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Impacts of CAADP on Africa's Agricultural-Led Development

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ABSTRACT

This paper uses panel data on 46 African countries from 2001 to 2014 to estimate the impacts of the Comprehensive Africa Agriculture Development Programme (CAADP), an agriculture-led integrated framework of development priorities in Africa, on agricultural expenditure and productivity, income, and nutrition. A difference-in-difference treatment-effects model (based on when a CAADP compact is signed and the level of CAADP implementation reached) and different estimation methods and model specifications are used. The results show that CAADP has had a positive impact on agricultural value-added and land and labor productivity. The impact on agriculture expenditure is generally negative, suggesting that there is a substitution effect between the government's own funding and external sources of funding for the sector. The estimated impact on income and nutrition is generally insignificant. There are some puzzling results from the interaction between specific period of compact signing and level of implementation reached. Implications for maintaining the positive impacts, as well as for further research to understand the puzzling results, are discussed.

Keywords: Africa, agriculture, CAADP, treatment effects

ACRONYMS

ATT	average treatment effect on the treated
AU	African Union
CAADP	Comprehensive Africa Agriculture Development Programme
GAFSP	Global Agriculture and Food Security Program
GDP	gross domestic product
IMR	inverse mills ratio
IPW	Inverse probability weighting
NAFSIP	national agricultural and food security investment plan
NAIP	national agricultural investment plan
NEPAD	New Partnership for Africa's Development
ReSAKSS	Regional Strategic Analysis and Knowledge Support System

1. INTRODUCTION

At the Second Ordinary Session of the Assembly of the African Union held in July 2003 in Maputo, Mozambique, the heads of state and government launched the Comprehensive Africa Agriculture Development Programme (CAADP). This agriculture-led integrated framework of development priorities in Africa is aimed at reducing poverty and increasing food security in the continent (AU-NEPAD 2003). Various processes at the national, regional, and continental levels have been put in place to facilitate the implementation of CAADP according to declared principles of African ownership and leadership, accountability and transparency, inclusiveness, and evidence-based planning and decision making, among others (AU-NEPAD 2014). Several achievements in the policy-making process have been associated with the program. For example, Ochieng (2007) argued that CAADP is an improvement on the policies that governed African agriculture in the past; CAADP has a broader vision that includes generating dynamic agricultural markets within countries and between regions and integrating farmers into the market economy, with farmers being a strategic partner in agricultural science and technology development. Brüntrup (2011) argued that because CAADP is continuously adapting to experiences during implementation and to expectations of stakeholders, it has not suffered the fate of many other African and AU-NEPAD (African Union–New Partnership for Africa's Development) initiatives that have faded away. Therefore, it seems that CAADP has significantly raised the political profile of agriculture in the continent and has promoted greater participation of multiple state and nonstate actors in agricultural policy dialogue and strategy development. Other studies (such as Zimmermann et al. 2009; Kolavalli et al. 2010) also point in that direction.

However, after more than a decade since its launch, the demand for knowledge of CAADP's impact on agricultural and economic growth, as well as other development outcomes that it set out to achieve, has become unequivocal. This paper attempts to fill the knowledge gap by using panel data on 46 African countries[1] from 2001 to 2014 to estimate the impact of countries' implementation of CAADP on several targets and development indicators, including agricultural expenditure and productivity, income, and nutrition. A difference-in-difference treatment-effects model is used to estimate the impacts, based on two definitions of *treatment*—a dichotomous variable of whether a CAADP compact is signed and a five-level ordered variable of the level of CAADP implementation reached. Two main methods (the potential outcome approach and the fixed-effects regression method) and different model specifications involving nested subsets of explanatory variables are used to assess sensitivity of the results.

The results show that CAADP has had a positive impact on agricultural value-added and land and labor productivity. The impact on agriculture expenditure (measured as a share of total expenditure or agriculture value-added) is generally negative, suggesting that there is a substitution effect between a government's own funding and external sources of funding for the sector. The estimated impact on income and nutrition is generally insignificant. Further tests on the estimates from interactions between specific periods of compact signing with levels of implementation reached reveal some puzzling results regarding the impact on productivity and nutrition; most of these results call for further research on actual dollar amounts spent on different productivity-enhancing and nutrition-security interventions in the various CAADP countries. Implications for maintaining the positive impacts are also discussed.

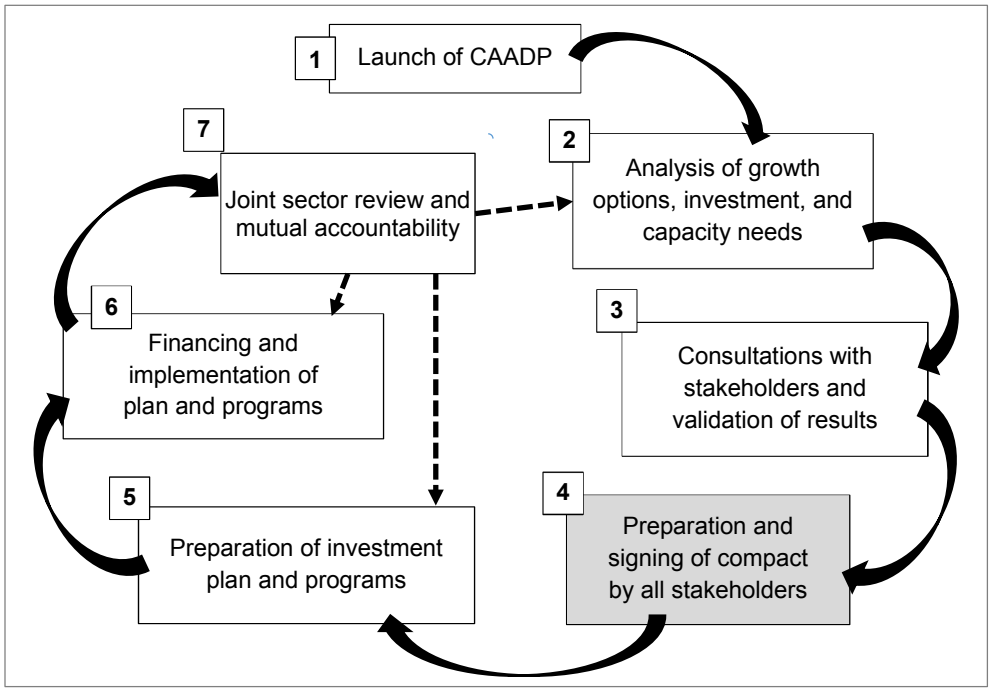
The next section of this paper presents a brief account of the CAADP implementation process and the conceptual framework used for measuring the treatment effects of CAADP. Section 3 presents the data and empirical methods used in the estimation. The results are presented and discussed in Section 4, followed by conclusions and implications in Section 5.

[1] These are the countries out of the total 54 that have adequate time-series data on the indicators of interest.

2. THE CAADP PROCESS AND CONCEPTUAL FRAMEWORK

When the African heads of state launched CAADP in 2003, they took on the Millennium Development Goal of reducing the 1992 levels of poverty and hunger by half by 2015, through the pursuit of 6 percent annual average growth in the agriculture sector, in addition to spending an annual average of 10 percent of total government expenditure in the sector. Various processes were put in place to facilitate implementation in a participatory, inclusive, evidence-based manner (AU-NEPAD 2010). At the country level, the idea of a dynamic roundtable process was adopted (Figure 2.1) with the signing of a CAADP compact representing a major milestone that demonstrates concrete progress of CAADP implementation on the ground.

Figure 2.1 CAADP country-level implementation process



Source: Author's illustration, based on AU-NEPAD (2010).
Notes: The solid arrows represent the progression from one stage to another. The broken arrows represent major feedback links among different stages for a dynamic process.

The initiation of the CAADP process in a country is marked by a launch event (stage 1 in Figure 2.1) where different stakeholders are sensitized about the objectives and principles of CAADP, as well as of the expectations of inclusive participation in implementation. This is followed by various analyses, including taking stock of policies and agricultural performance, growth and investment options, and capacities for implementation to help design appropriate plans and programs (stage 2). The results of the analyses are then discussed with the different stakeholders (stage 3) and are then used to develop the compact (stage 4) and, subsequently, the national agricultural investment plan (NAIP) and programs (stage 5). This is followed by funding and implementation (stage 6) and then by joint sector review and mutual accountability (stage 7). The dynamism and continuity of the process derives from the feedback of the results of joint sector reviews and mutual accountability into reevaluation of the growth and investment options; refinement of the NAIPs; and adjustment of policies, investments, and interventions. (See AU-NEPAD [2010] for details of the CAADP process.)

Several initiatives have emerged since CAADP's initial launch. For example, the Global Agriculture and Food Security Program (GAFSP 2016) and the New Alliance for Food Security and Nutrition (New Alliance 2016) emerged in 2009 and are expected to complement CAADP by providing additional financing opportunities for investment in the sector. Although these have specific funding-eligibility processes, they state CAADP compliance as an essential prerequisite for securing potential country support. These initiatives best fit stage 6 of the CAADP implementation process (Figure 2.1), even if they may not necessarily have been part of the initial thinking and development of CAADP; various countries can be expected to take them on differently in response to different national contexts, which are also shaped by political, cultural, social, and historical factors.

As Figure 2.1 shows, estimating the treatment effects of CAADP can be complex depending on how *treatment* is defined. For example, it can be defined by an initial treatment represented by the launch of CAADP in the country and then with each subsequent achievement of a milestone representing a booster or incremental treatment. Examples of this can be found in Papaioannou and Siourounis's (2008) study on the growth effects of democratization, which looked at regime transitions from autocracy to democracy, or in the epidemiological studies of survival analysis (see, for example, Robins, Hernan, and Brumback 2000). Adopting this definition of treatment for the CAADP analysis would require knowing when each country that is implementing CAADP achieved each milestone in Figure 2.1. Alternatively, achievement of a particular stage of implementation—say, preparation of an NAIP—could be used to represent a composite treatment, which would require knowing whether and when each country achieved that milestone only. This latter example is the typical definition of treatment that is used in many studies where participants in an experiment or intervention receive different components of the treatment at different times in a sequential manner.

To take full advantage of the limited data on each country's achievement of the different milestones and to generate greater confidence in the estimated treatment effects of CAADP, this paper uses both definitions of *treatment*. For each country that is implementing CAADP, there is complete information only on the dates of achieving stage 4 (preparing and signing a CAADP compact) onward. The CAADP compact represents a concrete achievement of CAADP implementation on the ground, because it encompasses a strategic agreement on joint and collaborative action on agriculture; includes both political and technical content; specifies key areas for investment commitment from the national government and development partners; and defines roles and responsibilities of all stakeholders (AU-NEPAD 2010). Therefore, the first definition of treatment is whether a CAADP compact is signed, represented by $d1_{it}$ = (0, 1), where 1 means country *i* has a compact at time *t* and 0 otherwise. The second definition builds on the first by including the postcompact levels or stages reached, represented by $d2_{it}$ = (0, 1, 2, …, M). If y_{is} represents the outcome measured for country *i* at time *s*, then the treatment-effects model can be written generally as

$$\Delta y_{is} = \alpha_s + \beta_s' \boldsymbol{x}_{is-\kappa}^{y} + \delta_s d_{it} + \varepsilon_{is}, \forall\, \kappa \leq s \geq t \tag{1}$$

$$d_{it} = \begin{cases} 1 & if\ \gamma_t' \boldsymbol{x}_{it-\tau}^{d} + \mu_{it} > 0,\ \forall\, \tau \leq t \\ 0 & otherwise \end{cases}, \tag{2}$$

where Δy_{is} is the annual change in the outcome; the covariates $\boldsymbol{x}_{is}^{y}$ and $\boldsymbol{x}_{is}^{d}$ distinguish the covariates in the outcome and treatment equations, respectively, but may have elements in common; κ and τ indicate the importance of pretreatment values of $\boldsymbol{x}$; ε and μ are unobservable error terms that are independent of each other and unrelated to $\boldsymbol{x}$; and α, β, δ, and γ are the parameters to be estimated.

Treatment Effects and Hypotheses

Equation 1 is a difference-in-difference model, and δ is the treatment effect or measure of the impact of CAADP, which can be interpreted as the percentage change in the outcome in countries that are implementing CAADP compared to the general change in the outcome in countries that are not implementing CAADP. For countries that are implementing CAADP, δ is differentiated and interpreted as the relative effect of implementing CAADP (or signing a compact) in different years or reaching different levels of implementation. By the time a country signs a CAADP compact, it would have undertaken rigorous analysis of growth options and investment requirements that could be used in designing effective policies and interventions in the agriculture sector (Figure 2.1). It also would have undergone several processes to ensure inclusive participation of different stakeholders in the design and implementation of those policies and interventions. Because it takes time to secure stakeholder buy-in of these processes and for the processes to be institutionalized, the earlier a country starts these processes, the sooner the processes can begin reforming evidence-based planning and implementation. Similarly, because the benefits of reforms take time to materialize, the earlier a country achieves the compact and postcompact activities, the sooner the effects may materialize. Furthermore, countries that reach higher levels of implementation (including access to external funding to implement their NAIP and related programs) have a greater chance of achieving their agricultural development objectives.

Thus, for any outcome measurement period *s*, the estimated treatment effect ($\hat{\delta}$) associated with $d1_{it}$ = (0, 1) is expected to be larger for treatment in earlier periods than in later periods, all other factors remaining unchanged. Specifically, it is expected that

$$\hat{\delta}_s^{d1=1|t=1} > \hat{\delta}_s^{d1=1|t=2} > \cdots > \hat{\delta}_s^{d1=1|t=T} > \hat{\delta}_s^{d1=0|t=T}. \quad (3)$$

Similarly, the treatment effect associated with $d2_{it}$ = (0, 1, 2, …, M) is expected to be larger for treatment at higher levels than at lower levels, all other factors remaining unchanged. Specifically, it is expected that

$$\hat{\delta}_s^{d2=M|t} > \hat{\delta}_s^{d2=M-1|t} > \cdots > \hat{\delta}_s^{d2=2|t} > \hat{\delta}_s^{d2=1|t} > \hat{\delta}_s^{d2=0|t}. \quad (4)$$

Equation 4 can be expanded to account for both the time of the start of implementation and the level reached. We expect that the treatment effect associated with starting implementation earlier and reaching a higher level of implementation would be larger than for starting later and reaching a lower level, all other factors remaining unchanged. When CAADP was launched Africa-wide in 2003, the expected year for achieving the two main targets of reaching 10 percent agricultural expenditure in total expenditure and 6 percent agricultural growth rate was 2008. After the heads of state renewed their commitment to CAADP at the 13th Ordinary Session of the Assembly of the African Union in Sirte, Libya, in 2009, the target year was extended to 2015. Therefore, it makes sense to examine the impact of CAADP on the various targets and outcomes over the two subperiods of 2003–2008 and 2008–2015, as well as over the entire 2003–2015 period, to assess whether there are differential effects. Because the data at hand end in 2014, it is only possible to assess the impact up to 2014. Basically, for treatment at any period *t* or for any treatment level *d*2 = *m* (where *m* = 1, 2, 3, 4), we can test the relevant null hypothesis

$$\hat{\delta}_{s=2003-08}^{d1=1|t} = \hat{\delta}_{s=2008-14}^{d1=1|t} \text{ or } \hat{\delta}_{s=2003-08}^{d2=m|t} = \hat{\delta}_{s=2008-14}^{d2=m|t}. \quad (5)$$

Because CAADP is continuously adapting to experiences during implementation and to expectations of stakeholders, including countries' adaption to fit their own national conditions and priorities, it may be possible for countries that started implementing CAADP at later periods to have more refined implementation strategies after taking into account the lessons from those that started implementing CAADP at earlier periods. By avoiding any of the pitfalls faced by the early-implementing countries, later-implementing countries could catch up in terms of the time between implementation and realization of outcomes. They could thus dampen the expected strict inequalities implied in equations 3 and 4.

