{ne} \left(\frac{z}{\bar{e}_{it-1}}\right) \right\}$$

for different values of GN_{it-1}, M_{it-1} and $\frac{z}{\bar{e}_{it-1}}$. If this holds, Equation (5) collapses to a simple regression of the rate of poverty reduction on the rate of growth of GDP. The debate about the advantages of fostering agriculture versus non-agriculture in alleviating poverty would then reduce to the question whether investments and policies favouring agriculture yield faster overall economic growth (i.e., the direct and indirect effects combined) than investments in non-agriculture.

To estimate Equation (5), poverty measures derived from nationally representative household surveys are combined with national accounts data on economic growth by sector. The poverty data here refer to periods of change or 'spells' derived from two (comparable) household surveys in years $t-\tau$ and t. Poverty and inequality estimates are from the World Bank's *Povcal* database in 1993 purchasing power parity terms (World Bank 2005a). Given the arbitrariness of the choice of any poverty line and its normative implications (Pritchett 2006), Equation (5) is estimated using both the $1- and $2-day poverty lines. For each, the poverty headcount and the distribution-sensitive poverty gap squared are taken as dependent variables. The latter provides insights into how growth affects the poorest of the poor.

The data cover 282 spells for 82 countries over the 1980-2002 period with about two thirds of the spells occurring during the 1990s (Table 5). Seven spells were dropped as they concerned only urban poverty. Per capita growth rates for the agricultural and non-agricultural sectors (World Bank 2005b) are in constant 2000 US$, each deflated by the overall GDP deflator. In merging sectoral GDP growth with the poverty spells another ten spells were dropped because of missing growth data, resulting in a total of 265 spells covering 80 countries from all continents. For 70 per cent of the countries there is more than one spell.[34]

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[34] Although observations are not weighted by country population size, China and India, the most populous countries, have the most observations in the sample (20 and 11, respectively) with other

The share of the extractive industry (mining and oil) in overall GDP is obtained from World Bank (2005b), complemented with data from the UN National Accounts Database. An indicator variable is used, taking the value of 1 if the share is larger than 10 per cent, which was the case in 18 of the 80 sample countries. In calculating $\frac{z}{e_{it-1}}$, average GDP per capita was taken as proxy for average income to avoid bias due to measurement error—the poverty and household average income measures are both derived from the same survey. Averages of the different variables used in the regressions are given in Table 5.

The application of the standard specification (4) to the data using country fixed effects ordinary least squares suggests that the poverty-reducing effects of GDP growth generated in agriculture are substantially larger than the poverty-reducing effects of GDP growth generated outside agriculture, irrespective of the poverty measure or poverty line used (Table 6 columns (1) and (5) for $1-day poverty, and Table 7 columns (1) and (5) for $2-day poverty). Closer inspection indicates that there is some variation in the poverty-reducing powers of agriculture along the income distribution. The poverty-reducing effect of agricultural growth is, on average, four times (-7.08/-1.78) larger in our sample when it comes to the $1-day poverty headcount and 2.8 times (-5.9/-2.1) larger when considering the $1-day poverty gap squared. For $2-day poverty, agriculture still has the greater impact, by a factor of 1.3 for the headcount and 2.1 for the poverty gap squared. Compared with the rest of the economy, agriculture appears especially powerful in lifting the poorer groups out of poverty, though its comparative edge declines substantially when it comes to those closer to the $2-day poverty line.

There are strong theoretical grounds, however, for augmenting this standard specification by taking into account the presence of extractive industries and the extent

Table 5
Data coverage of poverty spells

	No. of:		Poverty headcount (average at t-1)			No. of countries	
Continent	Countries	Survey spells	$1-day (%)	$2-day (%)	Gini (average at t-1)	extractive ind ≥10% of GDP	> 1 spell
Sub-Saharan Africa	20	42	36.9	68.9	0.44	4	11
South Asia	4	22	36.7	80.3	0.33	0	4
East Asia & Pacific	8	47	10.7	47.9	0.38	3	5
East Europe & Central Asia	21	52	3.1	13.4	0.33	2	15
Latin America & Caribbean	20	88	11.4	28.0	0.52	5	16
Middle East & North Africa	7	14	1.7	16.2	0.40	4	5
Total	80	265	15.3	38.1	0.40	18	56

Source: Authors' calculations.

large countries, such as Brazil and Indonesia, also having several spells. Consequently, the results implicitly reflect a coarse population weighting.

of initial income inequality. The results based on this specification are reported in columns (2) and (6) of Tables 6 and 7. Agriculture matters most for poverty reduction among the poorest of the poor (as captured by the $1-day poverty gap squared—Table 6 column (6)). The coefficients on non-agricultural growth and their interaction terms are jointly statistically insignificant irrespective of the country's resource position or the initial level of inequality (individual tests not reported). Those on the agricultural growth terms are highly significant (up to a Gini of 0.4). But non-agriculture is now found to be more effective in reducing the $2-day poverty headcount than agriculture, at least in *resource poor countries*—those with less than 10 per cent of GDP coming from extractive industries (p-values of 0.01 and 0.03 for, respectively, the 25th and 75th percentile Gini[35] in the sample).

The presence of a large extractive industry dampens the poverty-reducing effects of non-agricultural growth,[36] especially when it concerns $2-day poverty measures (Table 7, columns (2) and (6)). The effects can be substantial, to the point of eliminating the edge of non-agriculture over agriculture in reducing $2-day headcount poverty in countries where the extractive industry contributes more than 10 per cent to GDP (p-values equal to 0.47 and 0.49).[37] The extractive industry was also found to undermine the $1-day poverty-reducing effect of growth outside agriculture, but this was estimated with less precision. This is possibly because extractive industries are likely to attract the poorer, unskilled workers given the nature of the job, while those with some assets, hovering around the $2-day poverty line, may prefer to continue in agriculture or other remunerative non-mining activities outside agriculture.

