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Markus Brückner and Mark Gradstein

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Markus Brückner, National University of Singapore
Mark Gradstein, Ben-Gurion University and CEPR

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Centre for Economic Policy Research
77 Bastwick Street, London EC1V 3PZ, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

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ABSTRACT

Effects of Transitory Shocks to Aggregate Output on Consumption in Poor Countries*

This paper provides instrumental variables estimates of the response of aggregate private consumption to transitory output shocks in poor countries. To identify exogenous, unanticipated, idiosyncratic and transitory variations in national output we use year-to-year variations in rainfall as an instrumental variable in a panel of 39 sub-Saharan African countries during the period 1980-2009. Our estimates yield a marginal propensity to consume out of transitory output of around 0.2. To explain this result we show, using instrumental variables techniques, that there is a significant negative effect of transitory output shocks on net current transfers and a significant positive and quantitatively large effect on the trade balance. An important implication is that frictions to private financial flows do not necessarily imply large effects of transitory shocks to aggregate output on private consumption in poor countries.

JEL Classification: E21, F32, F35, F41 and O55
Keywords: consumption, international capital flows, net current transfers, permanent income hypothesis, risk sharing and transitory output shocks

Markus Brückner
Department of Economics
National University of Singapore
AS2 Level 6, 1 Arts Link
Singapore 117570
SINGAPORE

Email: ecsbm@nus.edu.sg

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Mark Gradstein
Department of Economics
Ben-Gurion University
Beer-Sheva 84105
ISRAEL

Email: grade@exchange.bgu.ac.il

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1. Introduction

Empirical studies of saving rates across countries typically find that these are positively correlated with economic growth and that, especially in developing countries, financial frictions play an important role for savings behavior (see, for example, Edwards, 1996, and Loayza et al., 2000). These results, in turn, may suggest limits to consumption smoothing in developing countries, thus challenging the permanent income theory of consumption (Friedman, 1957, Hall, 1978); evidence for the effect of financial frictions on consumption smoothing is presented in, for example, Japelli and Pagano, 1989, 1994. Specifically, Japelli and Pagano, 1989, find that consumption tends to be less smooth in countries with strong financial frictions. Further, there is mounting evidence that private financial flows to poor countries are quite limited, particularly because of institutional rigidities, see Alfaro et al., 2007, 2008, and Papaioannou, 2009. While this should impede private financial flows, inhibiting the opportunities for consumption smoothing, net transfers in poor countries that ultimately affect their current account, including aid and remittances, may theoretically make up for such impediments. It is, therefore, important when studying consumption smoothing in poor countries, to specifically explore the net current transfer channel in this regard.

This paper's point of departure is that existing empirical macroeconomic studies of consumption smoothing have had difficulty in disentangling transitory (and unanticipated) from permanent shocks and using strictly exogenous variations in aggregate output. In particular, from a theoretical point of view, consumption responses should differ depending on the transitory nature of the shock. In this paper, therefore, we seek to complement the existing empirical studies of aggregate consumption responses by focusing on the effects of transitory output shocks on private consumption in the context of poor and largely agrarian sub-Saharan African countries. We focus on the group of sub-Saharan African countries because this enables us to build on prior literature that has established a robust effect of year-to-year rainfall variations on aggregate output (Miguel et al., 2004; Brückner and Ciccone, 2011). In particular, because rainfall is exogenous, unanticipated, and has a transitory effect on aggregate output only, we can use rainfall as an instrumental variable to study the aggregate consumption response to transitory output shocks.[1]

While there is a substantial within-country correlation in the data between output and consumption, our instrumental variables estimates reveal a quantitatively small response of consumption to transitory output shocks: controlling for country and year fixed effects as well as country-specific linear time trends, the estimated marginal propensity to consume out of transitory output is around 0.2. The IV estimate of the marginal propensity to consume out of transitory output is thus positive, significantly different from one, but not significantly different from zero. This result may seem surprising because the countries in the sample are among the world's poorest, with much institutional rigidity (see Alfaro et al., 2007, 2008, and Papaioannou, 2009, where such rigidity appears to be a major obstacle for private financial flows to poor countries).