Selection Bias, Unobserved Heterogeneity, and Covariates

The main issues to deal with in the estimation of treatment effects are selection bias, endogeneity of treatment, and unobserved heterogeneity. The literature on these are well developed (see, for example, Heckman 1978; Maddala 1983; Angrist and Pischke 2008; Imbens and Wooldridge 2009; Semykina and Wooldridge 2010). The issue of unobserved heterogeneity can be addressed within a panel data framework, where differencing removes the bias associated with time-invariant unobserved heterogeneity, and inclusion of country- and time-specific fixed effects addresses cross-country and time-variant unobserved heterogeneity, respectively. Unobserved heterogeneity may derive from several sources, including willingness, capacity, and effort of governments to design and implement good policies to achieve stated objectives (Rodrik 2012). In addition, governments and countries may already have been engaging in policy reforms in harmony with the CAADP principles prior to adopting CAADP, and much of the CAADP framework may have been derived from earlier strategies and successful agricultural reforms in several African countries. For example, CAADP's broad-based development strategy, including the need for poverty-focused growth, participatory processes in strategic planning, public–private partnerships, and other principles of inclusiveness, are similar to those of poverty reduction strategy papers pursued during the beginning of the new millennium.

Endogeneity of treatment (due either to simultaneity of outcome and treatment or omitted variables in the outcome equation) is addressed in a standard way by instrumental variables, which involves predicting treatment using variables that are correlated with treatment but orthogonal to the error term ε_{is}. Because the omitted variables problem could be due to unobserved heterogeneity, as discussed earlier, the panel data framework also addresses this aspect of endogeneity. Regarding section bias, which is due to nonrandom assignment of treatment, the underlying assumption for an unbiased estimation of the treatment effect is that all the factors that affect the treatment ($\boldsymbol{x}_{is}^{d}$) and outcomes ($\boldsymbol{x}_{is}^{y}$) are known, observed, and used as explanatory variables in the estimation. This assumption is commonly referred to as the conditional independence assumption.

Because it is genuinely difficult to find credible instruments that satisfy both the exogeneity and the exclusion requirements and because the conditional independence assumption is not testable, comprehensive specification of the model becomes critical, identifying which factors are and are not observable and how to deal with those that are unobservable. The literature helps identify these factors.

With respect to the treatment equation, the main factors deriving from the principles of CAADP and the literature are relevance of and cost to implement CAADP; political will, peer pressure, and capacity of governments to implement CAADP; and citizens' demands, inclusiveness, and capacity to implement CAADP. CAADP is one of the nearly 50 charters, treaties, protocols, and conventions enacted by the AU since the AU Constitutive Act of 1963 (SOTU 2015). Apart from the Constitutive Act itself and the act on human rights, both of which have been ratified by all AU member states, there are substantial differences in the number of countries that have ratified the others. Much of the literature on treaties or international agreements suggests that compliance by states is commonly a reflection of states' preferences, as governments generally comply with the treaties that they sign or they sign treaties that they intend to comply with (Downs, Rocke, and Barsoom 1996; Simmons and Hopkins 2005; von Stein 2005). Furthermore, because ratifying and implementing a treaty is costly, governments that are willing and able to bear the cost would be more likely to comply. This is also consistent with the argument that governments are more likely to sign treaties that do not require significant departure from what they would have done without the treaties. Because CAADP is directly related to agriculture, variables that capture the role or potential of the agriculture sector in the economy would be good indicators of a country's preference in CAADP. Likewise, the size of the government's total budget would be a good indicator of its ability to bear the cost.

The literature on treaty compliance also suggests that political will is critical for whether a country ratifies a treaty. Political will is arguably unobservable; hence, Simmons and Hopkins (2005), for example, suggested a number of observable measures of political will, including prior implementation of preconditions in the treaty and membership in related treaties. Following this argument, a good variable for capturing political will in implementing CAADP is ratification of other AU charters. Other unobservable factors, such as peer pressure or negotiation posture, have been argued as key factors that influence treaty compliance (see, for example, Przeworski and Vreeland 2000; Vreeland 2003). With respect to peer pressure in implementing CAADP, the share of neighboring countries that are implementing CAADP seems a good indicator to use, as it can be measured in terms of national borders or economic unions. Negotiation posture may be captured by the share of a country's economy in Africa's total economy. The ability, capacity, or effort of governments to implement CAADP is also unobservable. Looking at the process leading to the adoption of CAADP in 2003, the ministers of agriculture in the different countries played a significant role and were expected to champion CAADP implementation in their respective countries (AU-NEPAD 2003). Country case studies on CAADP implementation (see, for example, Zimmermann et al. 2009; Kolavalli et al. 2010) show that progress in implementation depended on how committed and engaged ministers of agriculture were, beyond just chairing meetings. In countries where implementation had not started or had stalled, it was commonly attributed to the minister's lack of interest in the process or to the minister's ignorance of CAADP, which is likely a problem caused by the turnover of minsters in the sector. Therefore, this paper uses the number of years each minister of agriculture is in the position to capture the government's capacity to implement CAADP. Regarding citizens' demands, inclusiveness, and capacity to implement CAADP, this paper uses different indicators of institutional, political, and democratic processes that have also been shown to work well as instruments for national policy decision making (Cox and McCubbins 1986; Lindbeck and Weibull 1993). These indicators may also capture some of the unobservable factors associated with governments' capacity to implement CAADP.

After the Africa-wide launch of CAADP in 2003, it was not until 2007 that a country—Rwanda—signed a CAADP compact. No other country signed a compact until after the heads of state renewed their commitment to CAADP at the 2009 AU Assembly in Libya. Afterward, 12 more countries signed their compacts in 2009, 9 in 2010, 6 in 2011, 1 in 2012, 7 in 2013, and 1 each in 2014 and 2015. In 2009, most African countries felt the impact of the 2007–2008 global financial crisig and the high food prices crisis. Therefore, a 2009 time-specific fixed effect is included in the model. To capture other unobservable factors and cross-country heterogeneity, indictors on time-variant population density and time-invariant geographic location, economic classification, and agroecology are included.

In terms of how the aforementioned factors may affect treatment or implementation of CAADP, it is expected that countries in which agriculture contributes largest to the economy or those that have high agricultural potential would have a greater likelihood of implementing CAADP, compared with those in which agriculture plays a smaller role or those that have lower agricultural potential. Similarly, it is expected that countries with larger total budgets or that have signed a greater number of other AU charters would be more likely to implement CAADP. The same applies to countries facing higher peer pressure or having greater capacity to implement CAADP. Because of the time variation in treatment, it is rational to expect a differential effect of factors over time. For example, peer pressure would likely have a greater effect on signing in later periods or after many other countries already signed, compared with earlier periods or when only a small number of countries have signed. The 2009 time-specific fixed effect should also have a positive effect on implementation. The effects of population density, geographic location, economic classification, and agroecology are indeterminate a priori.

Regarding the factors that affect the change in outcome (Δy_{is}), the pretreatment levels of the outcome (y_{is}) and the lagged values of the change ($\Delta y_{is-\kappa}$) are the main factors considered, in addition to some of those discussed earlier. Because this paper is concerned with estimating the total (direct and indirect) effect of implementing CAADP on the specified outcomes, which are manifested via multiple pathways (see CAADP Monitoring and Evaluation and Results Framework [Benin, Johnson, and Omilola 2010; AU-NEPAD 2015]), it is important to not control for any intermediate transformations, outcomes,

or processes that are expected to be influenced by CAADP. Using change in agricultural productivity as an example, in normal situations, it is expected that this would be influenced by a change in agricultural land, labor, capital, irrigation, seed, fertilizer, and so on, which, in turn, are expected to be influenced by CAADP. As such, these intermediate factors are excluded in the outcome equation. To capture other factors and cross-country heterogeneity that affect the outcomes but that are least likley or not likely to be influenced by CAADP, the change in population density, total expenditure per capita, rainfall, and some of the political and democratic indicators are included, in addition to the 2009 time-specific fixed effect.

3. DATA AND ESTIMATION METHODS

Data, Sources, and Variables

This paper uses panel data on 46 African countries from 2001 to 2014 to estimate the treatment effect of CAADP on several CAADP target and outcome indicators, representing agricultural spending and productivity, income, and nutrition, as shown in equations 1–5 in the conceptual framework. These data were compiled from several publicly available sources, including the Statistics on Public Expenditures for Economic Development (SPEED; IFPRI 2015a) and the Regional Strategic and Knowledge Support System (ReSAKSS; IFPRI 2015b) for data on spending; FAOSTAT (FAO 2015) for data on agricultural production; and the World Development Indicators (World Bank 2015a) for data on income and nutrition. The 46 countries represent those out of a total of 54 that have adequate time-series data on the indicators of interest.[2]

Treatment

Information on the status of implementing CAADP in each country was obtained from ReSAKSS (IFPRI 2015b). Regarding the first definition of treatment in the conceptual framework, $d1_{it}$ = (0, 1), a dummy variable is used, and the value of 0 is given from 2001 until the year a compact is signed; then a value of 1 is given for the remaining years. For the second definition of treatment, $d2_{it}$ = (0, 1, 2, …, M), we consider five successive levels or stages of treatment (or M = 4): 0 for those that have not started implementing CAADP or are at the precompact stage; 1 for those that have signed a compact only; 2 for those that have a compact and an NAIP but that have not secured any of three external sources of funding; 3 for those that have a compact and an NAIP and that have secured any one of the three external sources of funding; and 4 for those similar to level 3 but that have secured more than one of the three external sources of funding.[3] Similar to the first definition of treatment, a value of 0 is given from 2001 until the year the next level is achieved; a value of 1 is given until the next level is achieved; and then a value of 2 is given and so on.[4] Regarding the first definition of treatment, the data show that there were three waves of compact signing: between 2007 and 2009, 2010 and 2012, and 2013 and 2014. Because the compact preparation and signing process involves the Regional Economic Communities, African Union Commission, and NEPAD Agency in substantial ways, these waves of compact signing may reflect capacity and other organizational constraints at those higher institutional levels, resulting in some form of prioritization or rollout plan to support the countries, as is often done with such continent-wide initiatives. To account for these issues, the estimation considers inclusion-exclusion of a country-specific fixed effect, using a categorical variable (c) that takes the value 1 for countries that signed a compact in 2007–2009, 2 for 2010–2012, and 3 for 2013–2014.[5]

[2] The eight excluded countries are Comoros, Equatorial Guinea, Gabon, Libya, Sao Tome and Principe, Seychelles, Somalia, and South Sudan.

[3] The three external funding sources considered here are Grow Africa, New Alliance Cooperation, and the Global Agriculture and Food Security Program (GAFSP). To date, 11 countries—Benin, Burkina Faso, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, and Senegal—have joined Grow Africa (Grow Africa 2016); 10 countries—Benin, Burkina Faso, Côte d'Ivoire, Ethiopia, Ghana, Malawi, Mozambique, Nigeria, Senegal, and Tanzania—have joined the New Alliance (New Alliance 2016); and 17 countries—Benin, Burkina Faso, Burundi, Ethiopia, Gambia, Kenya, Liberia, Malawi, Mali, Niger, Rwanda, Senegal, Sierra Leone, Tanzania, Togo, Uganda, and Zambia—have received GAFSP funds (GAFSP 2016).

[4] For estimation purposes, this is similar to creating four simultaneous dummy variables for levels 1 to 4 and using the 0,1 value assignment as was done for the first definition of treatment.

[5] For estimation purposes, this is similar to creating three simultaneous dummy variables for the three signatory periods and then using the 0,1 value assignment for those that did not sign or that signed in the respective periods.

Table 3.1 shows the distribution of countries according to the subperiods of compact signing and the level of CAADP implementation reached by the end of 2014. The distribution by compact signing shows that 13 of the 46 countries signed in 2007–2009, 16 in 2010–2012, and 8 in 2013–2014. Nine countries had not signed a compact by the end of 2014. Countries in the West Africa subregion seem to have created the momentum for signing the compacts, as 10 of the total 15 in the subregion signed their compacts in 2007–2009. The remaining 5 signed in 2010–2012, which is also when the majority (16) of the countries signed their compacts. Although 2010–2012 marks the immediate period following the renewal of the CAADP agenda by the heads of state at the July 2009 AU summit, it also immediately followed the implementation of the Grow Africa, New Alliance Cooperation, and GAFSP. Countries' expectations of accessing these facilities to help implement their NAIPs may have boosted the large number of compacts signed during that period, as preparation of compacts and NAIPs were some of the major eligibility criteria for African countries to access the funds. In fact, CAADP-like processes were part of the eligibility criteria for non-African countries to access the GAFSP funds (GAFSP 2016). Regarding the level of implementation reached, the number of countries are fairly equally distributed across the five levels—9 at levels 0 and 3 each, 8 at levels 1 and 2 each, and the remaining 12 at level 4.

Table 3.1 Distribution of the 46 countries by year of signing the CAADP compact and level of CAADP implementation reached by end of 2014

Signed CAADP compact in:				Level or stage of CAADP implementation reached by end of 2014				
2007–2009 (*c* = 1)	**2010–2012 (*c* = 2)**	**2013–2014 (*c* = 3)**	**Not signed (*c* = 0)**	**Level 0: not started or precompact (*d*2 = 0)**	**Level 1: signed compact (*d*2 = 1)**	**Level 2: level 1 plus NAIP (*d*2 = 2)**	**Level 3: level 2 plus one external funding source (*d*2 = 3)**	**Level 4: level 3 plus other external funding source (*d*2 = 4)**
Benin	Burkina Faso	Angola	Algeria	Algeria	Angola	Cameroon	Burundi	Benin
Burundi	Central Afr. Rep.	Cameroon	Botswana	Botswana	Chad	Cape Verde	Gambia	Burkina Faso
Cape Verde	Congo, Dem. Rep.	Chad	Egypt	Egypt	Congo, Rep.	Central Afr. Rep.	Liberia	Côte d'Ivoire
Ethiopia	Côte d'Ivoire	Congo, Rep.	Eritrea	Eritrea	Lesotho	Congo, Dem. Rep.	Mali	Ethiopia
Gambia	Djibouti	Lesotho	Mauritius	Mauritius	Madagascar	Djibouti	Niger	Ghana
Ghana	Guinea	Madagascar	Morocco	Morocco	Sudan	Guinea	Sierra Leone	Kenya
Liberia	Guinea Bissau	Sudan	Namibia	Namibia	Swaziland	Guinea Bissau	Togo	Malawi
Mali	Kenya	Zimbabwe	South Africa	South Africa	Zimbabwe	Mauritania	Uganda	Mozambique
Niger	Malawi		Tunisia	Tunisia			Zambia	Nigeria
Nigeria	Mauritania							Rwanda
Rwanda	Mozambique							Senegal
Sierra Leone	Senegal							Tanzania
Togo	Swaziland							
	Tanzania							
	Uganda							
	Zambia							

Source: Authors' illustration, based on IFPRI (2015b).