Initial inequality dampens the poverty-reducing effects of overall growth (Ravallion 2001; Adams 2004; Fosu 2009). It seems even more important in reducing the benefits to the poor from growth in agriculture than from growth elsewhere in the economy (Tables 6 and 7: columns (2) and (6)).[38] In resource poor countries at the 25 percentile of the Gini distribution in the sample, agriculture is four times more powerful in reducing $1-day poverty. However, at the 75th percentile of the Gini distribution agriculture has lost its comparative advantage (Table 6, column (2) p-value of the Wald-test of equality of coefficients equals 0.54).

Once the effects of the level of inequality and the presence of an extractive industry on the sectoral poverty elasticities are accounted for, controlling further for the level of development (i.e., the poverty line relative to mean income) does not change the results fundamentally (Tables 6 and 7, columns (3) and (7)). None of the interaction terms with

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35 In the sample 0.33 and 0.50 correspond to the 25th percentile and the 75th percentile Gini, respectively.

36 In none of the models was there an effect of the presence of an extractive industry on the poverty elasticity with respect to agricultural GDP. The interaction term was subsequently dropped to gain overall efficiency.

37 Similar results are obtained when using the mining share of GDP as such.

38 This is suggested by the larger ratio of the coefficient on the Gini-sectoral growth interaction term over the coefficient on the sectoral growth term for agriculture. This holds for all the poverty measures, except the $1-day poverty gap squared where the contribution of non-agricultural growth is in essence not statistically significant across Gini range. The coefficients on the Gini-sectoral growth interaction term are also always statistically significant for agriculture (columns (2) and (6) in Tables 6 and 7), but only in the $2-day headcount regressions for non-agriculture.

$\frac{z}{\bar{e}_{it-1}}$ is statistically significant, with the exception of the interaction with non-agriculture in the $2-day headcount regression, where it exercises a dampening effect—the $2-day poverty-reducing powers of non-agricultural growth decline as countries become poorer.

The additional controls for the level of development also address in principle the question of whether the findings so far hold in the African context. To investigate this the interaction term with the poverty line/average income ratios is further interacted with an SSA indicator to test whether level of development results are different for SSA (Tables 6 and 7, columns (4) and (8)). The interaction term is never statistically significant, giving reason to believe that the results also hold for Africa.[39]

Table 6
Agriculture substantially more effective in reducing $1-day poverty
with inequality reducing its edge over non-agriculture

$1-day poverty	Headcount				Poverty gap squared			
Country fixed effects estimates	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value
Agric growth/cap	-7.08***	-24.8***	-23.9***	-23.0***	-5.9**	-25.3***	-28.8***	-27.4**
	0.00	0.00	0.00	0.00	0.03	0.01	0.01	0.03
Agric growth/cap*Gini $_{t-1}$	–	50.92***	46.40**	44.89**	–	49.62**	65.70*	60.89*
		0.00	0.02	0.02		0.02	0.05	0.08
Agric growth/cap*(pov/avg income) $_{t-1}$	–	–	1.57	-1.51	–	–	-7.44	-11.91
			0.79	0.92			0.48	0.64
Ag growth/cap*(pov/avg income) $_{t-1}$ *SSA	–	–	–	3.31	–	–	–	8.45
				0.79				0.70
Non-Agric growth/cap	-1.78***	-4.63	-4.54	-4.71	-2.10*	1.67	2.91	4.35
	0.01	0.11	0.13	0.17	0.07	0.74	0.58	0.47
Non-Agric growth/cap*Gini $_{t-1}$	–	7.76	8.32	8.62	–	-8.39	-8.28	-9.64
		0.23	0.21	0.22		0.47	0.48	0.44
Non-Agric growth/cap*10% mining share	–	2.42	2.53	2.57	–	0.87	0.76	0.68
		0.16	0.15	0.15		0.78	0.81	0.83
Nonag growth/cap*(pov/avg income) $_{t-1}$	–	–	-1.08	-1.11	–	–	-4.79	-10.38
			0.73	0.82	–		0.40	0.23
Nonag growth/cap*(pov/avg inc) $_{t-1}$ *SSA	–	–	–	0.49	–	–	–	9.13
				0.92				0.27
R^2	0.14	0.25	0.25	0.25	0.05	0.08	0.08	0.09
F	15.06	11.95	8.49	6.54	4.6	3.12	2.35	1.99
N	265	265	265	265	265	265	265	265

39 Interactions of the SSA indicator directly with sectoral growth (instead of with poverty line/average income and SSA as in columns (4) and (8)), while maintaining interactions with inequality and presence of an extractive industry, are also never statistically significant.

Table 6 (con't)
Agriculture substantially more effective in reducing $1-day poverty
with inequality reducing its edge over non-agriculture

$1-day poverty	Headcount				Poverty gap squared			
Country fixed effects estimates	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value
p-value for Wald test								
ag=nag	0.00	–	–	–	0.01	–	–	–
ag+0.33*agG=nag+0.33*nagG	–	0.04	–	–	–	0.13	–	–
ag+0.50*agG=nag+0.50*nagG	–	0.54	–	–	–	0.62	–	–
ag+0.33*agG=nag+0.33*nagG+ mmin10pct	–	0.00	–	–	–	0.02	–	–
ag+0.50*agG=nag+0.50*nagG+ mmin10pct	–	0.64	–	–	–	0.75	–	–
ag+0.33*agG+0.14*agpov= nag+0.33*nagG+mmin10pct+0.14* nagpov	–	–	0.00	–	–	–	0.07	–
ag+0.33*agG+0.46*agpov= nag+0.33*nagG+mmin10pct+0.46* nagpov	–	–	0.00	–	–	–	0.02	–
ag+0.50*agG+0.14*agpov= nag+0.50*nagG+mmin10pct+0.14* nagpov	–	–	0.57	–	–	–	0.61	–
ag+0.50*agG+0.46*agpov= nag+0.50*nagG+mmin10pct+0.46* nagpov	–	–	0.57	–	–	–	0.54	–
ag+0.33*agG+0.38*agpov+ 0.38*agpovSSA= nag+0.33*nagG+mmin10pct+0.38* nagpov+0.38*nagpovSSA	–	–	–	0.01	–	–	–	0.08
ag+0.33*agG+0.73*agpov+ 0.73*agpovSSA=nag+0.33*nagG+ mmin10pct+0.73*nagpov+ 0.73*nagpovSSA	–	–	–	0.04	–	–	–	0.09
ag+0.50*agG+0.38*agpov+ 0.38*agpovSSA=nag+0.50*nagG+ mmin10pct+0.38*nagpov+ 0.38*nagpovSSA	–	–	–	0.61	–	–	–	0.76
ag+0.50*agG+0.73*agpov+ 0.73*agpovSSA=nag+0.50*nagG+ mmin10pct+0.73*nagpov+0.73* nagpovSSA	–	–	–	0.68	–	–	–	0.78