In contrast to the instrumental variables estimates, the least squares estimates of the marginal propensity to consume are in all specifications large and significantly different from zero at the 1 percent significance level. Quantitatively, the least squares estimates of the MPC are around 0.5, thus more than twice the size of the IV estimates. The significant difference between least squares and IV estimates suggests that it is not simply measurement error in aggregate consumption data that is driving the quantitatively small IV estimate of the MPC. Instead, the estimation strategy is crucial for correctly identifying the response of aggregate consumption to transitory output shocks. In particular, the least squares estimates capture the response of consumption to (a weighted average of) transitory and permanent output shocks. The least squares estimates are, therefore, not informative about the response of aggregate consumption to a transitory output shock.[2]

1 Japelli and Pistaferri, 2010, view distinguishing between insurance against unanticipated shocks and precautionary behavior with anticipated shocks as driving forces of consumption smoothing a main challenge for empirical research; this paper contributes to this issue by focusing on clearly transitory shocks.

It is important to realize that, despite frictions to private financial flows, international trade is not negligible for the group of sub-Saharan African countries: the sample average ratio of exports plus imports over PPP GDP exceeds 60 percent. When we examine the response of the trade balance to transitory output shocks, we find that it is strongly pro-cyclical. Our instrumental variables regressions yield that a one percent decrease in GDP per capita decreases the net exports to GDP ratio by around 1 percentage point. This suggests that the effects of transitory aggregate output shocks on private consumption in sub-Saharan African countries are dampened significantly because of pro-cyclical changes in net exports. International trade is thus a vehicle for keeping consumption smooth in the presence of transitory aggregate output shocks in sub-Saharan African countries. It is interesting to note that when we look at foreign direct investment and portfolio investment we find quantitatively small and statistically insignificant effects, which is consistent with the view of significant frictions in developing countries to private capital flows.

An important characteristic of the group of sub-Saharan African economies that is relevant when examining the response of consumption to transitory output shocks is the size of net current transfers. As a ratio of PPP GDP net current transfers comprise nearly 4 percent. We argue that, when motivated by altruism, such transfers may help poor, credit-constrained countries to keep consumption smooth in the presence of transitory shocks to aggregate output. In fact, rich countries may find it in their best interest to use such transfers

2 To see this formally, suppose the true model is $C=a_1Y^{Trans}+a_2Y^{Perm} + u$, where a_1 is the response of consumption, C, to a transitory shock to output, Y^{Trans}; a_2 is the response of consumption to a permanent shock to output, Y^{Perm}. C and Y may be measured with some error, i.e. $C^*=C+e_1$; $Y^*=Y+e_2$. An IV regression of C^* on Y^* which uses the observed data on consumption, C^*, and output, Y^*, and rainfall as an instrument yields: $a^{IV}=cov(Rain,C^*)/cov(Rain,Y^*)=cov(Rain, a_1Y^{Trans}+a_2Y^{Perm} +u + e_1)/cov(Rain,Y+e_2)$. Since year-to-year variations in rainfall have a transitory effect on output they, by definition, do not affect Y^{Perm} (i.e. $cov(Rain,Y^{Perm})=0$). It follows that $a^{IV}=a_1$, if and only if, year-to-year variations in the instrument (rainfall) do not affect systematically the errors made in the national account statistics (i.e. $cov(Rain, e_1)=cov(Rain,e_2)=0$); and $cov(Rain, u)=0$. By contrast, the least squares estimate is $a^{LS} = cov(C^*,Y^*)/Var(Y^*) = cov(a_1Y^{Trans}+a_2Y^{Perm} + u + e_1, Y+e_2)/Var(Y+e_2)$. Thus, the weights on a_1 and a_2 depend on the variances (and covariances) of Y^{Trans} and Y^{Perm}. The measurement error bias depends on the signal-to-noise ratio and the covariances of the two measurement errors, e_1 and e_2.

to achieve this goal. We find empirical support for this view, whereby transfers are strongly countercyclical with respect to transitory output shocks. Our instrumental variables regressions yield that a one dollar decrease in GDP per capita increases net current transfers by around 0.2 dollars. Thus, about one-quarter of the consumption smoothing in sub-Saharan African countries that occurs due to transitory rainfall-induced output shocks is financed via net current transfers.

It should be noted that this consumption smoothing mechanism of net current transfers, which comprise mostly aid and migrant remittances, is distinct from the private financial flow mechanism that Alfaro et al., 2007, 2008, and Papaioannou, 2009, focus on. This is because net current transfers, in contrast to private financial flows, are international transactions of economic value that do not have a quid pro quo.