Notes: NAIP = national agricultural investment plan. Three external funding sources are considered—Grow Africa, New Alliance Cooperation, and the Global Agriculture and Food Security Program.

Target and Outcome Variables

Regarding the CAADP targets and outcomes, agricultural spending is measured in two ways—share of government agriculture expenditure in total government expenditure (AgExpsh) and share of government agriculture expenditure in agricultural value added (AgExpint). The first measure is associated with the CAADP 10 percent agricultural expenditure target, whereas the second measure, commonly referred to as agricultural spending intensity, better reflects commitments to sector relative to its role. For agricultural production and productivity, the indicators are agricultural value-added (Agva), agricultural value-added per hectare (Agvaland), and agricultural value-added per worker (Agvalabor). Income is measured by gross domestic product per capita (GDPpc), and nutrition is measured by the proportion of population that is undernourished (Nourish).[6] The detailed description of these indicators are presented in Table 3.2.

Table 3.2 Description of outcome and explanatory variables and their main measures

Conceptual variable Empirical measure	Designation
Outcome variables[1]	
Agricultural spending	
Government agriculture expenditure (percent of total government expenditure)	AgExpsh
Government agriculture expenditure (percent of agricultural value-added)	AgExpint
Agricultural performance	
Agriculture value-added (constant 2006 US$)	Agva
Agriculture value-added per hectare of agricultural land (constant 2006 US$)	Agvaland
Agriculture value-added per agricultural worker (constant 2006 US$)	Agvalabor
Income and nutrition	
Gross domestic product (GDP) per capita (constant 2006 US$)	GDPpc
Prevalence of undernourishment (percent of population)	Nourish
Explanatory variables[2]	
Relevance of CAADP/Role of agriculture/Cost to implement CAADP	
Agriculture value-added (percent of GDP)	AgGDPsh
Agricultural land (percent of total land area)	AgAreash
Agriculture value-added (percent of Africa's total agriculture value-added)	AfAgGDPsh
Political will	
Number of AU charters, treaties, protocols, or conventions ratified	AUcharters
Peer pressure	
Share of bordering countries at the next stage of implementation	PressureC
Share of countries in geographic region at the next stage of implementation	PressureR
Negotiation posture	
GDP (percent of Africa's total GDP)	AfGDPsh
Total government expenditure per capita (constant 2006 US$)	TotExppc
Government capacity	
Cumulative number of consecutive years agricultural minister is in position	Capacity

[6] Other outcome indicators on poverty and child nutrition were considered. However, the indicators on these outcomes were irregularly measured over time or for fewer countries; therefore, they were not amenable to the time-varying treatment and time-varying outcome setup discussed in the conceptual framework.

Table 3.2 Continued

Conceptual variable Empirical measure	Designation
Explanatory variables[2] continued	
Citizens' demand and capacity	
Voice and accountability (index ranging from –2.5 to 2.5)	Voice
Autocracy-democracy (index ranging from –10 to 10)	Polity
Cross-country heterogeneity and country-specific fixed effects	
Population density (number of persons per square kilometer)	PopDensity
Geographic region (1 = central, 2 = eastern, 3 = northern, 4 = southern, or 5 = western)	Region
Economic classification (1 = LI1, 2 = LI2, 3 = LI3, 4 = M1)	Economic
Agroecology main (share of total area in humid zone)	Agromain
Agroecology variability (sum of the squared shares of zone area in total area)	Agrovar
Rainfall (total rainfall in millimeters)	Rainfall
Compact signing waves (1 = 2007–2009, 2 = 2010–2012, 3 = 2013–2014)	CompactWave
Time-specific fixed effect	
CAADP renewal/global crisis (0 = 2001, 2002, …, 2008; 1 = 2009, 2010, …, 2014)	Crisis2009

Source: Authors' representation, based on World Bank (2015a, 2015b), SOTU (2015), SCP (2015), IFPRI (2015a, 2015b), FAO (2015), HarvestChoice (2015), and CIA (2016).

Notes: [1] Initial values of the outcome variables and change in the values of the outcome variables are included as explanatory variables in the respective outcome equations. [2] Dummy variable measures of the continuous variables were tried when the median values were used as the cutoff points to demarcate high or low value status. LI1 = low-income countries with less favorable agricultural conditions, LI2 = low-income countries with more favorable agricultural conditions, LI3 = low-income countries with mineral-rich economies, and MI = middle-income countries.

Explanatory Variables

The data on the variables $\boldsymbol{x}$ that are conceptualized to affect the treatment and outcomes were also obtained from various sources. For the treatment equation, the conceptual factors are relevance of and cost to implement CAADP; political will, peer pressure, negotiation posture, and capacity of governments to implement CAADP; citizens' demands, inclusiveness, and capacity to implement CAADP; and cross-country heterogeneity factors captured by population density and characteristics of geographic location, economic classification, and agroecology. For several factors, we use different measures and try to determine which ones work best. For the relevance of and cost to implement CAADP, for example, we try three continuous measures—share of agricultural value-added in GDP, share of agricultural area in total land area, and share of the country's agricultural GDP in Africa's total agricultural GDP—and their dummy variable counterparts, where the median values were used as the cutoff points to define low and high shares. The main reason for trying different measures of a conceptual factor is that the factors are not observable. By trying different measures, we are able to assess the sensitivity of the results to different variable measures and thus generate greater confidence in the results to the extent that the results are robust to the different measures. For political will, we use the number of AU charters, treaties, protocols, or conventions ratified by each country prior to 2003, when CAADP was launched. The data are from SOTU (2015). We try two variations of the measure—the actual number ratified and then a dummy variable equal to 1 for those that have signed more than the median number of 17 and 0 otherwise. For measures of peer pressure, we use the share of neighboring countries that have achieved the next stage of CAADP implementation, relative to the stage of implementation in the reference country. We consider two types of neighbors—bordering countries and countries in the same geographic zone (central, eastern, northern, southern, or western Africa). For measures of negotiation posture, we try two main measures—total expenditure per capita and share of the country's gross domestic product (GDP) in Africa's total GDP. Capacity of government to implement CAADP is measured by the cumulative number of consecutive years each minister of agriculture is in position, with primary data on ministers obtained from

CIA (2016). For citizens' demands, inclusiveness, and capacity to implement CAADP, we try two measures—voice and accountability index (range of –2.5 to 2.5), obtained from the Worldwide Governance Indicators project (World Bank 2015b); we also use an autocracy-democracy index (range of –10 to 10), obtained from the Polity IV project (SCP 2015). Measures of geographic location, economic classification, and agroecology are categorical or dummy variables. For geographic location, the value is 1 if located in central Africa, 2 for eastern, 3 for northern, 4 for southern, and 5 for western. Economic classification is constructed based on three factors: agricultural potential, alternative (or nonagricultural) sources of growth, and income level (Benin et al. 2010). The categories reflect the notion that different countries, depending on their resource endowments and stage of development, are on different trajectories toward achieving their development objectives (Diao et al. 2007). The four categories of countries are low-income countries with less favorable agricultural conditions, low-income countries with more favorable agricultural conditions, low-income countries with mineral-rich economies, and middle-income countries. Based on eight-zone agroecology data obtained from HarvestChoice (2015), we use two measures—share of area located in the humid zone and an index of the variability of different zones in the country. The variability index is a fraction up to a maximum of 1, with 1 meaning no agroecology variation or a country that falls in one zone only. Table 3.2 provides a detailed description of all the above variables.

Regarding the explanatory variables for the outcome equations, they are the pretreatment levels of the outcome (y_{is}), lagged values of the change in the outcomes ($\Delta y_{is-\kappa}$), change in population density, change in total expenditure per capita, change in amount of rainfall, and change in the voice and accountability and autocracy-democracy indexes. For the lagged values of the change in the outcomes, we consider up to three lags. Detailed descriptions of these variables are also presented in Table 3.2. Variables in monetary values are measured in constant 2006 US dollars to remove the influence of inflation and to facilitate economic comparison across countries.

Estimation Methods and Issues

We use two general approaches to estimate and analyze the treatment effect of CAADP—potential outcome approach (Wooldridge 2007, 2010), accounting for time-varying treatment (Brand and Xie 2007) and an endogenous-treatment regression model (Heckman 1978; Maddala 1983) within a fixed-effect estimation framework (Greene 1993).

The potential outcome approach is applied to the first definition of treatment where the treatment periods are modified to reflect the compact signing waves such that $t = (1, 2, 3)$: 1 = 2007–2009, 2 = 2010–2012, and 3 = 2013–2014. In this case, equation 1 is estimated by a regression adjustment method to predict the potential outcome means, and equation 5 is estimated by an inverse probability weighting (IPW) method, which uses weighted means to disentangle the effects of treatment and covariates, where the weights are the inverse of the probability of being treated (Wooldridge 2007, 2010). Similar to the concept of overlap in the case of estimation of treatment effects by matching methods (Dehejia and Wahba 2002; Angrist and Pischke 2008; Imbens and Wooldridge 2009) is the issue of stability of the IPWs, which is checked using the balance test derived by Imai and Ratkovic (2014). The test is implemented as a chi-square test of the null hypothesis that the covariates are balanced. Thus, a statistically significant chi-square value implies that the treatment model failed to balance the covariates. Different model specifications involving different combinations of the measures of $\boldsymbol{x}$ are used to assess the sensitivity of the results to the use of different covariate patterns. The average treatment effect on the treated (ATT) is estimated, which requires a weaker conditional independence assumption only.[7] This potential outcome approach involves estimation of equations 1 and 2 for one treatment period and one measurement period at a time only. Furthermore, ATT_s^t is estimated for all $s \geq t$, as it is meaningless to estimate the effect of treatment at $t = 2$ on an outcome measured at $s = 1$. Because treatment at an

[7] Multivalued treatment under the potential outcome approach (Cattaneo 2010) was tried for the second definition of treatment ($d2 = 0, 1, 2, 3, 4$), but it turned out to be unsuccessful because of covariate balance problems due to the small number of observations (46 countries) relative to the five levels of treatment.

earlier period necessarily removes the option of treatment at a later period, the sample size over which the treatment is considered at later periods is reduced by the number of those that were treated at earlier periods. The approach explicitly considers the potential outcomes for the different paths that countries not treated at an earlier period (say, $t = 1$) could have taken; this is because countries that were not treated at time $t = 1$ could have been treated or not at time $t = 2$, and those not treated at $t = 2$ could have been treated or not at $t = 3$. Following Brand and Xie (2007), we use a country's probability of treatment conditional on $\boldsymbol{x}$ as a weight to estimate the ATT for treatment in period t on outcome measured in period s as follows:

$$ATT_s^{d=t} = E[y_s^{d=t}] - \sum_{v=t+1}^{s}\{\prod_{k=t+1}^{s} q(k)\, p(v) \cdot E[y_s^{d=v}]\} - \{\prod_{k=t+1}^{s} q(k) \cdot E[y_s^{d>s}]\}, \qquad (6)$$

where $\mathrm{p}(t)$ and $\mathrm{q}(t)$ represent the probability of being treated and not being treated at time t, respectively, and $\mathrm{p}(t) + \mathrm{q}(t) = 1$; and where $E[y_s^{d=t}]$ and $E[y_s^{d>s}]$ are the observed and potential outcomes, respectively. Essentially, the two terms in the brackets $\{\cdot\}$ represent the composite potential outcome for those treated in period t, which is the weighted sum of the potential outcome of those treated in period 1 had they been treated or not in later periods; the weights are the probabilities of treatment in the different periods. Because this involves estimation for one treatment period at a time only, with estimation at later periods being reduced by the number of those treated at earlier periods, the maximum sample size and number of observation is 46 countries, which places limits on the number of covariates that can be included in the estimation of equations 1 and 2 to avoid degrees of freedom problems. Therefore, we include only a few variables at a time, still trying different model specifications to assess sensitivity of the results to different covariate combinations.

With the second approach—that is, the endogenous-treatment regression model within a fixed-effect estimation framework—equation 2 is first estimated by a probit model to generate the inverse mills ratio (IMR; Heckman 1978), which is then included with the treatment variable in a second-stage, fixed-effect estimation of equation 1. The direction and statistical significance of the selection bias can be obtained from the sign and test of the ratio of the estimated parameter on the IMR and the overall standard error of the estimated model, respectively (Maddala 1983). For example, a negative relationship would indicate that unobservables that raise outcomes tend to occur with unobservables that lower CAADP implementation. As the IMR is estimated, robust standard errors are obtained in the second-stage estimation of the treatment effects. This approach allows the treatment effect to be estimated for the two definitions of treatment simultaneously, and estimation within the fixed-effects framework allows full use of the panel data format with time-varying treatment and outcomes.

To obtain a reference point with which to compare the results of the above two approaches, we present results associated with fixed-effect estimation of equation 1 only—that is, under assumption of exogenous treatment. As with the treatment equation, the outcome equation is estimated using different but nested model specifications, starting with the treatment variable only and then adding subsets of the explanatory variables. All the estimations were carried out with STATA software version 14.1 (StataCorp 2016).

4. RESULTS AND DISCUSSION

Descriptive Statistics at Baseline, 2001–2003

Before looking at the results of the treatment effects, let us look first at the state of the countries with respect to the different outcome and explanatory variables prior to the launch of CAADP at the continental level. We use the average value over 2001 to 2003 to represent this baseline. The results are presented in Tables 4.1 and 4.2 for the two definitions of treatment.