Finally, $2-day poverty measures were not available for China, which makes up 7.5 per cent of our sample (20 out of 265 spells). This could have unduly influenced the results for $1-day poverty as agricultural growth has been demonstrated to be much more poverty reducing in China than growth outside agriculture (Ravallion and Chen 2007). However, excluding China from the $1-day regressions does not change the reported findings at all.[40]

40 Results are available from authors upon request.

Table 7
Non-agriculture more effective in reducing $2-day poverty, but less so when coming from extractive industries and not when accounting for the depth of poverty

$2-day poverty	Headcount				Poverty gap squared			
Country fixed effect estimates	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value
Agric growth/cap	-4.47***	-6.38	-3.74	-2.95	-4.01***	-9.76**	-9.1	-3.9
	0.00	0.12	0.42	0.59	0.00	0.04	0.10	0.55
Agric growth/cap*Gini $_{t-1}$	–	19.32**	8.68	8.95	–	21.25*	18.27	12.58
		0.04	0.55	0.55		0.05	0.29	0.48
Agric growth/cap*(pov/avg income) $_{t-1}$	–	–	2.71	1.31	–	–	0.67	-9.8
			0.24	0.83			0.81	0.17
Ag growth/cap*(pov/avg income) $_{t-1}$*SSA	–	–	–	0.38	–	–	–	9.94
				0.94				0.11
Non-Agric growth/cap	-3.33***	-17.1***	-18.30***	-19.48***	-1.87***	-5.56**	-5.8**	-7.4**
	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.02
Non-Agric growth/cap*Gini $_{t-1}$	–	32.65***	31.64***	32.87***	–	7.85	7.8	10.29
		0.00	0.00	0.00		0.18	0.19	0.10
Non-Agric growth/cap*10% mining share	–	5.15***	5.12***	5.21***	–	3.27**	3.29**	3.48**
		0.00	0.00	0.00		0.04	0.04	0.03
Nonag growth/cap*(pov/avg income) $_{t-1}$	–	–	2.96**	4.78**	–	–	0.42	1.46
			0.02	0.01			0.78	0.51
Nonag growth/cap* (pov/avg inc) $_{t-1}$*SSA	–	–	–	-2.46	–	–	–	-0.38
				0.17				0.86
R^2	0.24	0.44	0.46	0.47	0.11	0.17	0.18	0.19
F	25.21	25.74	19.66	15.5	10.55	6.81	4.82	4.05
N	245	245	245	245	245	245	245	245
p-value for Wald test								
ag=nag	0.00	–	–	–	0.00	–	–	–
ag+0.33*agG=nag+0.33*nagG	–	0.01	–	–	–	0.93	–	–
ag+0.50*agG=nag+0.50*nagG	–	0.03	–	–	–	0.23	–	–
ag+0.33*agG=nag+0.33*nagG+ mmin10pct	–	0.47	–	–	–	0.10	–	–
ag+0.50*agG=nag+0.50*nagG+ mmin10pct	–	0.49	–	–	–	0.68	–	–
ag+0.33*agG+0.29*agpov= nag+0.33*nagG+mmin10pct+ 0.29*nagpov	–	–	0.18	–	–	–	0.35	–
ag+0.33*agG+0.93*agpov= nag+0.33*nagG+mmin10pct+ 0.93*nagpov	–	–	0.14	–	–	–	0.33	–
ag+0.50*agG+0.29*agpov= nag+0.50*nagG+mmin10pct+ 0.29*nagpov	–	–	0.74	–	–	–	0.53	–

Table 7 (con't)
Non-agriculture more effective in reducing $2-day poverty, but less so when coming from extractive industries and not when accounting for the depth of poverty

$2-day poverty	Headcount				Poverty gap squared			
Country fixed effect estimates	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value	Coeff/ p-value
ag+0.50*agG+0.93*agpov= nag+0.50*nagG+mmin10pct+ 0.93*nagpov	–	–	0.67	–	–	–	0.32	–
ag+0.33*agG+0.76*agpov+ 0.76*agpovSSA=nag+0.33* nagG+mmin10pct+0.76*nagpov +0.76*nagpovSSA	–	–	–	0.23	–	–	–	0.98
ag+0.33*agG+1.47*agpov+ 1.47*agpovSSA=nag+0.33* nagG+mmin10pct+1.47*nagpov +1.47*nagpovSSA	–	–	–	0.34	–	–	–	0.85
ag+0.50*agG+0.76*agpov+ 0.76*agpovSSA=nag+0.50* nagG+mmin10pct+0.76*nagpov + 0.76*nagpovSSA	–	–	–	0.69	–	–	–	0.89
ag+0.50*agG+1.47*agpov+ 1.47*agpovSSA=nag+0.50* nagG+mmin10pct+1.47*nagpov +1.47*nagpovSSA	–	–	–	0.4	–	–	–	0.93

In sum, agriculture is more powerful in reducing $1-day poverty (headcount and poverty gap squared) for the majority of the countries (including SSA), with its advantage declining as inequality increases. Non-agriculture is more powerful in reducing the $2-day poverty headcount, but not if it is driven by an extractive industry,[41] which dampens its poverty-reducing effect. It is also less effective in the poorer countries. The full effect of agricultural and non-agricultural growth on total poverty in a series of different settings can now be explored.