The rest of the paper proceeds as follows. The next section contains some theoretical background and literature review. Section 3 describes the data. In Section 4 we discuss the estimation strategy. In Section 5 the main results are presented. In Section 6 we present further empirical results to demonstrate the robustness and quality of our instrumental variables estimates. Section 7 concludes with brief remarks. A supplementary online appendix contains additional results.[3]

2. Theoretical Background and Related Literature

2.1 Theoretical Background

Standard neoclassical theories of consumption stipulate that consumption should mostly respond to unpredictable and permanent income changes (Friedman, 1957, Deaton, 1991, Hall, 1978). While these insights were originally formulated in the context of a closed

3 The supplementary online appendix can be downloaded from https://sites.google.com/site/markusbrucknerresearch/research-papers

economy, they have also been extended to the open economy context. In particular, the basic textbook model of the intertemporal approach to the current account, see e.g. Obstfeld and Rogoff, 1995, 1996, predicts that, in the absence of frictions to international capital flows, a transitory shock to a countries' aggregate income has: (i) negligible effects on current private consumption; (ii) intertemporal consumption smoothing occurs via changes in the countries' net exports which implies that there needs to be a change in the current account. To clarify the essence of these two predictions it is useful to recall the national income accounting identity:

(1) $$Y_t=C_t+I_t+G_t+NX_t$$

Equation (1) makes it clear that if private consumption, C, does not respond to a shock that changes aggregate income, Y, then other components have to move. The basic textbook model predicts that for a small open economy with perfect integration in world financial markets it is net exports, NX, that change. In other words, consumption smoothing is achieved by exporting goods if a positive shock hits aggregate output and by importing goods if a negative shock hits.

In the textbook model, however, such a change in net exports entails changes in intertemporal obligations between countries. For example, in chapter 1 of Obstfeld and Rogoff, 1996, one finds the following formula for the current account:

(2) $$CA_t\equiv B_{t+1}-B_t=Y_t-C_t-G_t-I_t+r_tB_t=NX_t+r_tB_t$$

Equation (2) makes it clear that the current account captures changes in intertemporal obligations, i.e. changes in countries' net foreign assets, ΔB. From equation (2) one would conclude that a change in net-exports needs to lead to a change in the current account.

However, the key point of the foreign asset accumulation view of the current account is that the change in net foreign assets, ΔB, implies a change in obligations between (sovereign) countries, i.e. represents international trade over time (Obstfeld and Rogoff, 1996, p. 6). In that regard the international finance literature has come up with various reasons for why there may exist frictions to changes in countries' net foreign assets which, in turn, would inhibit movements in net exports according to equation (2). One reason that has gained particular attention in recent years is that frictions to changes in net foreign assets arise from institutional risk. See for example Alfaro et al., 2008 or Papaioannou, 2009. Such institutional risk factors are particularly pervasive in sub-Saharan Africa. Many of the sub-Saharan African countries are characterized by extremely severe corruption and weak law and order.[4] There exists hence a significant risk that claims by foreigners (i.e. property rights) are not respected in the future.

Thus, from the above point of view, one might expect that net exports cannot be a major vehicle for consumption smoothing in poor sub-Saharan African countries. We certainly agree with the literature that the institutional frictions view makes sense for private financial flows, such as, foreign direct investment and portfolio investment for which it appears safe to assume that they are motivated by (expected) profit-making. However, there is an additional component of the current account that in the context of net-exports acting as a vehicle for consumption smoothing in poor countries has not received much attention by the literature, namely, net current transfers. In particular, the full version of the current account is:

(3) $$CA \equiv \Delta B = NX + NCT + NFI$$

Equation (3) states that the change in a country's net foreign assets, ΔB, is equal to the sum of net exports, NX, net current transfers, NCT, and net factor income, NFI.

Net current transfers differ from other international capital flows in that they are international transactions of economic value which do not have a quid pro quo. Net current

4 Many of these countries consistently score among the worst in the world on measures of the quality of governance, see Kaufmann et al., 2008; Medard, 2002, discusses the sources of corruption in sub-Saharan Africa. See also Reinikka and Svensson, 2004, for a careful study documenting the extent of corruption in Uganda.

transfers can therefore be thought of as gifts. These gifts may well be motivated by an altruistic rather than profit-maximizing motive. In Appendix A of the supplementary online appendix we show that in poor countries which cannot (easily) borrow or lend in the international financial markets, say, due to institutional rigidities that create significant risk of expropriation of foreign investors, altruistically motivated net current transfers will help consumption smoothing.