Table 4.1 Mean values of variables at the baseline (2001–2003), by period of treatment group

	Signed compact in				
Variable	**2007–2009 (*c* = 1)**	**2010–2012 (*c* = 2)**	**2013–2014 (*c* = 3)**	**Not signed (*c* = 0)**	**Significant difference**
Outcome variable					
AgExpsh	4.06	4.67	4.50	4.19	
AgExpint	2.69	3.94	2.54	11.74	10, 20, 30, 23
Agva	21,424.12	2,974.11	5,531.00	8,663.39	10, 20, 12, 13, 123
Agvaland	350.24	140.64	104.65	1,278.58	12, 13, 123
Agvalabor	1,816.52	552.58	996.06	2,942.72	20, 30, 12, 123
GDPpc	498.89	513.58	706.01	2,495.91	10, 20, 30, 13
Nourish	15.64	29.70	36.62	6.42	20, 30, 12, 13, 123
Explanatory variable					
Relevance of CAADP/Role of agriculture					
AgGDPsh	39.58	27.66	29.62	11.18	10, 20, 30, 12, 13, 123
AgAreash	66.99	44.62	47.01	38.61	12, 13, 123
AfAgGDPsh	16.70	2.32	4.10	6.75	10, 20, 12, 13, 123
Political will					
AUcharters	21.73	18.10	16.79	15.47	10, 12, 13, 123
Peer pressure					
PressureC	0.00	0.00	0.00	0.00	
PressureR	0.00	0.00	0.00	0.00	
Negotiation posture					
AfGDPsh	6.70	1.38	2.11	12.29	20, 30, 12, 13, 123
TotExppc	116.82	102.34	158.94	677.61	10, 20, 30
Government capacity					
Capacity	1.41	1.57	1.51	1.98	10, 20, 30
Citizens' demand and capacity					
Voice	-0.63	-0.77	-1.31	-0.61	30, 13, 23, 123
Polity	3.73	1.44	-3.99	-2.06	10, 12, 13, 23, 123
Cross-country heterogeneity and country-specific fixed effects					
PopDensity	123.71	49.94	18.54	53.35	10, 30, 12, 13, 23, 123
Region (cf.: 1 = central)					
2 = eastern	0.10	0.40	0.56	0.01	20, 30
3 = northern	0.00	0.02	0.00	0.78	10, 20, 30
4 = southern	0.00	0.13	0.17	0.20	12
5 = western	0.88	0.31	0.00	0.00	10, 20, 12, 13, 23, 123

Table 4.1 Continued

Variable	Signed compact in 2007–2009 (*c* = 1)	2010–2012 (*c* = 2)	2013–2014 (*c* = 3)	Not signed (*c* = 0)	Significant difference
Cross-country heterogeneity and country-specific fixed effects (continued)					
Economic (cf.: 1 = LI1)					
2 = LI2	0.13	0.55	0.13	0.00	20, 12, 23, 123
3 = LI3	0.09	0.02	0.08	0.00	
4 = MI	0.75	0.23	0.79	1.00	20, 12, 23, 123
Agromain	0.57	0.66	0.28	0.06	10, 20, 23
Agrovar	0.76	0.78	0.83	0.53	10, 20, 30
Rainfall	1,084.50	1,059.40	703.44	202.59	10, 20

Source: Authors' calculation, based on World Bank (2015a, 2015b), SOTU (2015), SCP (2015), IFPRI (2015a, 2015b), FAO (2015), HarvestChoice (2015), and CIA (2016).

Notes: LI1 = low-income countries with less favorable agricultural conditions, LI2 = low-income countries with more favorable agricultural conditions, LI3 = low-income countries with mineral-rich economies, and MI=middle-income countries. Significant difference, 10, 20, 30, 12, 13, 23 = statistically significant difference of 10 percent or less between the treatment pairs (for example, 10 refers to those treated at $c = 1$ and those never treated or $c = 0$, and 23 refers to those treated at $c = 2$ and those treated at $c = 3$) and 123 = statistically significant difference of 10 percent or less across the three treatment groups.

Outcomes at the Baseline

There are some substantial and statistically significant differences in the mean values of the outcome indicators at the baseline across the different groups of countries by the period of treatment (Table 4.1) or the achieved implementation level (Table 4.2). Only the share of agriculture expenditure in total expenditure (AgExpsh) is not statistically different across the different groups, except between the level 2 and 3 groups of countries. The share ranges from 4.0 percent to 4.8 percent for the various groups; however, it is lower for the level 2 group (3.3 percent) and higher for the level 3 group (7.1 percent). Agriculture spending intensity is much higher (11.7 percent) for countries that have not started implementing CAADP or are at the precompact level of implementation, compared to the range of 2.5 percent to 4 percent for those implementing CAADP; those signing a compact in 2010–2012 or at level 3 of implementation recorded the highest shares among their respective comparative groups. With the baseline values of AgExpsh at 3.3–4.8 percent for the different groups of countries that are implementing CAADP, achieving the CAADP 10 percent agriculture expenditure target means at least doubling the actual amount spent on the sector, assuming total expenditure remains unchanged. In other words, agriculture expenditure must increase at least twice as fast as the increase in total expenditures in order to meet the target. This seems very ambitious, as African leaders also signed on to various charters that demanded similar or larger public expenditures—for example, the 2001 Abuja Declaration calls for spending 15 percent of the national budget on the health sector, and the 2007 Year of Science and Technology calls for spending 1 percent of GDP on science and technology. Those and other commitments make it difficult to see how the leaders can make significant shifts in expenditures across different sectors to achieve the 10 percent agriculture expenditure target.

Table 4.2 Mean values of variables at the baseline (2001–2003), by level of treatment

Variable	Treatment level					Significant difference
	Level 0 (*d*2 = 0)	Level 1 (*d*2 = 1)	Level 2 (*d*2 = 2)	Level 3 (*d*2 = 3)	Level 4 (*d*2 = 4)	
Outcome variable						
AgExpsh	4.19	4.81	3.32	7.06	3.96	23
AgExpint	11.74	2.68	2.48	4.88	2.94	10, 20, 30, 40, 13, 23, 34
Agva	8,663.39	6,001.72	2,316.90	1,225.74	17,715.71	20, 30, 13, 23, 24, 34, 1234
Agvaland	1,278.58	54.61	195.59	114.54	310.23	12, 13, 14, 34, 1234
Agvalabor	2,942.72	1,029.85	584.38	430.46	1,564.92	10, 20, 30, 40, 13, 24, 34, 1234
GDPpc	2,495.91	685.96	533.78	348.18	537.36	10, 20, 30, 40, 13, 34, 1234
Nourish	6.42	39.80	28.08	27.10	19.35	10, 20, 30, 40, 12, 13, 14, 1234
Explanatory variable						
Relevance of CAADP/Role of agriculture						
AgGDPsh	11.18	31.24	27.37	34.51	35.69	10, 20, 30, 40, 24
AgAreash	38.61	53.01	20.76	45.14	63.92	12, 23, 24, 34, 1234
AfAgGDPsh	6.75	4.40	1.81	0.96	13.81	20, 30, 13, 23, 24, 34, 1234
Political will						
AUcharters	15.47	16.30	14.62	21.01	21.07	13, 14, 23, 24, 1234
Peer pressure						
PressureC	0.00	0.00	0.00	0.00	0.00	
PressureR	0.00	0.00	0.00	0.00	0.00	
Negotiation posture						
AfGDPsh	12.29	2.13	1.22	0.55	5.70	10, 20, 30, 13, 23, 24, 34, 1234
TotExppc	677.61	166.33	97.84	78.29	118.62	10, 20, 30, 40, 34, 1234
Government capacity						
Capacity	1.98	1.49	1.35	1.76	1.45	10, 20, 30, 40, 13, 23, 34, 1234
Citizens' demand and capacity						
Voice	-0.61	-1.34	-1.29	-0.58	-0.63	10, 20, 13, 14, 23, 24, 1234
Polity	-2.06	-4.05	-1.47	1.93	3.31	40, 13, 14, 24, 1234
Cross-country heterogeneity and country-specific fixed effects						
PopDensity	53.35	15.65	26.95	67.21	107.41	10, 20, 40, 12, 13, 14, 24, 1234
Region (cf.: 1 = central)						
2 = eastern	0.01	0.67	0.00	0.23	0.23	10, 12, 1234
3 = northern	0.78	0.00	0.07	0.00	0.00	10, 20, 30, 40
4 = southern	0.20	0.22	0.00	0.13	0.04	
5 = western	0.00	0.00	0.11	0.59	0.73	30, 40, 13, 14, 23, 24, 1234
Economic (cf.: 1 = LI1)						
2 = LI2	0.00	0.16	0.03	0.33	0.30	30
3 = LI3	0.00	0.09	0.07	0.40	0.01	30, 34
4 = MI	1.00	0.75	0.39	0.00	0.69	20, 30, 13, 1234
Agromain	0.06	0.16	0.85	0.55	0.59	20, 30, 40, 12, 13, 14, 24, 1234
Agrovar	0.53	0.81	0.90	0.85	0.74	10, 20, 30, 40, 24, 1234
Rainfall	202.59	507.15	1,453.58	1,012.21	1,063.05	20, 30, 40, 12, 14, 24, 1234

Source: Authors' calculation, based on World Bank (2015a, 2015b), SOTU (2015), SCP (2015), IFPRI (2015a, 2015b), FAO (2015), HarvestChoice (2015), and CIA (2016).

Notes: LI1 = low-income countries with less favorable agricultural conditions, LI2 = low-income countries with more favorable agricultural conditions, LI3 = low-income countries with mineral-rich economies, and MI = middle-income countries. Significant difference, 10, 20, 30, 40, 12, 13, 13, 14, 23, 24, 34 = statistically significant difference of 10 percent or less between the signatory pairs (for example, 10 refers to level 1 and 0, and 23 refers to levels 2 and 3) and 1234 = statistically significant difference of 10 percent or less across the four groups.

Agricultural value-added was significantly much higher for those that signed their compact in 2007–2009 (US$21.4 billion per country) or at level 4 of implementation (US$17.7 billion per country), compared to the other groups of countries, with those not implementing CAADP or at the precompact level of implementation recording the next highest, at US$8.7 billion per country. Agricultural land and labor productivity and GDP per capita were much higher for the group of countries that were not implementing CAADP at all or that were at the precompact level of implementation, compared to the different groups of treated countries. Regarding GDP per capita, the baseline value was US$2,496 for the untreated group, compared to less than US$1,000 for the different treated groups. For those treated by year of treatment, the baseline values are US$499 for those treated in 2010–2012, US$514 for those treated in 2007–2009, and US$706 for those treated in 2013–2014. For those treated by level of implementation achieved, the baseline values are US$348 for those at level 3, US$534 for those at level 2, US$537 for those at level 4, and US$686 for those at level 1. Looking at the differences in land and labor productivity across the treated groups, the mean values were highest for those that signed their compact in 2007–2009 or at level 4 of implementation. The pattern of relative performance in the baseline values of the nutrition indicator is similar to the pattern for GDP per capita, with the untreated group outperforming the others at only 6.4 percent of the population being undernourished, compared to 15.6 percent for those that signed a compact in 2007–2009, 29.7 percent for those that signed in 2010–2012, and 36.6 percent for those that signed in 2013–2014. In general, we can see that the pattern of relative performance in the baseline values of the seven outcome indicators is not the same across the different groups by either definition of treatment. These differences suggest that countries are at different development stages; therefore, controlling for the differences in the pretreatment values of the outcomes will be critical for an unbiased estimation of the treatment effects of CAADP.

Explanatory Variables at the Baseline

Looking now at the mean values of the explanatory variables at the baseline, we see a specific pattern in several of the variables across the different treated and untreated groups. For example, the group of countries that signed a compact in 2007–2009 or at level 4 of implementation has the largest shares of agriculture in the economy (36–40 percent and 64–67 percent for the two indicators, compared to 11–34 percent and 20–53 percent, respectively, for the other groups), signed the most number of AU charters (21–22 percent, compared to 15–21 percent for the others), largest shares of Africa's GDP (5.7–6.7 percent, compared to 0.6–2.1 percent for the other treated groups), largest shares of Africa's agricultural GDP (13.8–16.7 percent, compared to 0.9–6.7 percent for the other groups), and highest population density (107.4–123.7 persons per square kilometer, compared to 15.6–53.3 for the other groups). All the countries in the untreated group are of middle-income status (that is, they have GDP per capita values of at least US$1,000). This group had the highest mean values for total expenditure per capita, share of Africa's GDP, and government capacity. It also had the least share of area in the humid zone, agroecological variability, and amount of rainfall. The later, for example, was about 203 mm per year, compared to 507–1,454 mm per year for the treated groups. Looking at the other variables, voice and accountability were better (or least negative) in the untreated group of countries. The negative values of the index across all the groups indicate less-than-average performance everywhere. Regarding the autocracy-democracy index, those that signed a compact in 2007–2009 or 2010–2012, as well as those at levels 3 or 4 of implementation, were more democratic compared to other groups that tended to be more autocratic. In terms of the regional location by year of treatment, for example, the groups that signed a compact in 2007–2009 were concentrated in the western region, whereas those that signed in later periods were concentrated in the eastern region. For economic classification, those that had signed a compact were all of middle-income status. The other groups were also mostly of middle-income status or LI2 status. From the above results, it is clear that controlling for the differences in the explanatory variables will be critical for an unbiased estimation of the treatment effects of CAADP.

Treatment Effects Assuming Exogenous Treatment—Naive Impacts of CAADP

Tables 4.3 and 4.4 present results of the treatment effect for the two definitions of treatment on the various outcome indicators, assuming treatment is exogenous. These results derive from fixed-effects estimation of equation 1 only. For the definition of treatment based on signing a CAADP compact, the estimated treatment effects are not statistically significant, except in the case of agricultural value-added (Agva), which is weakly positive (Table 4.3). The estimated treatment effects for the definition of treatment based on the level of CAADP implementation achieved is mixed (Table 4.4). Compared to countries that are at the precompact stage (that is, level 0 achievement), level 4 achievement is associated with a significantly smaller growth rate in the share and intensity of government agriculture expenditure but a significantly larger growth rate in agriculture value-added, land and labor productivity, and GDP per capita. The significantly smaller growth rate in the share and intensity of government agriculture expenditure suggests substitution of government and external sources of financing for the sector, as the level 4 achievement countries have two or more of the external sources of financing considered. Looking at the results for the levels of achievement, whereas level 1 achievement is associated with a significantly larger growth rate in agriculture value-added and land productivity, level 2 achievement is associated with a significantly lower growth rate in land and labor productivity, and level 3 achievement is associated with a significantly lower growth rate in the prevalence of adult malnourishment.

The other explanatory variables also have significant effects on the growth rates in the outcomes, though their effects vary across the different outcomes. In particular, the negative and significant effect of the lagged value of the outcome (y_{t-1}) suggests that the growth rate in the outcomes is larger for countries with lower levels of the outcomes. The lagged values of the growth rate in the outcomes (Δy_{t-i}) are more important in the estimation with respect to agriculture value-added and prevalence of adult malnourishment. The positive and significant effect of the dummy variable representing the renewal of CAADP at the Africa-wide level and of the high food price crisis in 2009 (represented by Crisis2009) suggests that the growth rate in agriculture value-added and land and labor productivity are larger after 2009 (Tables 4.3 and 4.4).