6 The (evolving) role of agriculture in poverty reduction

To quantify the *overall* poverty-reducing impacts of agriculture and non-agriculture, the marginal effect on total poverty of one per cent growth in agricultural GDP per capita and one per cent growth in non-agricultural GDP per capita are simulated across a series of settings and for different poverty measures. The simulations consist of two components:

1) The *direct effect* of one per cent additional growth in agricultural GDP per capita on total poverty. From Equation (5), this is given by,

$$\frac{\partial \Delta \ln P_{it}}{\partial \Delta \ln Y_{ait}} = [\pi_a + \pi_{ax} X_{it-1}] s_{ait-1}.$$

41 None of the p-values on tests of equality of coefficients for 25 and 75 percentile poverty over average income ratios (0.14 and 0.46, respectively) are statistically significant (Table 7, column 3).

Columns (2) and (6) of Tables 6 and 7 are the basis of the simulations (because the level of development made little independent contribution econometrically). This effect was calculated separately for resource poor and resource rich countries, and for Gini coefficients ranging from 0.25 to 0.60 (covering 95 per cent of the countries in the sample). The statistical significance of the different sectoral participation effects was tested for the different values of the Gini coefficient and the substantial presence of an extractive industry, and set to zero if they were not significant at the 10 per cent level.

2) The *indirect impact* on poverty, arising from its knock-on effects on growth in non-agriculture one period later (and the ensuing poverty impact coming from non-agriculture's participation effect). This is defined as,

$$\frac{\partial \Delta \ln P_{it+1}}{\partial \Delta \ln Y_{ait}} = [\pi_n + \pi_{nx} X_{it}] s_{nit} \frac{\partial \Delta \ln Y_{nit+1}}{\partial \Delta \ln Y_{ait}}.$$

This component of the simulation is based on the coefficients reported in columns (2) and (5) of Table 3. Again if the estimated coefficients were statistically non-significant (including the linkage effects for the middle-income countries) parameters were set to zero in the simulations.[42]

In considering different settings, one criterion is the country's stage of development. Not only do the linkage effects evolve as countries develop (section 4), so do their sectoral shares in GDP (s_j), with the share of agriculture in GDP declining as countries become richer. The sectoral GDP shares form the fourth important factor in evaluating the relative powers of the different sectors in reducing poverty (in addition to the direct and indirect growth effects and the participation effect). While agriculture is often the largest individual sector, as a whole it is usually substantially smaller than the rest of the economy (by a factor two to nine).[43] This renders it much less likely that one per cent of agricultural GDP growth would yield a similar amount of total poverty reduction than an equivalent per cent growth in non-agricultural GDP. Or, if it does, it would be so much more striking.

In these simulations agriculture is penalized by its relatively small size (compared with the rest of the economy). Being smaller, the resources needed to achieve a one per cent agricultural GDP growth hike would be far less than those required for a one per cent growth in all other sectors combined. Put another way, if we are interested in the question 'by how much would \$100 invested in agriculture reduce poverty compared with non-agriculture?' the results of these simulations would give an unduly pessimistic impression of agriculture—\$100 invested in agriculture would probably yield a higher sectoral growth hike compared with the same investment in a much larger sector. While it is beyond the scope of this paper to investigate just how much this disadvantages agriculture in any comparison with other sectors, the simulation results (of the first two

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42 The total effect of one per cent non-agricultural growth on total poverty is obtained similarly, but using the coefficients in columns (2) and (5) of Table 4 for the knock-on effects of growth in non-agriculture on agriculture.

43 On average, the share of agriculture in GDP in the sample is, respectively, 34 per cent and 25 per cent in the resource poor and resource rich SSA low-income countries, 25 and 21 per cent in the resource poor and resource rich non-SSA low-income countries, and 11 and 13 per cent in the resource poor and resource rich middle-income countries.

columns of Figures 2-4) should be viewed as a *lower bound* estimate of the relative advantage of the sector in reducing poverty.

In line with the estimates of the indirect growth effects, three groups of countries are considered: middle-income, low-income excluding SSA, and low-income SSA countries. The combined direct and indirect effects on total poverty for each sector are plotted for resource rich and resource poor countries for each of the three country types (first and second columns in Figures 2-4), and for each of the four poverty measures, starting from the most distribution sensitive ($1-day poverty gap squared) to the least distribution sensitive ($2-day headcount).

An alternative approach to simulating the poverty impact of sectoral growth would be to control for the size of the sector, and assess the poverty impact of a one per cent aggregate GDP growth originating in each of the sectors—weighting the sectoral growth rates by the share of the sector in aggregate GDP. This is the approach taken in the literature, and it is the results of this exercise that should be compared with the important country studies of China (Ravallion and Chen 2007) and India (Ravallion and Datt 1996). For simulating the impact of agricultural growth, this is given by the sum of,[44]

$$\frac{\partial \Delta \ln P_{it}}{\partial s_{ait-1} \Delta \ln Y_{ait}} = [\pi_a + \pi_{ax} X_{it-1}] \text{ and } \frac{\partial \Delta \ln P_{it+1}}{\partial s_{ait-1} \Delta \ln Y_{ait}} = [\pi_n + \pi_{nx} X_{it}] s_{nit} \frac{\partial \Delta \ln Y_{nit+1}}{\partial s_{ait=1} \Delta \ln Y_{ait}}$$

To obtain the share weighted indirect (growth linkage) effects, equation (3) was re-estimated using share weighted lagged agricultural growth. The counterpart linkages to agriculture from non-agriculture were obtained similarly using share weighted lagged non-agricultural growth.[45]

By weighting sectoral growth by its share, these simulations can be considered as presenting an *upper bound* of the impact on poverty of a relatively small agricultural sector compared with growth in the rest of the economy. In effect they assume that it is as easy for a small sector (agriculture) to generate 1 percentage aggregate GDP growth as a larger sector (non-agriculture). The results of these simulations are reported in the third column of Figures 2-4.