In particular, beyond consumption smoothing, the model predicts that net current transfers are counter-cyclical with respect to country-specific transitory output shocks while net exports are pro-cyclical. As equation (3) makes clear, if net-exports are pro-cyclical but net current transfers are counter-cyclical the current account will not change. Hence, a substantial amount of consumption smoothing can occur vis-a-vis net exports in poor countries -- even if these countries face significant frictions in adjusting their net foreign asset position.

We now turn to reviewing relevant empirical work on consumption smoothing to better position our contribution in the empirical literature.

2.2 Related Empirical Literature

Empirical literature testing the consumption smoothing hypothesis consists of several parts. As the hypothesis was originally formulated with aggregate regularities in mind, first studies were conducted using aggregate data (see Attanasio and Weber, 2010, for a review). One potential issue with aggregate data is that the original hypothesis of consumption smoothing pertains to a representative agent framework. In particular, Attanasio and Weber, 1993, argue that agents' heterogeneity can introduce estimation biases when using aggregate consumption data. Based on quarterly data from the National Accounts (CSO Data Bank) and from the Family Expenditure Survey in the UK during the period 1970-1986, Attanasio and Weber, 1993, detect significant excess sensitivity when using aggregate data but not when using household data. They therefore argue that aggregate data can lead to significant estimation biases, and provide several theoretical explanations for why such aggregation biases can arise.

It is noteworthy that the empirical results in Attanasio and Weber, 1993, are obtained from an estimation strategy that does not use strictly exogenous instruments. Hence, as the authors point out in their paper, omitted variables (such as, for example, demographic factors) can lead to a bias when using aggregate data, whereas this type of bias does not arise if strictly exogenous instruments are used. There is, therefore, a concern that in Attanasio and Weber's, 1993, paper the difference in empirical estimates between household data and aggregate data arises because standard instrumental variable regressions that use internal instruments (i.e. lagged variables) suffer from omitted variables bias, which is well-known in the applied econometrics literature. Moreover, another reason why micro estimates may differ from macro estimates, and which goes beyond any sort of aggregation "bias", is that idiosyncratic household shocks, which could be also of a more transitory nature, are dominated in aggregate data by permanent shocks (e.g. changes in technology).

Thus, in search for a better identification, researchers turned to quasi-experimental contexts, as exemplified by the substantial amount of empirical micro studies on consumption smoothing in developing countries. For example, Paxson, 1992, uses specifically regional rainfall data as an IV for household income (in Thailand). Additional studies include, but are not limited to, Deaton, 1992, Dercon, 2004, Fafchamps and Lund, 2003, Foster and Rosenzweig, 2001, Kazianga and Udry, 2006, and Rosenzweig, 1988.[5]

One caveat of such micro-econometric studies of consumption behavior is the difficulty to control for spillover effects that can arise, for example, due to inter-regional migration, inter-regional goods trade, or inter-regional government transfers. Another, related

5 These studies, it should be noted, come up with differing evidence on household consumption smoothing, some supporting it, whereas others rejecting it.

caveat is that because micro-econometric studies use regional variation in incomes and consumption, the estimated effects are not informative about the response of consumption to an aggregate income shock (i.e. a shock that is perfectly correlated across regions).[6] For example, Kalemli-Oscan et al., 2003, in their analysis of risk sharing find that its pattern across regions is different from that across countries; in particular, inter-regional risk sharing is more pronounced than inter-country risk sharing. We thus complement the microeconometric work by using aggregate data, which enables us to focus on aggregate private consumption as a general equilibrium phenomenon.

Another literature that deals with related issues in the context of an open economy focuses on the behavior of the current account, see Feldstein and Horioka, 1980, and Ghosh, 1995, for some leading contributions. It typically tends to focus on developed economies and struggles distinguishing between permanent and transitory shocks as well as with identifying clearly exogenous variations in aggregate output.

Thus, to the best of our knowledge, ours is the first paper to use detailed year-to-year rainfall data as a transitory, unanticipated, and exogenous shock to aggregate output to study aggregate private consumption responses in a large sample of poor countries.[7] And, as argued in Section 2.1 above, our empirical analysis of the response of the trade balance as well as net current transfers also aims at making a contribution to the literature on the intertemporal approach to the current account.

In a recent paper Arezki and Brückner (2012) used rainfall in sub-Saharan African countries to examine the response of one particular component of net current transfers: migrant remittances. These authors do not, however, provide estimates of the private

6 The reason is that for a perfectly correlated shock there would be no regional variation left from which to identify the (aggregate) effect.