Table 4.3 Fixed-effect estimation of CAADP impact, assuming exogenous treatment of signing a CAADP compact, 2001–2014

Variable	ΔAgExpsh		ΔAgExpint		ΔAgva		ΔAgvaland		ΔAgvalabor		ΔGDPpc		ΔNourish	
CAADP compact	-3.10		-0.89		4.70	*	-2.66		-5.47		0.73		1.29	
y_{t-1}	-5.11	***	-3.53	***	-39.59	***	-45.58	***	-49.38	***	-13.06	***	0.02	
Δy_{t-i}														
i = 1	-0.12		-0.08		-0.09	*	0.02		0.02		0.04		0.92	***
i = 2	-0.03		-0.06		-0.15	***	-0.05		-0.06		-0.02		-0.29	***
i = 3	0.00		0.00	*	-0.11	**	-0.05		-0.03		-0.02		-0.21	***
Crisis2009	-5.39		-6.22		9.75	***	10.09	***	9.90	***	0.69		0.05	
ΔRainfall	-0.09		-0.16	**	-0.01		-0.04		-0.01		-0.01		0.00	
ΔPopDensity	11.72		23.86	*	-3.53		-8.29	**	-3.93		0.17		0.58	
ΔTotExppc	-0.41	***	0.61	***	0.00	***	0.00	***	0.00	***	0.00		0.00	***
ΔCapacity	3.54		4.29		-3.67	**	-3.34	**	-2.76	**	1.65		-1.21	
ΔVoice	-24.97		-19.58		-14.08	***	-20.70	**	-17.48	**	-2.05		0.99	*
Intercept	-0.68		-31.60		368.03	***	276.07	***	369.47	***	90.75	***	-2.53	*
R-squared	0.18		0.20		0.37		0.33		0.37		0.16		0.70	

Source: Authors' calculation, based on treatment-effect regression model results.

Notes: Δ means the variable is measured as the annual percentage change for continuous variables and the annual change for index variables. y_{t-1} is the lagged value of the outcome variable, and Δy_{t-i} are lagged values of the growth rate in the outcome variable. Table 3.2 provides a detailed description of the variables. The total number of observations is 644 (46 countries over 14 years). *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 4.4 Fixed-effect estimation of CAADP impact, assuming exogenous treatment of level of CAADP implementation reached, 2001–2014

Variable	ΔAgExpsh		ΔAgExpint		ΔAgva		ΔAgvaland		ΔAgvalabor		ΔGDPpc		ΔNourish	
CAADP level														
Level 1	-4.78		-3.05		5.23	**	9.42	**	4.87		-0.61		0.60	
Level 2	-4.55		-1.42		3.11		-14.17	**	-15.62	**	0.87		0.97	
Level 3	5.98		6.75		4.95		-2.82		-5.87		1.95		2.84	*
Level 4	-23.37	***	-19.09	**	14.84	***	12.33	***	8.27	**	2.86	**	0.55	
y_{t-1}	-5.14	***	-3.53	***	-40.42	***	-45.70	***	-49.36	***	-13.90	***	0.04	
Δy_{t-i}														
i = 1	-0.12		-0.09		-0.09	*	-0.01		-0.02		0.04		0.93	***
i = 2	-0.02		-0.05		-0.14	**	-0.06		-0.07		-0.01		-0.29	***
i = 3	0.00		0.00		-0.10	**	-0.03		-0.02		-0.01		-0.24	***
Crisis2009	-5.63		-6.45		9.87	***	10.47	***	10.24	***	0.79		0.06	
ΔRainfall	-0.07		-0.15	*	-0.01		-0.01		0.01		-0.01		0.00	
ΔPopDensity	12.18		24.32	*	-3.54		-8.18	***	-3.83		0.13		0.64	
ΔTotExppc	-0.44	***	0.59	***	0.00	***	0.00	***	0.00	***	0.00		0.00	***
ΔCapacity	3.20		4.14		-3.99	**	-5.27	**	-4.40	**	1.63		-1.31	
ΔVoice	-25.62	*	-20.52		-13.67	***	-16.69	***	-14.12	***	-2.38		0.78	
Intercept	-1.17		-32.40		375.56	***	277.94	***	370.43	***	96.44	***	-3.12	*
R-squared	0.19		0.20		0.38		0.43		0.45		0.17		0.71	

Source: Authors' calculation, based on treatment-effect regression model results.

Notes: Δ means the variable is measured as the annual percentage change for continuous variables and the annual change for index variables. y_{t-1} is the lagged value of the outcome variable, and Δy_{t-i} are the lagged values of the growth rate in the outcome variable. Table 3.2 provides a detailed description of the variables. The total number of observations is 644 (46 countries over 14 years). *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Treatment Equation Results

The treatment equation results are presented in Table 4.5 for the potential outcome approach and in Table 4.6 for the fixed-effects endogenous-regression approach. As explained earlier, we tried different model specifications, including different measures of each conceptual variable and different combinations of the explanatory variables, to determine which ones work best and to assess sensitivity of the results to different specifications. For the treatment equations regarding the potential outcome approach, there are fewer explanatory variables in each specification because of the smaller number of observations and to avoid problems with lack of degrees of freedom. Thus, whereas the model specifications shown in Tables 4.5 and 4.6 are representative of the variety of the treatment equations estimated, they are the best estimates in terms of overall model fit with respect to the chi-squared and *R*-squared statistics and the number of parameters that are statistically significant, as well as the overidentification test of covariate balance in the case of the potential outcome approach method.

Potential Outcome Approach

For the treatment equations regarding the potential outcome approach, which were estimated by logit, the importance or statistical significance of the variables are different across the different periods in which a compact is signed. Regarding treatment in 2007–2009, variables representing the role of agriculture (AgAreash and AgGDPsh), political will (AUcharters), and peer pressure (PressureR) are the most consistent and statistically significant determinants of signing a CAADP compact in 2007–2009 (Table 4.5). Variables representing government capacity (Capacity) and citizens' demand and capacity (Polity or Voice) are not statistically significant, or they are weak when they are statistically significant. Regarding treatment in 2010–2012, the results are mixed in terms of sign and statistical significance, depending on the combination of the variables. In general, the variables of importance are those on role of agriculture, peer pressure, government capacity, and citizens' demand and capacity. Because of the smaller sample for estimating the model on treatment at 2013–2014, several of the counterpart model specifications that were estimated for treatment at the two preceding periods were not statistically significant or could not be estimated due to convergence problems. The results shown in Table 4.5 show that the main determinants for signing a compact in 2013–2014 are peer pressure, citizens' demand, and capacity, with the negative sign on the parameters for Polity and Voice indicating a lower likelihood of signing a compact in the more democratic or freedom countries. A fundamental question arises from these results that needs further research: Did the countries that signed their compacts later (say, in 2013–2014) do so only after they had observed some positive returns among those that had signed before them?

Table 4.5 also shows the covariate balance test results for the respective model specifications; these results indicate a failure to reject the null hypothesis that the estimated treatment models balanced the covariates, particularly regarding treatment in 2007–2009 or 2010–2012. In two of the model specifications presented for treatment in 2013–2014, the covariates could not be balanced. This finding was common in several of the models tried due to the smaller sample.

Table 4.5 Selected logit results for the potential outcome approach, 2001–2014

	Signed CAADP compact in 2007–2009			Signed CAADP compact in 2010–2012			Signed CAADP compact in 2013–2014		
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
AgAreash			1.02		-0.91		-0.02	0.02	0.04 *
AgGDPsh		2.50 **		5.08 ***					
AUcharters	4.11 **					1.14			
PressureR	0.34 **	0.24 *	0.28 ***	-0.14 **	0.17 **	-0.01	0.07 ***	0.14 **	0.11 **
Capacity	-0.90			-2.04 *			-0.27		
Polity		1.48				2.36 **		-8.26 **	
Voice			1.75		1.70 *				-8.23 **
Intercept	-6.23 **	-6.84 ***	-6.03 **	4.23	-2.18 *	-2.03	-0.91	-3.65 ***	-3.76 ***
Wald chi-squared	9.94 **	7.84 **	10.77 **	21.17 ***	8.20 **	5.99	7.66 *	7.73 *	8.68 **
Pseudo *R*-squared	0.59	0.54	0.53	0.54	0.27	0.16	0.22	0.61	0.64
Overid test & p-value	1.13 0.89	2.81 0.59	4.73 0.32	2.35 0.67	1.08 0.90	3.07 0.55	4.73 0.19	7.74 0.05	8.00 0.09
Predicted probability	0.35 0.13	0.35 0.13	0.35 0.14	0.31 0.09	0.31 0.06	0.31 0.05	0.31 0.07	0.31 0.13	0.31 0.13

Source: Authors' calculation, based on treatment-effect regression model results.

Notes: Table 3.2 provides a detailed description of the variables. The dependent variable is equal to 1 for countries that signed a CAADP compact (treated) during the period and 0 for others (untreated). The number of observations is 13 treated and 33 untreated for 2007–2009, 16 treated and 17 untreated for 2010–2012, and 8 treated and 9 untreated for 2013–2014. The explanatory variables are pretreatment or baseline values (that is, average of 2001–2003). Overid test is overidentification test for covariate balance where the null hypothesis is that the covariates are balanced. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. Blank cells mean the relevant variable is not included in the model (for example, AgAreash and AgGDPsh and Polity and Voice are alternative measures of the same conceptual variable). Predicted probability is the mean predicted probability of a positive outcome and standard error to be used in the second-stage weighted calculation of the treatment effect.

Endogenous-Treatment Regression Approach

Fixed-effects logit was used for the first definition of treatment ($d1 = 0, 1$), representing whether a CAADP compact is signed, and fixed-effect ordered logit was used for the second definition of treatment ($d2 = 0, 1, 2, 3, 4$), representing successive levels of CAADP implementation reached over time. Table 4.6 presents the results. Here, too, the estimates are generally consistent with the hypotheses presented in the conceptual framework.

For the first definition of treatment regarding whether a CAADP compact is signed, variables representing the role of agriculture (AgGDPsh), political will (AUcharters), peer pressure (PressureC or PressureR), and government capacity (Capacity) have positive and statistically significant influence. Variables representing negotiation posture (AgGDPsh or TotExppc) have negative influence, suggesting that relatively richer countries are less likely to sign—likely because they may have alternative (nonagriculture) sources of development. Citizens' demands and capacity (represented by Polity and Voice) are not as important. Including the dummy variable representing the renewal of CAADP at the Africa-wide level, as well as for the high food price crisis in 2009 (represented by Crisis2009), preserves the above results and strengthens the positive influence of democracy (Polity) and population density. The strong positive influence of the Crisis2009 variable is consistent with the flurry of countries that signed their compacts from 2009 onward.

For the second definition of treatment, the fixed-effects ordered logit results have fewer statistically significant factors, but those that are statistically significant (that is, peer pressure, government capacity, population density, and Crisis2009) have similar influence as discussed for the first definition of treatment. Here, however, inclusion of the Crisis2009 variable reduces the significance of population density and removes the significance of peer pressure. Because the parameters with this traditional ordered logit approach are constrained to be the same for the different outcomes (also called proportional odds assumption), the variation in the estimated IMRs across the different outcomes is not much. Therefore, using all four together in the second-stage regression causes multicollinearity problems that result in a couple of them being dropped, as will be seen later. As such, we also estimate a generalized ordered logit or nonproportional odds model (Fu 1988) that provides a unique set of parameters for the different comparative outcomes. Here, however, the traditional fixed-effects framework does not work well; therefore, we tried to include as many as possible of the time-invariant country factors—that is, measures of geographic location, economic classification, and agroecology. Only the agroecology variables (Agromain and Agrovar) worked well. The results for two selected model specifications presented in Table 4.7 suggest that there are some differences in the factors that affect countries' likelihood of achieving different levels of CAADP implementation. For example, there are fewer statistically significant factors in equations 3 and 4. In Model 1, for example, only three of the variables (peer pressure, government capacity, and population density) are significant in equation 4, compared with seven or eight variables in the other three equations. In general, the signs of the significant factors are consistent with the hypothesis in the conceptual framework. Most important, the variation in the estimated IMRs across the different equations seems to be significantly different, as using all four estimated IMRs together in the second-stage regression does not cause multicollinearity problems, as will be discussed later.

Table 4.6 Selected fixed-effects logit and ordered logit results for the endogenous treatment regression approach, 2001–2014

	Fixed-effects logit for signing compact (*d*1)								Fixed-effects ordered logit for level of implementation (*d*2)							
Variable	**Model 1**		**Model 2**		**Model 3**		**Model 4**		**Model 1**		**Model 2**		**Model 3**		**Model 4**	
AgGDPsh	0.61	***	0.57	***	0.31	***	0.48	***	-0.01		-0.01		0.02		0.02	
AUcharters	0.70	***	0.70	**	0.32		0.63	**	-6.69		-3.66		-6.38		-3.05	
PressureC	0.08	***			0.10	***					0.01				0.02	***
PressureR			0.06	***			0.11	***	0.00				0.02	***		
AfGDPsh			-1.49	**			-1.56	***	1.47				1.56			
TotExppc	-0.01	***			-0.01	***					-0.00				-0.00	
Capacity	5.01	***	3.71	***	4.26	***	5.38	***	2.11	***	2.17	***	2.27	***	2.33	***
Polity	0.58	**			0.40	*					-0.05				-0.09	
Voice			0.58				0.80		0.63				0.16			
PopDensity	0.04	***	0.03	***	0.02	*	0.02	*	0.06	*	0.06	*	0.11	***	0.11	***
Crisis2009	29.89	***	23.24	***					4.86	***	4.79	***				
Intercept	-94.95	***	-75.72	***	-46.77	***	-65.06	***	n.a.		n.a.		n.a.		n.a.	
Cut point 1	n.a.		n.a.		n.a.		n.a.		-78.94		-30.06		-73.84		-20.82	
Cut point 2	n.a.		n.a.		n.a.		n.a.		-76.12		-27.23		-71.44		-18.39	
Cut point 3	n.a.		n.a.		n.a.		n.a.		-73.13		-24.26		-68.51		-15.48	
Cut point 4	n.a.		n.a.		n.a.		n.a.		-68.68		-19.83		-63.88		-10.85	
Chi-sq. stat.	151.87	***	58.85	***	94.33	***	81.28	***	803.2	***	802.9	***	769.0	***	769.3	***
IMR (*d*1 = 1)	6.10	0.38	6.17	0.32	3.95	0.25	5.71	0.23	n.a.		n.a.		n.a.		n.a.	
IMR (*d*2 = 1)	n.a.		n.a.		n.a.		n.a.		18.28	0.07	11.77	0.10	17.64	0.06	9.92	0.11
IMR (*d*2 = 2)	n.a.		n.a.		n.a.		n.a.		18.12	0.07	11.53	0.10	17.50	0.06	9.67	0.11
IMR (*d*2 = 3)	n.a.		n.a.		n.a.		n.a.		17.96	0.07	11.27	0.10	17.33	0.06	9.36	0.11
IMR (*d*2 = 4)	n.a.		n.a.		n.a.		n.a.		17.71	0.07	10.86	0.11	17.07	0.06	8.85	0.12

Source: Authors' calculation, based on treatment-effect regression model results.

Notes: Table 3.2 provides a detailed description of the variables. For *d*1, the value is equal to 0 (untreated) until the year a compact is signed; it then takes a value of 1 (treated). For *d*2, the value is equal to 0 (level 0 treatment), 1 when a compact is signed (level 1 treatment), 2 when a national agricultural investment plan is prepared (level 2 treatment), 3 when one external source of financing is secured (level 4 treatment), and 4 when additional external sources of financing are secured (level 4 treatment). The explanatory variables are lagged values. The total number of observations is 644 (46 countries over 14 years). *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. Blank cells mean the relevant variable is not included in the model (for example, PressureC and PressureR, AfGDPsh and TotExppc, and Polity and Voice are alternative measures of the same conceptual variable). IMR is the mean and standard error of the inverse mills ratio to be used in the second-stage estimation of the treatment effects. n.a. = not applicable.