Four important messages emerge from Figures 2-4. First, the top row depicting the marginal (direct and indirect) effects on the $1-day poverty gap squared, shows that irrespective of the setting, agriculture is much more powerful in reducing poverty among the poorest of the poor (when inequality is not too high). This is consistent with the findings of Ligon and Sadoulet (2007). In resource poor low-income countries (excluding SSA) agricultural growth was found to be more than five times as poverty reducing than growth outside agriculture. For SSA countries, it was more than eleven times more poverty reducing.

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44 And vice versa for the share weighted effect of non-agricultural growth.

45 The coefficients for middle-income countries remained statistically insignificant, while the estimated coefficients (p-value) on share weighted lagged agriculture and share weighted lagged agriculture interacted with SSA were 0.28 (0.63) and 0.16 (0.80) respectively (Table 3, column (5)) and those on share weighted lagged non-agriculture and share weighted lagged non-agriculture interacted with SSA 0.24 (0.0) and -0.14 (0.35) respectively.

Figure 2
MIDDLE-INCOME COUNTRIES
Agriculture most powerful in reducing poverty among the poorest
and in resource-rich countries; non-agriculture most powerful among the lesser poor if inequality not extreme

Total poverty change (%) given 1% sectoral GDP/cap change in resource poor countries | Total poverty change (%) given 1% sectoral GDP/cap change in resource rich countries | Total poverty change (%) given 1% aggregate GDP/cap change by sector in resource poor countries

$1-day - poverty gap squared | $1-day - poverty gap squared | $1-day - poverty gap squared

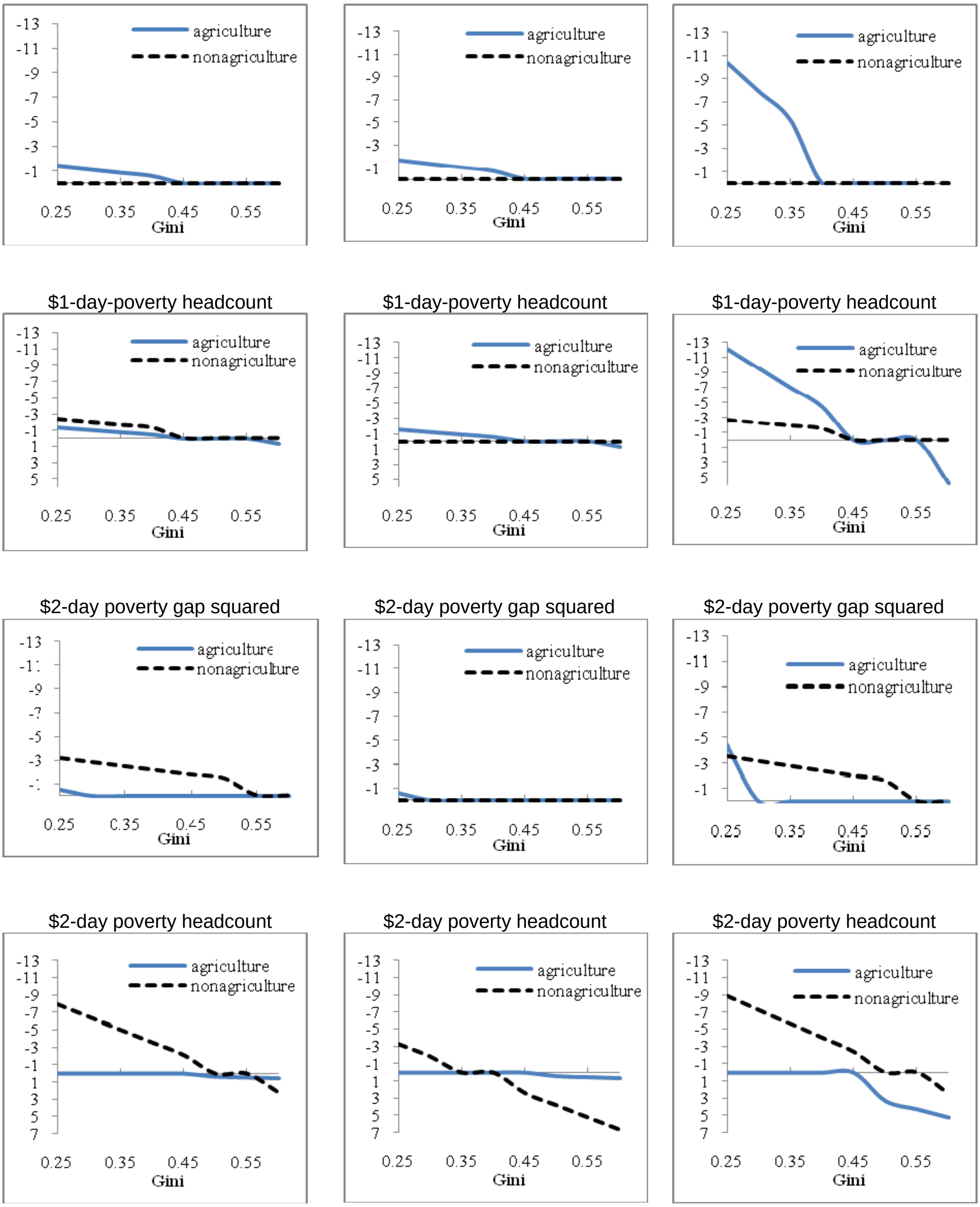


Figure 3
LOW-INCOME COUNTRIES (EXCL SSA)
Agriculture most powerful in reducing $1-day poverty and in resource-rich countries; non-agriculture most powerful in reducing $2-day poverty

Total poverty change (%) given 1% sectoral GDP/cap change in resource poor countries	Total poverty change (%) given 1% sectoral GDP/cap change in resource rich countries	Total poverty change (%) given 1% aggregate GDP/cap change by sector in resource poor countries