7 In contrast to microeconometric work, aggregate studies of the permanent income hypothesis, particularly in the context of developing countries are rare (see Loayza et al., 2000, for such an attempt), presumably because of identification difficulties.

consumption response to transitory output shocks, i.e. they do not test consumption smoothing in sub-Saharan African countries. Intertemporal consumption smoothing is a cornerstone of modern macroeconomic models. It is therefore important to know whether at the macroeconomic level the data supports or rejects the hypothesis of consumption smoothing. Furthermore, the empirical analysis in our paper goes far beyond Arezki and Brückner (2012) in several other important dimensions. One is that Arezki and Brückner do not provide estimates of the response of the trade balance. Changes in the trade balance to country-specific output shocks are the main mechanism of consumption smoothing in basic models of the intertemporal approach to the current account. However, as discussed in detail in Section 2.1, the literature on country-specific risk (in particular, risk arising from poor institutional quality) viewed consumption smoothing vis-a-vis the current account as limited. In light of this literature, we provide estimates of the effects that transitory output shocks have on net exports and on net current transfers. As argued in Section 2.1, if net current transfers are counter-cyclical but net exports are pro-cyclical consumption smoothing can take place even if there are significant frictions to adjusting the country's net foreign asset position. Of course, what matters for this mechanism is the response of total net current transfers and not just migrant remittances. Beyond this mechanism of net current transfers, we also explore other mechanisms that could explain consumption smoothing, such as, variations in the terms of trade, population size, and private financial flows.

3. Data

National Accounts Data. In order to estimate the macroeconomic effects that shocks to countries' output have on private consumption we need aggregate data. Our main data source is the Penn World Table, version 7.0 (Heston et al., 2011). The PWT provides purchasing power parity (PPP) adjusted national accounts data for a large set of countries and time span. We use PPP data because, in the empirical analysis, we will be interested in examining how net exports affect countries' ability to smooth consumption. Exports and imports are tradables so it is appropriate to value this series in US dollars; however, GDP and consumption also consist of non-tradables, hence, for purposes of international comparison these series need to be measured in PPP terms (see also Alcala and Ciccone, 2004).

Our main measure for countries' real output per capita is the PPP converted GDP per capita series (*rgdpl*) from the Penn World Table, version 7.0 (Heston et al., 2011). This is a Laspeyres constant price series at 2005 prices. Other relevant series of countries' PPP GDP per capita provided by the PWT are a chain-series adjusted constant price PPP GDP per capita (*rgdpch*); PPP converted Gross Domestic Income (GDI) per capita (*rgdptt*), which is the *rgdpl* series adjusted for income effects arising from changes in countries' terms of trade; and current US dollar Geary-Khamis PPP converted GDP per capita (*cgdp*). The sample correlations for the levels (growth rates) of these series are all in excess of 0.98 (0.80), thus, in practical terms, there is some difference between these series but that difference is not large. For a thorough discussion of the exact details how the PWT series are constructed we refer the reader to Deaton and Heston (2010). We will examine the sensitivity of the specific GDP series used in our econometric analysis in Section 5.2.

Another issue in our empirical analysis of consumption smoothing in poor countries is that conceptually there is a difference between Gross Domestic Product (GDP) and Gross National Product (GNP). GNP measures the total domestic and foreign value added claimed by residents, and comprises GDP plus net receipts of primary income (compensation of employees and property income) from nonresident sources. Yet, the sample ratio of PWT GNP over GDP is 0.97. The sample correlation between PWT GDP and GNP is 0.99 for the levels and 0.93 for the growth rates. Hence in practical terms, while there is some difference between GDP and GNP, the difference is not large. We will examine the empirical consequences of using GNP instead of GDP in Section 5.2.

We compute countries' consumption per capita by multiplying the country-year specific private consumption shares of PPP converted GDP (*kc*) with PPP converted GDP per capita (*rgdpl*). Based on the PWT data, we calculate the domestic savings rate, *s*, as 1-*kc*-*kg* where *kg* is the government consumption share of PPP converted GDP. The net exports to PPP GDP ratio is calculated as 1-*kc*-*kg*-*ki*, where *ki* is the investment share of PPP converted GDP. The descriptive statistics in Table 1 show that the average domestic savings rate for the group of sub-Saharan African countries is around 10 percent. The descriptive statistics also show that the share of private consumption in GDP is quite high: around 0.8 with a panel standard deviation of 0.25. The net-export to GDP ratio is negative, -0.09, indicating that, on average, sub-Saharan African countries ran trade deficits.