Table 4.7 Selected generalized ordered logit results for the level of CAADP implementation (*d*2), 2001–2014

Equation/Explanatory variable	Model 1	Model 2
Equation 1		
AgGDPsh	0.03 **	0.05 ***
AUcharters	0.03	0.08 ***
PressureC	0.04 ***	
PressureR		0.04 ***
AfGDPsh		-0.11 **
TotExppc	-0.00 ***	
Capacity	0.64 ***	0.50 ***
Polity	0.13 ***	
Voice		0.25
PopDensity	0.13 ***	0.00 *
Agromain	0.07	0.68 *
Agrovar	2.08 **	1.39
Intercept	-8.62 ***	-9.03 ***
Equation 2		
AgGDPsh	0.03 *	0.06 ***
AUcharters	-0.01	0.05 *
PressureC	0.02 ***	
PressureR		0.01
AfGDPsh		0.01
TotExppc	-0.00 ***	
Capacity	0.64 ***	0.47 ***
Polity	0.18 ***	
Voice		0.80 ***
PopDensity	0.01 ***	0.00
Agromain	-0.41	0.06
Agrovar	2.76 ***	3.37 ***
Intercept	-8.45 ***	-8.79 ***
Equation 3		
AgGDPsh	0.04 **	0.08 ***
AUcharters	0.09 **	0.15 ***
PressureC	0.01	
PressureR		0.01
AfGDPsh		-0.10
TotExppc	-0.00 *	
Capacity	0.82 ***	0.86 ***
Polity	0.09 **	
Voice		0.44
PopDensity	0.01 **	0.00 *
Agromain	-0.70	-0.23
Agrovar	-0.31	-0.50
Intercept	-9.80 ***	-12.48 ***
Equation 4		
AgGDPsh	-0.09	0.08
AUcharters	0.07	0.42
PressureC	-0.04 **	
PressureR		-0.04 *
AfGDPsh		-0.15
TotExppc	-0.01	
Capacity	1.06 ***	0.70 **
Polity	-0.07	
Voice		5.55 **
PopDensity	0.01 **	0.00 **
Agromain	-2.25	-2.97 *
Agrovar	-2.68	-11.41 **
Intercept	-5.49	-8.74

Table 4.7 Contiuned

Equation/Explanatory variable	Model 1	Model 2
Chi-squared statistic	498.02 ***	487.02 ***
Pseudo *R*-squared	0.43	0.42
IMR (equation 1)	1.75 0.09	1.92 0.08
IMR (equation 2)	2.02 0.09	1.66 0.06
IMR (equation 3)	2.38 0.09	2.45 0.08
IMR (equation 4)	3.19 0.08	3.52 0.08

Source: Authors' calculation, based on treatment-effect regression model results.

Notes: Table 3.2 provides a detailed description of the variables. For *d*2, the value is equal to 0 for level 0 treatment, 1 when a compact is signed (level 1 treatment), 2 when a national agricultural investment plan is prepared (level 2 treatment), 3 when one external source of financing is secured (level 4 treatment), and 4 when additional external sources of financing are secured (level 4 treatment). In equation 1, the dependent variable is 1 for *d*2 = (1, 2, 3, 4) and 0 for *d*2 = 0. In equation 2, the dependent variable is 1 for *d*2 = (2, 3, 4) and 0 for *d*2 = (0, 1). In equation 3, the dependent variable is 1 for *d*2 = (3, 4) and 0 for *d*2 = (0, 1, 2). In equation 4, the dependent variable is 1 for *d*2 = 4 and 0 for *d*2 = (0, 1, 2, 3). The explanatory variables are lagged values. The total number of observations is 644 (46 countries over 14 years). *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. Blank cells mean the relevant variable is not included in the model (for example, PressureC and PressureR, AfGDPsh and TotExppc, and Polity and Voice are alternative measures of the same conceptual variable). IMR is mean and standard error of the inverse mills ratio to be used in the second-stage estimation of the treatment effects.

Estimated Treatment Effects

Tables 4.8–4.11 show the results of the estimated treatment effects using the different estimation methods or approaches. For each estimation method, we use the treatment equation results presented under model 1 in Tables 4.5–4.7. Detailed results for each estimation method are shown for the full model specification only: Table 4.8 shows the fixed-effects regression model for whether a compact is signed; Table 4.9 shows the fixed-effects regression model for level of implementation reached based on conventional ordered logit treatment; Table 4.10 shows the fixed-effects regression model for the level of implementation reached based on generalized ordered logit treatment; and Table 4.11 shows results using the potential outcome approach on treatment in specific time periods. Table A.1 in the appendix provides a summary of the estimated impacts for each estimation method using different model specifications involving nested subsets of explanatory variables.

Table 4.8 Fixed-effects regression results for whether a CAADP compact is signed (*d*1), 2001–2014

Variable	ΔAgExpsh		ΔAgExpint		ΔAgvaland		ΔAgvalabor		ΔAgva		ΔGDPpc		ΔNourish	
CAADP compact	-3.59		-1.89		-4.13		-6.55		4.94		-0.46		1.27	
y_{t-1}	-4.96	***	-3.42	***	-54.57	***	-55.43	***	-42.32	***	-16.23	***	0.01	
Δy_{t-i}														
i = 1	-0.12		-0.08		0.05		0.03		-0.10	*	0.05		0.92	***
i = 2	-0.04		-0.06		-0.04		-0.05		-0.15	***	-0.02		-0.29	***
i = 3	0.00		0.00	*	-0.02		-0.01		-0.09	***	-0.01		-0.21	***
Crisis2009	-9.65	*	-12.36	*	-1.11		2.64		7.13		-4.71	*	0.26	
ΔRainfall	-0.08		-0.16	*	-0.04		-0.01		-0.01		-0.01		-0.00	
ΔPopDensity	10.51		22.63	*	-11.14	**	-5.58		-4.57		-0.47		0.60	
ΔTotExppc	-0.42	***	0.60	***	-0.00	***	-0.00	***	-0.00	***	0.00		-0.00	***
ΔCapacity	4.19	*	4.96	*	-1.95		-1.75	*	-3.25	**	1.91	*	-1.25	
ΔPolity	-0.12		-0.11		0.03		0.25		-0.08		-0.09		0.11	*
IMR	0.55		-0.84		-1.81	*	-1.16		-0.41		-0.88	*	0.02	
Intercept	6.60		-21.59		348.23	***	427.00	***	398.28	***	121.92	***	-2.81	
R-squared	0.17		0.19		0.31		0.35		0.36		0.19		0.70	

Source: Authors' calculation, based on treatment-effect regression model results.

Notes: Δ means the variable is measured as the annual percentage change for continuous variables and the annual change for index variables. y_{t-1} is the lagged value of the outcome variable, and Δy_{t-i} are the lagged values of growth rate in the outcome variable. Table 3.2 provides a detailed description of the variables. IMR = inverse mills ratio. The total number of observations is 644 (46 countries over 14 years). *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 4.9 Fixed-effects regression results for level of CAADP implementation reached (*d*2) estimated by conventional ordered logit, 2001–2014

Variable	ΔAgExpsh		ΔAgExpint		ΔAgvaland		ΔAgvalabor		ΔAgva		ΔGDPpc		ΔNourish	
CAADP level														
Level 1	-3.27		-0.93		10.88	*	8.91	*	5.87	*	-0.39		-0.23	
Level 2	-4.77		-0.55		-14.38	***	-11.33	*	2.65		0.52		-0.53	
Level 3	6.12		7.94		-3.89		-1.02		4.33		1.12		1.16	
Level 4	-22.96	*	-17.19		13.41	***	15.08	***	15.17	***	3.24		-0.96	
y_{t-1}	-5.01	***	-3.41	***	-52.44	***	-54.56	***	-47.98	***	-24.18	***	0.14	*
Δy_{t-i}														
i = 1	-0.13		-0.09		0.03		-0.00		-0.06		0.06		0.94	***
i = 2	-0.04		-0.06		-0.04		-0.06		-0.11		-0.02		-0.26	***
i = 3	0.00		-0.00	**	-0.00		-0.01		-0.07	**	-0.01		-0.28	***
Crisis2009	-4.36		-7.50		7.10		7.31	*	5.99		-2.38	**	-1.06	***
ΔRainfall	-0.07		-0.15	*	-0.00		0.02		-0.01		-0.01		-0.00	
ΔPopDensity	11.74		22.88	*	-10.25	***	-6.14		-5.53		-1.52		0.11	
ΔTotExppc	-0.43	***	0.59	***	-0.00	***	-0.00	***	-0.00	***	0.00		-0.00	***
ΔCapacity	3.31		4.39		-4.53	*	-3.92		-3.32		2.06		-1.10	
ΔPolity	-0.25		-0.21		-0.29		-0.01		-0.11		-0.16		0.12	*
IMR1	975.23		-1494.27		-201.61		-6607.23	*	908.72		-558.95		1182.81	
IMR2	-964.83		1481.29		194.50		6549.34	*	-908.22		-537.62		-1175.43	
IMR3	n.e.		n.e.		n.e.		n.e.		n.e.		n.e.		n.e.	
IMR4	n.e.		n.e.		n.e.		n.e.		n.e.		n.e.		n.e.	
Intercept	-341.03		436.62		482.55		2483.73	**	299.27		462.35		-319.42	
R-squared	0.18		0.20		0.42		0.45		0.37		0.19		0.73	

Source: Authors' calculation, based on treatment-effect regression model results.

Notes: Δ means the variable is measured as the annual percentage change for continuous variables and the annual change for index variables. y_{t-1} is the lagged value of the outcome variable, and Δy_{t-i} are the lagged values of growth rate in the outcome variable. Table 3.2 provides a detailed description of the variables. IMR1, …, IMR4 = inverse mills ratio for CAADP levels 1 to 4, respectively. The total number of observations is 644 (46 countries over 14 years). *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. n.e. = not estimated due to multicollinearity.

Table 4.10 Fixed-effects regression results for level of CAADP implementation reached (*d*2) estimated by generalized ordered logit, 2001–2014

Variable	ΔAgExpsh		ΔAgExpint		ΔAgvaland		ΔAgvalabor		ΔAgva		ΔGDPpc		ΔNourish	
CAADP level														
Level 1	-3.99		-4.98		12.90	**	8.74	*	8.57	**	-1.27		1.08	
Level 2	-5.10		-7.80		-6.97	*	-9.04	**	7.43	**	-0.31		1.09	
Level 3	6.32		-2.27		8.27	**	3.58		10.85	**	-0.16		2.96	
Level 4	-23.02	***	-20.11	**	16.52	***	11.56	***	16.73	***	1.49		-0.11	
y_{t-1}	-4.73	***	-3.27	***	-51.91	***	-54.42	***	-47.98	***	-22.00	***	0.11	
Δy_{t-i}														
i = 1	-0.15		-0.09		0.04		0.01		-0.06		0.06		0.93	***
i = 2	-0.05		-0.06		-0.03		-0.05		-0.11	*	-0.01		-0.27	***
i = 3	0.00		-0.00	**	-0.00		-0.01		-0.07	**	-0.01		-0.27	***
Crisis2009	-0.13		-2.80		4.24	*	4.90	*	5.99	**	-1.19	*	-0.25	
ΔRainfall	-0.07		-0.15		-0.00		0.02		-0.01		-0.01		-0.00	
ΔPopDensity	12.93		23.94	*	-10.28	***	-5.29		-5.53	*	-1.21		0.50	
ΔTotExppc	-0.41	***	0.59	***	-0.00	***	-0.00	***	-0.00	***	0.00		-0.00	***
ΔCapacity	3.76		4.49		-4.99	*	-4.19	*	-3.32	*	2.21		-1.08	
ΔPolity	0.11		0.33		-0.67		-0.52		-0.11		-0.09		0.05	
IMR1	20.72		31.97		-33.84	***	-34.22	***	-13.93	***	-1.33		-2.02	
IMR2	-41.68		-35.59		25.46		36.75	**	9.16	**	1.27		4.08	
IMR3	25.68		-4.60		16.22		4.19		-10.03		-3.07		-1.60	
IMR4	-5.61		7.02		-9.88	**	-6.46		-11.78		-0.53		-0.84	
Intercept	-3.00		-29.21		318.63	***	407.19	***	412.19	***	164.70	***	-2.04	
R-squared	0.18		0.21		0.46		0.48		0.39		0.21		0.72	

Source: Authors' calculation, based on treatment-effect regression model results.

Notes: Δ means the variable is measured as the annual percentage change for continuous variables and the annual change for index variables. y_{t-1} is the lagged value of the outcome variable, and Δy_{t-i} are lagged values of growth rate in the outcome variable. Table 3.2 provides a detailed description of the variables. IMR1, …, IMR4 = inverse mills ratio for CAADP levels 1 to 4, respectively. The total number of observations is 644 (46 countries over 14 years). *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 4.11 Treatment effect results for whether a CAADP compact is signed in period *c* using the potential outcome approach, 2001–2014

Variable	ΔAgExpsh		ΔAgExpint		ΔAgvaland		ΔAgvalabor		ΔAgva		ΔGDPpc		ΔNourish	
2007–2009														
CAADP compact	-0.06		1.89		1.68		-4.24		-1.96		2.65	***	-0.01	
y_0	-1.24	*	-3.91	***	0.33		0.99		0.96	**	-3.15	***	-0.08	*
Rainfall	6.36		3.44		-3.78		-4.28		-3.85		0.78		-2.80	
PopDensity	-3.87		-5.50	**	2.33		2.96	*	1.51		0.91		3.61	**
TotExppc	-2.70		-6.51	***	-0.16		-0.46		-1.30		0.88	**	-1.93	**
Intercept	-6.72		43.70		20.71		16.70		23.28		9.89		9.39	
$E[y_s^{d>s}]$	1.82		-0.69		4.87	***	10.11	**	8.61	***	1.63	*	-3.38	
2010–2012														
CAADP compact	-8.17		1.45		5.22	***	3.21	***	3.39	***	1.68		-0.61	
y_0	-1.43	***	-0.84	*	-1.15		-0.63		0.83	*	-3.53	**	0.01	
Rainfall	1.33		4.81	*	-1.69		-0.16		-2.70	***	-0.25		2.95	***
PopDensity	0.47		-3.03		2.39	***	1.47	**	2.11	***	0.12		-0.28	
TotExppc	-2.58		-3.19		-1.74	***	-0.31		-2.33	***	1.80		0.66	
Intercept	9.80		0.80		20.22	***	3.75		19.46	**	17.22	***	-24.78	***
$E[y_s^{d>s}]$	10.78	*	3.86		-1.05		-0.25		1.45	**	0.67		-1.76	**
2013–2014														
CAADP compact	-1.47		-8.65		13.47	*	11.38	**	13.17	**	-2.12		n.e.	
y_0	-1.12		-0.01		1.29		2.06		0.68		-1.80	**	n.e.	
Rainfall	10.15	**	10.07	***	2.79	**	5.80	***	5.48	**	-1.05	***	n.e.	
PopDensity	-2.64		-4.99	***	-9.13	***	-8.03	***	-8.96	***	-1.99	***	n.e.	
TotExppc	-6.50	***	-2.00	***	0.17		-0.76		-0.35		2.35	***	n.e.	
Intercept	-22.34		-43.36	***	6.67	**	-21.51		-9.14		15.81	***	n.e.	
$E[y_s^{d>s}]$	-1.33		4.39		-8.47		-8.92		-9.25	*	5.35		n.e.	