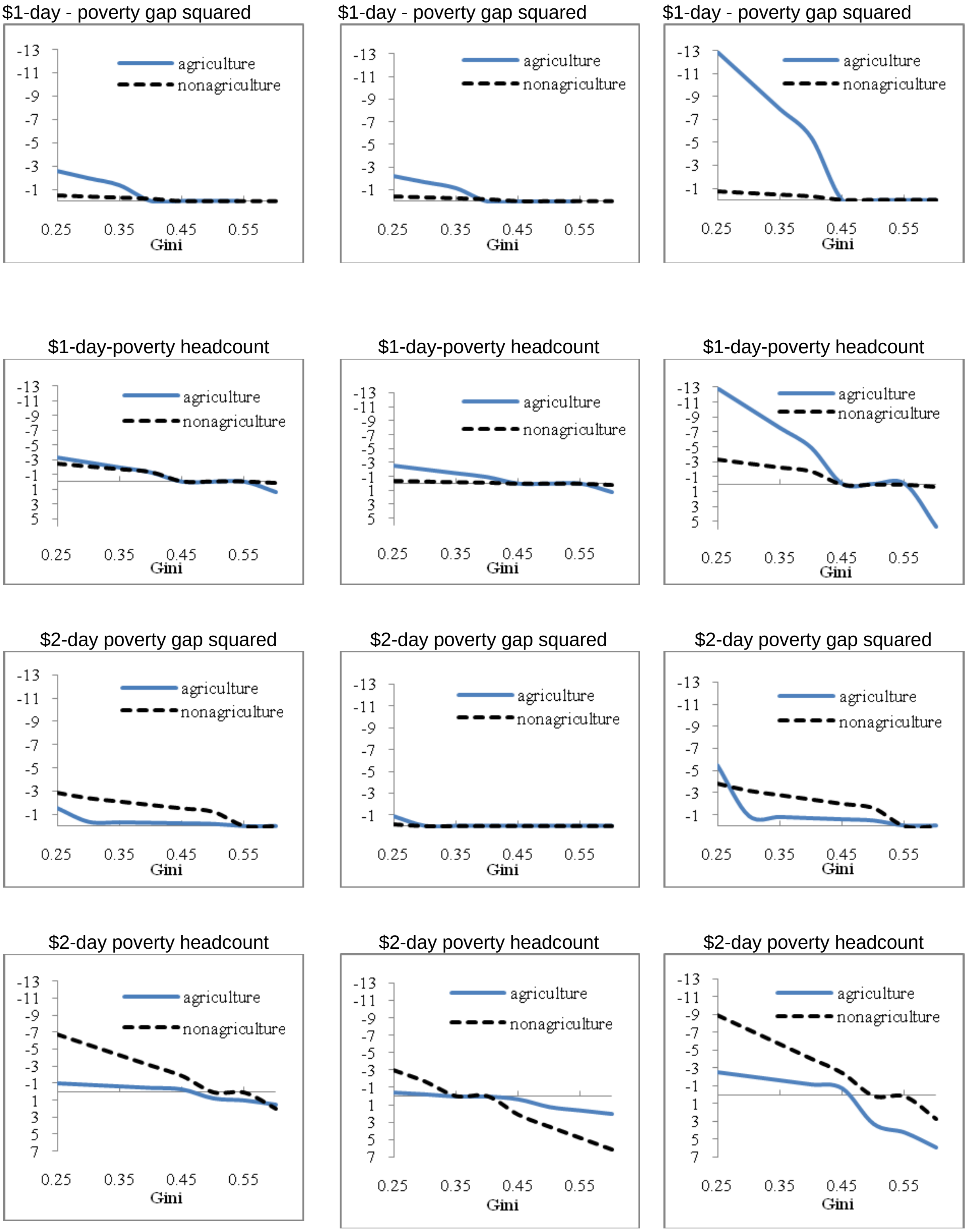
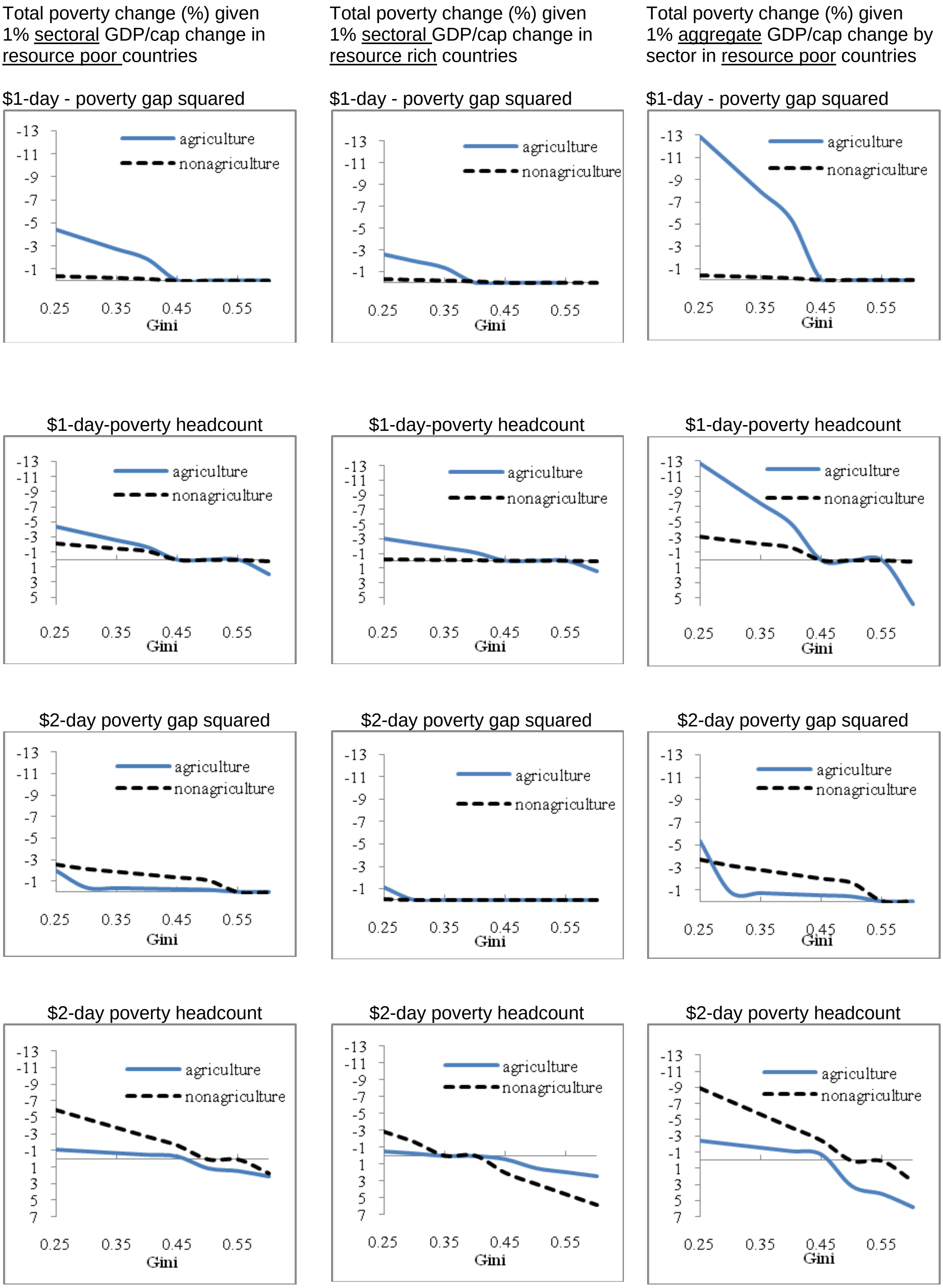