The reason why we choose the PWT as our main source of data is that for the sample of sub-Saharan African countries it provides a much larger number of observations for real consumption per capita than the WDI. For our sample of 39 sub-Saharan African countries during 1980-2009, PWT provides 976 country-year observations for PPP consumption and PPP GDP per capita. The number of country-year observations that the WDI provide for PPP consumption per capita is 718. Hence, the PWT provides roughly more than one-third as many observations as the WDI data. This is also the case if we use from the WDI data on constant price GDP and private consumption. The WDI provides a total of 742 overlapping country-year observations for constant price GDP and private consumption in local currency units for the sample at hand. Given recent literature that has pointed to measurement errors in PPP data (e.g. Feenstra et al., 2009; Johnson et al., 2013) we will examine robustness to using WDI data on consumption and GDP in Sections 5 and 6. We will also examine robustness to using the WDI data on the GDP share of the external balance of goods and services. Like the PWT data, the WDI data on the net-export to GDP ratio is negative, -0.10, and hence indicates that on average sub-Saharan African countries ran substantial trade deficits. We note that, in contrast to least squares estimates, measurement errors will not lead to inconsistent instrumental variables estimates as long as the errors are uncorrelated to rainfall.

Rainfall. The data on year-to-year variation of rainfall are from the National Aeronautics and Space Administration (NASA) Global Precipitation Climatology Project (GPCP), version 2.1 (Adler et al., 2003). These rainfall data are available since 1979 and they come on a 2.5°x2.5° latitude-longitude grid. We aggregate the rainfall data to the country level by assigning grids to the geographic borders of countries. We use satellite-based rainfall data because these data have a number of important advantages over gauge-station based rainfall data. As pointed out in Brückner and Ciccone (2011), satellite-based rainfall data are less likely to suffer from the measurement error that is due to the sparseness of operating gauge stations in sub-Saharan African countries (especially after 1990). Also, as Brückner and Ciccone (2011) point out, the number of operating gauge stations in a country may be affected by socio-economic conditions, which could lead to non-classical measurement error in gauge-station based rainfall estimates.

Net Current Transfers. We obtain data on net current transfer payments, in current US dollars, from the World Development Indicators (2011). According to WDI, net current transfers are recorded in the balance of payments whenever an economy provides or receives goods, services, income, or financial items without a quid pro quo. These transfers mainly comprise foreign aid (including aid from NGOs) and migrant remittances. For the sub-Saharan African countries net current transfers constitute a significant income factor: the ratio of net current transfers in PPP GDP (from PWT) is around 0.04.

Other Data. Data on net foreign direct investment and portfolio investment are from WDI (2011). Both of these series are in current US dollars. We normalize them by PPP GDP in current US dollars. Data on population size and the labor force participation rate are from WDI (2011). Data on agricultural value added are from WDI (2011) and are in current US dollars. Data on the net barter terms of trade are from WDI (2011). Data on political institutions are from the Polity IV (2010) project. Our main measure is the Polity2 score that ranges between -10 and 10, with higher values denoting stronger democratic institutions. Civil conflict incidence data are from the Peace Research Institute Oslo (PRIO, 2010). The conflict incidence variable is a binary indicator that is one in the presence of civil conflict and zero otherwise.

4. Estimation Framework

We estimate the response of private consumption to transitory variation in GDP per capita using two-stage least squares estimation. The second stage equation is:

$$(4) \qquad \Delta\ln(Cons\ P.C.)_{ct} = a_c + b_c\, t + d_t + \beta\Delta\ln(GDP\ P.C.)_{ct} + z_{ct}$$

where a_c are country fixed effects; $b_c t$ are country-specific linear time trends; d_t are year fixed effects; $\Delta\ln(GDP\ P.C.)$ and $\Delta\ln(Cons\ P.C.)$ is the annual change in the log of real GDP per capita and private consumption per capita, respectively; z_{ct} is an error term that is clustered at the country level.