Source: Authors' calculation, based on potential outcome model results.

Notes: Δ means the dependent variable is measured as the average annual percentage change from 2001 to 2014. y_0 is the outcome at baseline, measured as the average of 2001–2003 values. Explanatory variables are also baseline values. Table 3.2 provides a detailed description of the variables. $E[y_s^{d>s}]$ is the estimated potential outcome. The number of observations is 13 treated and 33 untreated for 2007–2009, 16 treated and 17 untreated for 2010–2012, and 8 treated and 9 untreated for 2013–2014. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. n.e. = not estimated due to insufficient observations.

Impact of CAADP on Agricultural Sector Spending

Results from the fixed-effects regression model show that the impact of CAADP on the share of agriculture expenditure (AgExpsh) and agricultural spending intensity (AgExpint) is generally negative (Tables 4.8–4.10); it is statistically significant only for the group of countries that have reached level 4 of CAADP implementation (Tables 4.9 and 4.10) and strongly so in the specifications based on the generalized ordered logit treatment (Table 4.10). Because of multicollinearity problems with the IMRs obtained with the conventional ordered logit treatment (Table 4.9), results from the generalized ordered logit treatment (Table 4.10) are preferred. The statistically insignificant coefficients for the IMRs, however, suggest that there may be little or no value addition to these results compared with those obtained without estimation of the treatment equation presented in Tables 4.3 and 4.4. In fact, the estimated impacts with respect to level 4 implementation are very close to each other. Regarding AgExpsh, for example, the estimated impact is –23.4 percent in Table 4.3 and –23.0 percent in Table 4.10. For AgExpint, it is –19.1 percent in Table 4.3 and –20.1 percent in Table 4.10. In general, the negative signs suggest a substitution effect between governments' own funding and external (or off-budget)[8] sources of funding for the sector. This finding is not surprising, as countries at level 4 of implementation have two or more sources of external funding for the sector, most of which tend to be off budget. These results are consistent with those obtained using the different model specifications (Table A.1 in the Appendix), which also show substitution effects associated with level 2 implementation with respect to AgExpint, though they are not sustained with inclusion of more explanatory variables.

A key question raised in the conceptual framework is whether there are significant differences in the impact when a compact is signed and level of implementation is reached. Table 4.12 shows results for two types of tests conducted on this: the impact of different levels of implementation reached for the same period a compact is signed and impact of different periods a compact is signed for the same level of implementation reached. For the period a compact is signed, the relevant tests are for signing in 2007–2009 and 2010–2012, as countries that signed in 2013–2014 have not progressed beyond compact signing. The results show that the impacts associated with the different levels of implementation reached are significantly different within the group that signed the compact in 2010–2012, with those at level 4 experiencing the greatest substitution effect. Across different periods of compact signing, the most interesting result is for those at level 3 of implementation, where the impact is positive for those that signed in 2010–2012 (23 percent versus 31 percent) and negative for those that signed in 2007–2009 (–8 percent versus –16 percent). This finding is consistent with the results obtained from the potential outcome approach, which shows a positive impact of about 9 percent for those that signed the compact in 2010–2012 (Table 4.11).

On the effect of other variables, the main influential ones (that is, those that are statistically significant at the 5 percent or 1 percent level in both outcomes across the different modeling approaches) are the initial level of the shares, whose effect is mostly negative, and total expenditure per capita, whose effect is mostly negative on AgExpsh and mixed on AgExpint. The negative effect of the initial level of a share means that countries with an initial high share tend to reduce it in subsequent years.

[8] Off budget means outside the government's financial management and procurement processes.

Table 4.12 Statistical tests of the impacts from interaction between when a compact is signed and level of implementation reached using fixed-effects estimation method, 2001–2014

Variable	ΔAgExpsh	ΔAgExpint	ΔAgvaland	ΔAgvalabor	ΔAgva	ΔGDPpc	ΔNourish
Year compact signed							
2001–2009 (1)	-7.35	-3.40	4.19	-10.08 **	-11.97 ***	-0.32	2.36 ***
2010–2012 (2)	6.33	3.60	7.01 **	4.90	2.20	-0.29	-0.60
2013–2014 (3)	-18.46 **	-16.88 **	0.63	3.29	-3.78	-2.82	2.22
Differences	12, 23, 123	23	23	12, 13, 123	12, 13, 23, 123	13, 23	12, 23, 123
Year compact signed and level reached							
2001–2009							
Level 1	-3.69	-0.17	15.84 **	11.00 **	9.87 **	-0.79	1.74 **
Level 2	-9.78	-10.47	-13.98 ***	-16.93 ***	6.86	-0.57	1.99 *
Level 3	-8.25	-15.51	-2.02	-7.97 *	9.20	-0.47	4.76 **
Level 4	-20.62 **	-13.88	19.77 ***	13.17 ***	20.82 ***	3.70 **	2.42 *
Differences			12, 13, 23, 24, 34, 1234	12, 13, 23, 24, 34, 1234	14, 24, 34, 1234	14, 24, 1234	13, 23, 34
2010–2012							
Level 1	4.53	-4.19	7.82 **	6.44	8.65 **	-1.39	-1.15 ***
Level 2	4.04	-2.18	6.75 *	4.56	8.60 **	0.21	0.04
Level 3	31.28	23.35	16.63 ***	11.76 **	13.36 ***	0.20	0.86
Level 4	-30.02 ***	-28.46 ***	11.71 ***	7.02 **	13.67 ***	-0.04	-0.87 **
Differences	14, 24, 34, 1234	24, 34, 1234	13, 23, 1234		14		13, 34, 1234
2013–2014							
Level 1	-15.21 *	-19.28 **	10.95 ***	2.98	4.27	-2.78	3.24
Cross differences	3	1, 3, 4	2, 3, 4	2, 3		1, 4	1, 3, 4

Source: Authors' calculation, based on fixed-effects regression model results.

Notes: Δ means the variable is measured as the annual percentage change. Table 3.2 provides a detailed description of the variables. The total number of observations is 644 (46 countries over 14 years). *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. Differences = statistically significant difference of 10 percent or less between the relevant subgroups (for example, 23 refers to 2010–2012 and 2013–2014 or levels 2 and 3; and 123 and 1234 refer to all subgroups). For cross difference, 3 for example refers to a statistically significant difference of 10 percent or less between 2007–2009, level 3, and 2010–2012, level 3.

Impact of CAADP on Agricultural Output and Productivity

Results from the fixed-effects regression model show that the impact of CAADP on agricultural value-added and land and labor productivity, based on whether a CAADP compact is signed only, is not statistically significant (Table 4.8). The impact based on the level of CAADP implementation reached, however, is mixed (Tables 4.9 and 4.10). Based on the results presented in Table 4.10, the estimated impact of CAADP on agricultural value-added, for example, is 16.7 percent for the group of countries at level 4, compared with those at the precompact stage or level 0; 10.8 percent for level 3; 7.4 percent for level 2; and 8.6 percent for level 1. With respect to land and labor productivity, the impact is positive for levels 1, 3, and 4 (estimated at 8 percent to 17 percent); but it is surprisingly negative for level 2 (estimated at –7 percent to –9 percent). The signs, patterns, and statistical significance of the above impacts are consistent with those obtained from the different model specifications (Table A.1 in the Appendix). Because several coefficients on the IMRs are statistically significant, unobservables that affect agricultural value-added and land and labor productivity are correlated with unobservables that affect CAADP implementation. Thus, controlling for the factors that affect treatment, as done here, is critical.

The negative impact on land and labor productivity for the group of countries at level 2 of CAADP implementation is puzzling. Looking at results in Table 4.12 with respect to the differences in the impact by year of signing a compact and the level of implementation reached, this negative effect is particular to the group of countries that signed the compact in 2007–2009. In fact, for those that signed the compact in 2007–2009 and that are at level 2 of implementation, the estimated impact on agricultural value-added is significantly lower, and the impact on land and labor productivity is negative. Those at level 3 of implementation also performed worse than those at levels 1 and 4. These differences are also statistically significant across the different periods of signing a compact.

The estimated impacts obtained from the potential outcome modeling approach for when a compact is signed in a specific subperiod are not statistically significant for signing in 2007–2009 or in 2010–2012, but they are positively significant for signing in 2013–2014 (Table 4.11). These results are generally inconsistent across the different model specifications, except for the impact on agricultural value-added in the case of signing in 2013–2014 (Table A.1 in the Appendix).

Looking at the effect of other influential variables, the main variables are, again, the initial level of the outcome and the total expenditure per capita. The effect of the initial level of the outcome is negative, which suggests a declining trend for those with high initial values. Similarly, the effect of total expenditure per capita is negative. The capacity of the government and the dummy variable for CAADP renewal or the food price and financial crisis from 2009 onward (Crisis2009) also seem important, though their effects are weaker statistically.

Impact of CAADP on Income and Nutrition

The estimated impacts of CAADP on income (GDP per capita) and nutrition (prevalence of adult undernourishment) are statistically insignificant across the different modeling approaches (Tables 4.8–4.11). Some weak impacts that were found using model specifications with smaller numbers of the explanatory variables vanished when additional explanatory variables were included (Table A.1 in the Appendix). This finding seems to suggest that the overall positive impacts on agricultural value-added and land and labor productivity have not yet infiltrated into the general economy. However, results of the testing for differences in the impact by year of signing a compact and the level of implementation reached reveal some interesting findings, including some puzzling ones. This is especially so in the case of the impact on nutrition (Table 4.12). For example, the group of countries that signed the compact in 2007–2009 and that reached level 4 of implementation were associated with 3.7 percent larger growth rate in GDP per capita, as compared with those at level 0. This finding is significantly different from the rates achieved by the groups at the other levels. The differences are also significant across the different compact signing groups. This finding is consistent with the notion that the benefits of reforms take time to materialize; thus, countries that start reforms early, deepen them over time, and have the resources to do

so are more likely to have greater success. The impact on nutrition is counterintuitive, however. As Table 4.12 shows, those that signed their compact in 2007–2009 are associated with a rising prevalence of adult malnourishment (1.7 percent to 4.8 percent), with higher rates of increase for those that have achieved higher levels of implementation. On the other hand, those that signed their compact later in 2010–2012 and that are at levels 1 or 4 of implementation are associated with a declining prevalence of adult malnourishment (–0.9 percent to –1.1 percent).

With respect to the effect of other influential variables, the main ones are, again, the initial level of the outcome (negative effect) and the total expenditure per capita (positive effect on GDP per capita and negative effect on nutrition). The dummy variable for CAADP renewal or the food price and financial crisis from 2009 onward also seem important with a negative effect.

Explaining the Puzzling Results

The results described as puzzling are counter to the expectations presented in the conceptual framework, which stated that countries that signed their compact early or that reached higher levels of implementation were more likely to have larger, positive impact on the outcomes. Regarding the impact on land and labor productivity, for example, the group of countries that signed their compact in 2007–2009 and that reached level 2 (and, to some extent, level 3) of implementation had a negative impact compared with the generally positive impact found. Similarly, those that signed their compact in 2007–2009 had an increase in the prevalence of adult malnourishment, compared with a decrease for those that signed their compact in 2010–2012. The other puzzling result is the impact on agricultural spending, in which those that signed their compact in 2010–2012 and that reached level 3 of implementation had a positive impact as compared with the generally negative impact or substitution effect found.

Because we have tried to be comprehensive with the estimations in terms of capturing the major observable factors and we also used the fixed-effects modeling approach to deal with unobservable factors, there are few areas left to explore to explain the puzzles, including aspects of the definitions of treatment or data issues. The puzzling result in terms of the impact on agricultural spending is related to the group of countries that signed their compact in 2010–2012 and that reached level 3 of implementation or that accessed one source of external funding. Table 4.13 shows that the average amount of the external funding received by this group of countries is nearly 30 percent lower than the average received by their counterpart that signed in 2007–2009, and it is much lower compared with those that received external funding from more than one source or that reached level 4 of implementation. This amount may not be high enough to drive the substitution effect observed in the groups that received much larger amounts.

From a data issue perspective, the fact that only two countries (Uganda and Zambia) signed their compact in 2010–2012 and reached level 3 of implementation may also be a contributing factor, as there is little variation in the data with fewer observations. Therefore, this result must be interpreted with caution; it also applies to other results involving specific comparisons with the group that signed their compact in 2010–2012 and that reached level 3 of implementation

Table 4.13 CAADP-related external funding received or investments undertaken by year of signing compact and level of implementation reached (million US$)

Compact year/ level/country	GAFSP	Grow Africa		New Alliance		Total
	Actual	Planned	Actual	Planned	Actual	Actual
2007–2009						
Level 3						
Burundi	30.0					30.0
Gambia	28.0					28.0
Liberia	46.5					46.5
Mali	37.2					37.2
Niger	33.0					33.0
Sierra Leone	50.0					50.0
Togo	39.0					39.0
Average	*37.7*	*0.0*	*0.0*	*0.0*	*0.0*	*37.7*
Level 4						
Benin	24.0	157,301.3	7,951.1	65.0	7.0	7,982.1
Ethiopia	51.5	768.2	144.7	1,489.0	218.0	414.2
Ghana		165.7	61.1	573.0	192.0	253.1
Nigeria		5,342.0	3,752.9	477.0	128.0	3,880.9
Rwanda	50.0	99.7	2.3			52.3
Average	*41.8*	*32,735.4*	*2,382.4*	*651.0*	*136.3*	*2,516.5*
2010–2012						
Level 3						
Uganda	27.6					27.6
Zambia	31.1					31.1
Average	*29.4*	*0.0*	*0.0*	*0.0*	*0.0*	*29.4*
Level 4						
Burkina Faso	37.1	15,414.8	4,181.3	563.0	428.0	4,646.4
Côte d'Ivoire		963.8	114.6	261.0	218.0	332.6
Kenya	24.0	22.7	5.6			29.6
Malawi	39.6	233.3	81.5	629.0	257.0	378.1
Mozambique		612.5	153.6	514.0	195.0	348.6
Senegal	40.0	519.4	12,379.7	851.0	253.0	12,672.7
Tanzania	22.9	1,144.9	90.7	867.0	337.0	450.6
Average	*32.7*	*2,701.6*	*2,429.6*	*614.2*	*281.3*	*2,694.1*

Source: Authors' calculation, based on IFPRI (2015b), GAFSP (2016), Grow Africa (2016), and New Alliance/Grow Africa (2015).