Figure 4
LOW-INCOME COUNTRIES – SSA
Agriculture most powerful in reducing $1-day poverty and in resource-rich countries; non-agriculture most powerful in reducing $2-day poverty



Second, non-agriculture is more powerful in reducing poverty among the better-off poor in resource poor countries, i.e., in reducing the $2-day poverty headcount in countries where the extractive industry makes up less than 10 per cent of GDP. The relative advantage is strongest in middle-income countries, but still by a factor of 5 in SSA. When it comes to resource rich countries, the picture is mixed, with non-agriculture more effective in reducing the $2-day head count when inequality is low, but potentially more harmful (poverty increasing) at higher levels of inequality.[46]

Third, non-agricultural growth originating in the extractive industry substantially dampens its effect on poverty reduction. As a result, in resource rich countries, agriculture is usually more powerful in reducing poverty, especially when it comes to $1-day poverty. This also holds in middle-income countries where the advantage of non-agriculture in reducing the $1-day poverty headcount reverses in going from resource poor to resource rich countries middle-income countries (second row Figure 2).

Fourth, the advantage of agriculture in reducing $1-day headcount poverty declines as countries become richer and inequality increases, from being on average 1.7 times more poverty reducing in resource poor low-income SSA countries at a Gini below 0.45, to about equally powerful in resource poor non-SSA low-income countries, and about 40 per cent as powerful in middle-income countries (2nd row, first column in Figures 2-4). But for reasons already discussed, these effects can be considered as a lower-bound assessment of the effect of agricultural growth. The upper bound estimate, reflecting more closely the approach taken in the recent literature (the marginal effects of an aggregate percentage point GDP change reported in the 2nd row, third column in Figures 2-4), gives agriculture as significantly more effective in reducing the overall $1-day poverty headcount in all settings (on average by a factor 3.2 for low-income SSA countries, a factor 3 in non-SSA low-income countries, and a factor 3.4 in middle-income countries at a Gini below 0.45). The extent to which agriculture has the edge in reducing $1-day poverty in societies that are not fundamentally unequal, clearly depends on where in the range between the lower- and upper-bound simulations the empirical truth lies.

7 Concluding remarks

The debate about the role of agriculture in development continues unabated. Consistent with the Millennium Development Goals adopted by the international community in 2000, this paper contributes to this debate taking poverty reduction as the central development objective, as opposed to overall GDP growth per se. The relative contribution of a sector to poverty reduction is shown to depend on four factors: its direct growth component; its indirect growth component, the participation of poor people in the growth of the sector, and the size of the sector in the overall economy.

It has been shown that slower agricultural growth (the direct growth component) should not be taken to mean that agriculture is less productive, even though agricultural GDP growth will on the whole continue to be less than growth outside agriculture, especially in countries where agriculture is less tradable and Engel's Law manifests itself more

[46] There is no correlation in the data between the resource position of the country and its level of inequality.

prominently—later in the development process. The empirical results suggest further an evolving relation between agriculture and the rest of the economy (the indirect growth component), from serving as a key source of growth throughout the economy, especially in lower-income SSA countries, to end up in a stage with little discernable linkage effects in most of the middle-income countries. Clear differences were identified in the extent to which different segments of the poorer populations participate in growth across the different sectors, with these differences driving the large differential effects of sectoral growth on poverty.

Simultaneous consideration of the indirect growth, participation and share components shows that growth in agriculture is especially beneficial for the poorest of the poor. Irrespective of the setting, a one per cent increase in agricultural per capita GDP was found to reduce the total $1-day poverty gap squared by at least five times more than a one per cent increase in GDP per capita outside agriculture, despite being substantially smaller than the non-agricultural sector. Non-agricultural growth on the other hand is more powerful in reducing poverty among the better-off ($2-day) poor (also in SSA). When it comes to $1-day headcount poverty, agriculture is up to 3.2 times better at reducing poverty than non-agriculture, when accounting for the differences in sector size, with the advantage diminishing as countries become richer (and inequality increases). Across poverty measures, the poverty-reducing potential of non-agriculture reduces substantially when extractive industries make up a sizeable part of the economy

In sum, the empirical evidence presented in this paper supports the overall premise that enhancing agricultural productivity remains a critical starting point in designing effective poverty reduction strategies to reduce $1-day poverty (the first MDG), especially in low-income and resource rich countries. When it comes to reducing poverty among the richer $2-day poor, non-agriculture has the edge, especially in resource poor country settings.