Notes: GAFSP = Global Agriculture and Food Security Program, referring to the public-sector window of financing. Blank cell means no amount was received as the GAFSP proposal was not funded or no investment was made as the country has yet to join Grow Africa or New alliance.

Regarding the puzzling increase in the prevalence of adult undernourishment with respect to those that signed their compact in 2007–2009, this is likely due to the quality of the investment plans or the actual investments made relative to nutrition security in the reference countries. At the start of the CAADP process, although food and nutrition security were among the areas being planned on and budget allocated to, the general concept of the NAIP was what was strongly articulated. It was not until after the launch of the L'Aquila Food Security Initiative in 2009 that the concept of a national agricultural and food security investment plan (NAFSIP) began to be articulated and to influence the focus areas of the plans and budget allocation (see, for example, Benin 2014). Therefore, those that signed their compacts and developed their NAIPs or NAFSIPs later were more likely to have given special treatment to food and nutrition security or allocated a higher budget to it, which may have led to the seemingly puzzling results. Based on the budget allocated to the different areas in the investment plans, results presented in Benin and Yu (2013), based on a review of 18 country NAIPs, showed that very few countries made explicit budget allocation to food and nutrition security. Of the seven countries that had an explicit allocation, six of them signed their compact in 2007–2009 and had an average allocation of 31.3 percent,

as opposed to only one country that signed in 2010–2012 and had an allocation of 46.9 percent.[9] Because the budget allocations stated in the NAIPs more likely reflect the policies or wishes of the government at the time of preparing the NAIPs, further research that focuses on the actual amounts spent on nutrition security and involving more countries is needed to evaluate the puzzle.

The negative impact on land and labor productivity for the group of countries that signed their compact in 2007–2009 and that reached levels 2 or 3 of implementation is due to a mix of data issues and, likely, the quality of investment plans or actual investments on raising agricultural productivity. Regarding the data issue, the group that signed the compact in 2007–2009 and that reached level 2 of implementation includes only one country (Cape Verde), which means there is no cross-country variation in the data for the group. As such, a similar cautionary note as with the puzzling case on agricultural spending is applicable here. Looking again at the budget allocation results presented in Benin and Yu (2013) for seven countries that signed their compact in 2007–2009, those that reached level 3 of implementation had an average allocation of about 46 percent of the total budget to raising productivity, compared with 55 percent for those at level 4.[10] Again, further research on the actual amounts spent on different productivity-enhancing interventions and involving more countries is needed to draw more concrete implications.

[9] This is based on the average shares of the total budget allocated to "food and nutrition security and emergency preparedness" as reported in Benin and Yu (2013) for seven countries: those that singed their compact in 2007-2009 = Benin (44.7 percent), Ethiopia (17.1 percent), Gambia (15.2 percent), Ghana (36.9 percent), Liberia (39.9 percent), and Sierra Leone (33.7 percent); and the only one that singed its compact in 2010-2012 = Malawi (46.9 percent)

[10] This is based on the average shares of the total budget allocated to "productivity, growth, or income" as reported in Benin and Yu (2013) for seven countries that signed their compact in 2007–2009: those that reached level 3 = Burundi (55.9 percent), Sierra Leone (17.3 percent), and Togo (66.1 percent); and those that reached level 4 = Benin (55.9 percent), Ghana (55.7 percent), Nigeria (35.5 percent), and Rwanda (37.7 percent).

5. CONCLUSIONS AND IMPLICATIONS

This paper attempts to quantify the impact of CAADP on several target and outcome indicators using panel data on 46 African countries from 2001 to 2014. A difference-in-difference treatment-effect model was used to estimate the treatment effects of CAADP on agricultural expenditure, agricultural value-added, land and labor productivity, income (GDP per capita), and nutrition (prevalence of adult malnourishment). Two definitions of treatment were employed: a dichotomous variable of whether a CAADP compact is signed and a five-ordered level of the stage of CAADP implementation reached, comprising precompact (level 0), compact signed (level 1), NAIP developed (level 2), and accessed one (level 3) or more than one (level 4) external sources of funding. Two estimation methods (potential outcome approach and fixed-effects regression approach) and different model specifications involving nested subsets of explanatory variables were used to assess the sensitivity of the results and to generate greater confidence in the findings. Because the implementation of CAADP involves several processes that take time to be institutionalized—and whose effect takes time to materialize—the treatment effects are expected to be larger for those countries that signed their compact earlier than later and, similarly, for those that reached higher rather than lower levels of implementation. The main findings and implications are summarized below.

Factors Influencing Signing a Compact or Level of Implementation Reached

Based on a conceptual framework that draws mostly on the literature on compliance with international agreements or treaties and on national policy decision-making processes, we find that variables representing the relevance of CAADP (measured by the importance of agriculture in the economy), political will (prior signatory to other AU charters), peer pressure (share of neighboring countries that are implementing CAADP), and government implementation capacity have a generally positive influence on a country to implement CAADP, as expected. Variables representing negotiation posture in the AU (measured by income and total expenditure) have a negative influence, likely reflecting alternative or nonagricultural sources of development. Variables representing citizens' demands and capacity are not as important or are weakly significant.

Impact of CAADP on Agricultural Performance, Income, and Nutrition

Results show that the impact of CAADP on agriculture expenditure (measured as a share of total expenditure or agriculture value-added) is generally negative, though it is statistically significant for the group of countries that reached level 4 of CAADP implementation (estimated range of –23.0 percent to –20.1 percent). This finding suggests a substitution effect between governments' own funding and external sources of funding for the sector, which is not surprising as countries at level 4 of implementation have access to two or more sources of external funding for the sector, most of which tend to be off budget. The estimated impact on agricultural value-added is positive: 16.7 percent for the group of countries at level 4, 10.8 percent for level 3, 7.4 percent for level 2, and 8.6 percent for level 1. The impact on land and labor productivity is mixed: it is positive for countries at levels 1, 3, and 4 (estimated at 8 percent to 17 percent) but surprisingly negative for those at level 2 (estimated at –9 percent to –7 percent). The estimated impact of CAADP on income and nutrition is generally insignificant, which seems to suggest that the overall positive impacts on agricultural value-added and land and labor productivity have not yet infiltrated into the general economy.

Further tests on the treatment effects from interactions between specific periods of compact signing with levels of implementation reached reveal or enhance some puzzling results. These results are counter to expectations presented in the conceptual framework, which stated that countries that signed their compact early or that reached higher levels of implementation were more likely to have larger and positive impacts on the outcomes. For example, the group of countries that signed their compact in 2007–2009 and that reached level 2 or 3 of implementation had a negative impact as compared with the

generally positive impact found. Similarly, those that signed their compact in 2007–2009 had an increase in the prevalence of adult undernourishment compared with a decrease for those that signed their compact in 2010–2012. Against the general substitution effect found with respect to the impact on agricultural spending, those that signed their compact in 2010–2012 and that reached level 3 of implementation had a positive impact. The puzzling result of the negative impact on productivity for those that signed their compact in 2007–2009 and that reached the level 2 implementation, as well as of the positive impact on spending, is likely due to data issues—there were few observations and, thus, little variation in the data for the specific country groups being evaluated. Regarding the negative impact on productivity observed for those that signed their compact in 2007–2009 and that reached level 3 of implementation, and of the negative impact on nutrition for those that signed their compact in 2007–2009, these are likely due to the quality of the investment plans or the actual investments undertaken in these areas. This finding is suggested by the limited results from previous studies on stated budget allocations in selected NAIPs. This calls for further research on actual amounts spent on different productivity-enhancing and nutrition-security interventions in the different CAADP countries.

Overall Implications

Because CAADP is a framework for inclusive stakeholder participation, ownership, evidence-based policy making, and donor alignment for an agricultural-led development, several interconnecting processes and activities take time to gain buy-in from all the stakeholders in order to safeguard successful implementation. As such, finding a shortcut is unlikely. A process that is likely to yield benefits would be one that includes a systematic effort to identify strategies that are likely to work (as expected of the growth options and investment and capacity requirements analyses), to articulate those strategies in a plan that is adequately funded and implemented accordingly, and to monitor and evaluate progress to continuously refine the investments and programs. Because the positive impacts found in this paper are not universal, with lower or negative impacts obtained for some groups of countries, it is important to continue to innovate in ways that sustain or raise the returns to effort, including transitioning from growth that is driven by expansionary agricultural production process to growth that derives from shifting out of the agricultural technological frontier (Benin and Nin-Pratt 2016). Further research on the quality of the processes in developing and implementing CAADP, as well as on the investments in different productivity-enhancing and nutrition-security interventions, in the different countries is needed to substantiate or refute these hypotheses.

APPENDIX: SUPPLEMENTARY TABLE

Table A.1 Summary of estimated treatment effects of CAADP using different methods and model specifications, 2001–2014

Method/variable set	ΔAgExpsh	ΔAgExpint	ΔAgvaland	ΔAgvalabor	ΔAgva	ΔGDPpc	ΔNourish
Fixed-effects for whether CAADP compact signed							
IMR only	-4.40	-3.59	-4.69 *	-5.51 *	-1.60	-0.11	3.08
IMR+initial	-0.57	-2.60	-2.49	-6.18	4.66	0.55	1.04
IMR+initial+crisis	-0.63	-4.29	-2.55	-6.16	4.82	0.38	1.02
IMR+initial+crisis+other	-3.59	-1.89	-6.55	-4.13	4.94	-0.46	1.27
Fixed-effects for level of CAADP implementation, conventional ordered logit							
IMR only							
Level 1	8.05	-2.77	5.92	4.46	5.40	0.70	2.09
Level 2	3.87	1.16	-14.79 ***	-11.91 ***	-1.13	1.56	3.30
Level 3	13.75	21.39	-5.79	-3.70	-1.18	3.57	2.99
Level 4	-4.85	-5.46	-2.83	-0.12	3.03	4.05	-0.46
IMR+initial							
Level 1	2.94	-4.54	11.22 *	8.39	5.91	-0.06	-0.86 *
Level 2	-1.00	-2.52	-11.63 **	-8.73 *	3.43	0.46	-0.74
Level 3	7.73	17.32	-5.76	-3.29	2.98	2.11	0.07
Level 4	-19.68	-10.86	9.84	12.33 **	12.59 **	3.45	-1.67 *
IMR+initial+crisis							
Level 1	3.14	0.85	8.96 *	6.22 *	4.13	0.26	-0.32
Level 2	-0.84	1.76	-13.81 **	-10.92 *	1.80	0.70	-0.29
Level 3	7.88	21.61	-7.29	-4.77	1.47	2.28	-0.52
Level 4	-19.51	-6.03	7.69	10.40 **	10.77 **	3.74	-1.10
IMR+initial+crisis+other							
Level 1	-3.27	-0.93	8.91 *	10.88 *	5.87 *	-0.39	-0.23
Level 2	-4.77	-0.55	-11.33 *	-14.38 ***	2.65	0.52	-0.53
Level 3	6.12	7.94	-1.02	-3.89	4.33	1.12	1.16
Level 4	-22.96 *	-17.19	15.08 ***	13.41 ***	15.17 ***	3.24	-0.96

Table A.1 Continued

Method/variable set	ΔAgExpsh	ΔAgExpint	ΔAgvaland	ΔAgvalabor	ΔAgva	ΔGDPpc	ΔNourish
Fixed-effects for level of CAADP implementation, generalized ordered logit							
IMR only							
Level 1	1.85	-11.50	8.02	5.67	4.71	-1.95 *	3.34
Level 2	-4.21	-19.48 **	-6.86 ***	-5.75 **	2.84	-1.56	4.29 **
Level 3	5.11	-7.17	6.07 *	5.40	5.74	0.31	3.88
Level 4	-16.39	-23.52 **	4.85	4.36	6.55	1.81 **	0.07
IMR+initial							
Level 1	1.40	-12.84	12.13 **	6.77	8.48 **	-1.08	0.80
Level 2	-0.39	-18.20 *	-6.22 *	-8.19 **	8.56 **	-0.51	0.97
Level 3	10.27	-4.24	2.61	-1.30	9.52 **	1.06	1.85
Level 4	-18.62 **	-21.19 **	15.00 ***	10.82 ***	16.84 ***	2.52 **	-0.28
IMR+initial+crisis							
Level 1	0.62	-10.79	11.28 **	5.88	7.26 **	-0.90	0.90
Level 2	-1.55	-14.88 *	-7.56 *	-9.63 **	6.62 **	-0.23	1.08
Level 3	9.17	-0.92	1.17	-2.84	7.27 **	1.37	1.96
Level 4	-19.72 **	-17.81 *	13.62 ***	9.42 ***	14.93 ***	2.83 **	-0.16 *
IMR+initial+crisis+other							
Level 1	-3.99	-4.98	12.90 **	8.74 *	8.57 **	-1.27	1.08
Level 2	-5.10	-7.80	-6.97 *	-9.04 **	7.43 **	-0.31	1.09
Level 3	6.32	-2.27	8.27 **	3.58	10.85 **	-0.16	2.96
Level 4	-23.02 ***	-20.11 **	16.52 ***	11.56 ***	16.73 ***	1.49	-0.11
Potential outcome approach of period CAADP compact is signed							
2007–2009							
Treatment only	-0.32	1.81 *	-1.24 **	-0.01	-0.89 **	-0.36 **	1.67 **
Treatment+initial	2.78	-2.95	1.15 *	1.29 *	0.67	-0.38	1.37 **
Treatment+initial+other	4.22 *	-0.39	0.40	0.67	-0.21	-0.42	n.e.
2010–2012							
Treatment only	-0.39 **	1.89 **	-1.34 **	-0.01 **	-0.98 **	-0.39 **	1.79 **
Treatment+initial	6.89 ***	6.06 ***	1.21 ***	0.12	2.14 ***	-1.02 **	0.90 ***
Treatment+initial+other	8.57 ***	8.70 ***	0.61	-0.30	1.40	-1.15 *	n.e.
2013–2014							
Treatment only	1.19	-5.77	4.09 ***	0.04	2.99 **	1.18	n.e.
Treatment+initial	1.66	-6.23	4.01 ***	0.97	3.02 **	0.19	n.e.
Treatment+initial+other	-1.47	-8.65	13.47 *	11.38 **	13.17 **	-2.12	n.e.

Source: Authors' calculation, based on potential outcome model results.

Notes: Δ means the dependent variable is measured as the annual percentage change for the fixed-effects method and the average annual percentage change from 2001 to 2014 for the potential outcome approach. For subsets of explanatory variables, treatment = treatment variable; IMR = treatment variable and inverse mills ratio; initial = lagged or baseline (2001–2003) values of the outcome variables; crisis = dummy variable equal to 1 from 2009 onward and 0 otherwise; and other = other relevant explanatory variables. Table 3.2 provides a detailed description of the variables. For the fixed-effects method, the number of observations is 644 (46 countries over 14 years). For the potential outcome approach, the number of observations is 13 treated and 33 untreated for 2007–2009, 16 treated and 17 untreated for 2010–2012, and 8 treated and 9 untreated for 2013–2014. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. n.e. = not estimated due to insufficient observations.

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