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Appendix A1: Specification and estimation of agriculture and non-agriculture linkage equations

For the analysis of the cross-sectoral linkages in section 4, non-agricultural per capita GDP growth ($y_{it}^n \approx d\ln Y_{it}^n$) in country *i* at time *t* is assumed to depend on per capita non-agricultural GDP growth in the previous periods as well as on per capita agricultural GDP growth now[47] and in the past. In addition, we consider a vector X_{it} of country-specific exogenous or predetermined explanatory factors, yielding:

$$y_{it}^n = \alpha^0 + \sum_{k=1}^{Kn} y_{it-k}^n \alpha_k^1 + \sum_{k=0}^{Ka} y_{it-k}^a \alpha_k^2 + X_{it}\alpha^3 + u_t + c_i + \varepsilon_{it} \tag{A1}$$

where u_t denotes a global time dummy, c_i reflects unobserved country specific characteristics that determine the sectoral output, and ε_{it} an idiosyncratic error term free of autocorrelation and uncorrelated across countries. Per capita agricultural GDP growth can be similarly expressed as[48]:

$$y_{it}^a = \beta^0 + \sum_{l=1}^{Ln} y_{it-l}^n \beta_l^1 + \sum_{l=0}^{La} y_{it-l}^a \beta_l^2 + X_{it}\beta^3 + z_t + f_i + \varphi_{it} \tag{A2}$$

with z_t a time dummy, f_i a time invariant country-specific unobserved effect and φ_{it} an idiosyncratic error term. The specifications (A1) and (A2) are assumed to capture the full correlations between (per capita) growth in non-agricultural and agricultural GDP, and ε_{it} and φ_{it} are therefore assumed to be uncorrelated.

Equations (A1) and (A2) constitute our model of intersectoral growth linkages, where agricultural and non-agricultural GDP growth rates are interdependently determined in a dynamic process. Through the substitution of equation (A2) into equation (A1), we can obtain a reduced form expression for non-agricultural growth:

$$\begin{aligned} y_{it}^n &= \alpha_0 + \sum_{k=0}^{Ka} \beta^0 \alpha_k^2 + \sum_{k=1}^{Kn} y_{it-k}^n \alpha_k^1 + \sum_{k=0}^{Ka}\sum_{l=1}^{Ln} y_{it-k-l}^n \beta_l^1 \alpha_k^2 + \sum_{k=0}^{Ka}\sum_{l=0}^{La} y_{it-k-l}^a \beta_l^2 \alpha_k^2 \\ &+ \sum_{k=0}^{Ka} X_{it-k}\beta^3\alpha_k^2 + X_{it}\alpha^3 + (\sum_{k=0}^{Ka}\alpha_k^2)v_t + z_t + (\sum_{k=0}^{Ka}\alpha_k^2) f_i + c_i + (\sum_{k=0}^{Ka}\alpha_k^2)\varphi_{it} + \varepsilon_{it} \end{aligned} \tag{A3}$$

which can be further reduced to:

$$y_{it}^n = \chi^0 + \sum_{p=1}^{P} y_{it-p}^n \chi_p^1 + \sum_{q=1}^{Q} y_{it-q}^a \chi_q^2 + \sum_{k=0}^{Ka} X_{it-k}\chi_k^3 + w_t + h_i + v_{it} \tag{A4}$$

47 The level of contemporaneous agricultural GDP is included since a good agricultural harvest can induce final demand effects from the agricultural sector for goods and services from the non-agricultural sector.

48 Concurrent non-agricultural GDP is also included as the change in non-agricultural incomes may affect the contemporaneous demand for agricultural products and thus its prices. Agricultural production can only respond with a lag.

This single equation now constitutes a dynamic relationship between non-agricultural GDP growth and lagged levels of agricultural and non-agricultural GDP growth. The lagged levels of non-agricultural (and agricultural) GDP growth are correlated with the unobserved country specific effects h_i and OLS is therefore inconsistent. First-differencing of Equation (A4) eliminates the country-specific effect h_i yielding:

$$\Delta y_{it}^{n} = \sum_{p=1}^{P} \Delta y_{it-p}^{n} \chi_{p}^{1} + \sum_{q=1}^{Q} \Delta y_{it-q}^{a} \chi_{q}^{2} + \sum_{k=0}^{Ka} \Delta X_{it-k} \chi_{k}^{3} + \Delta w_{t} + \Delta v_{it} \tag{A5}$$

The assumed feedback mechanism between changes in agricultural and non-agricultural GDP growth introduces another correlation between Δv_{it} and the lagged changes in agricultural and non-agricultural GDP growth (Δy_{it-1}^{a} and Δy_{it-1}^{n}). To ensure consistent estimates the system GMM estimator outlined in Arellano and Bover (1995) and Blundell and Bond (1998) was applied, using further lagged levels as instruments in the first difference equation (A5) and lagged differences to instrument y_{it-1}^{a} and y_{it-1}^{n} in the levels Equation (A4). Predetermined explanatory factors in X_{it} are treated the same way, while strictly exogenous explanatory variables in $X_{it}, t = 1,...,T$ provide further instruments for the estimator.

The additional moment conditions in the system GMM estimator following from the level equations help address the potential problem of weak instruments, and thus low efficiency, that afflicts the Arellano-Bond estimation when the data generation process of the variables of interest approaches a unit root. At the same time, guidelines by Roodman (2009b) are followed to avoid overfitting when using too many lags as instruments. A reduced form along the lines of equations (A3-A5) can also be constructed for agricultural GDP growth (y_{it}^{a}).