The corresponding first stage equation is:

$$(5) \qquad \Delta\ln(GDP\ P.C.)_{ct} = g_c + d_c\, t + f_t + \gamma\ln(Rainfall)_{ct} + e_{ct}$$

We base our decision rule on whether variables are used in levels or first-differences on the variables' time-series persistence.[8] We note that the panel unit root test of Im et al., 2003, cannot reject the hypothesis that the level of GDP per capita contains a unit root (p-value 0.94); however, the test easily rejects the null that the first difference contains a unit root (p-value 0.00). Therefore, we use the change in the log of GDP per capita as the main

8 Specifically, in the context of using rainfall as an IV for GDP, our specification differs from Miguel et al. (2004) who do not tailor their analysis to the variable's persistence. In contrast, our approach follows the work of Brückner and Ciccone (2011) and Ciccone (2011).

explanatory variable. In a similar vein, we use the change in the log of consumption per capita as the dependent variable because the panel unit root test cannot reject the null of unit root (p-value 0.99), while it rejects the null of the first-difference having a unit root at the 1 percent significance level. Concerning rainfall, the panel unit root test rejected the null hypothesis of a unit root at the 1 percent significance level (p-value 0.00). This is not surprising since year-to-year variations in rainfall are highly transitory: controlling for country fixed effects and country-specific time trends, the average AR(1) coefficient on rainfall is 0.07 with a standard error of 0.03.

Under the exclusion restriction that rainfall affects private consumption through its effect on GDP, the two-stage least squares estimate β in equation (1) reflects the effect that transitory variations in GDP per capita have on private consumption. Thus, beyond correcting for possible bias that stems from reverse causality and omitted variables, an important advantage of our instrumental variables estimation framework is that it allows us to separate transitory from permanent variations in GDP. This is key to our estimation purpose since we are interested in estimating the response of private consumption to transitory variations in national output. We discuss and examine the exclusion restriction underlying our instrumental variables estimation in detail in Section 6.1.

5. Results

5.1. First-Stage Effects of Rainfall on GDP

Table 2 presents our first-stage estimates of the effect that year-to-year rainfall has on GDP per capita growth.[9] We first document in column (1) that year-to-year rainfall has a positive, but transitory effect on the level of GDP per capita. This can be seen from the estimated

9 All the estimates are based on the largest possible sample given the availability of data on rainfall, domestic savings, GDP, and net current transfers. For a list of the countries in the sample and the respective number of observations for each country, see Data Appendix Table 1.

coefficient on rainfall in year *t*, which is positive and significant, thus implying that on impact an increase in rainfall leads to a short-run increase in GDP per capita growth. The estimated coefficients on rainfall in year *t*-1 and *t*-2, while positive, are insignificant; and the estimated coefficients on year *t*-3 to *t*-5 rainfall are negative. Summing up the impact and lagged effects of rainfall on GDP per capita growth over the five year horizon yields a cumulative effect of -0.01 (standard error 0.03). This effect is quantitatively small and statistically insignificant, thus indicating that rainfall has a transitory effect on the level of GDP per capita.

In column (2) we report the first-stage effect that rainfall has on GDP per capita growth when only rainfall in year *t* is included as a right-hand-side regressor. Because the serial correlation in year-to-year rainfall is close to zero, it is not surprising that this yields a coefficient on year *t* rainfall that is very similar to the coefficient in column (1). The estimated elasticity coefficient on year *t* rainfall is 0.05 and has a standard error of 0.01. Hence, the first-stage effect of year *t* rainfall on GDP per capita growth is positive and highly statistically significant.

Economically, the elasticity coefficient of 0.05 implies that a ten percent increase in rainfall increases GDP per capita growth in that year by around 0.5 percentage points. This is quite a large effect. We can also get a sense of the economic significance of the link between rainfall and (short-run) GDP per capita growth of sub-Saharan African countries by using sample standard deviations. The sample standard deviation of GDP per capita growth is 0.07; for the log of rainfall it is 0.62. Hence, a first stage coefficient of 0.05 implies that approximately a one standard deviation change in rainfall induces a 0.4 standard deviation change in GDP per capita growth.

In column (3) we add year fixed effects to the right-hand side of the regression. The year fixed effects account for sub-Saharan Africa-wide shocks. For example, they account for variations in the world business cycle and global climate trends that are common across the sample countries. Adding these year fixed effects decreases the size of the estimated coefficient on rainfall somewhat, which is now 0.04, but still positive and significant at the 1 percent level. Columns (4) and (5) show that, when adding to the right-hand side of the regression country-specific linear time trends, the first-stage relationship between rainfall and GDP growth continues to be positive and highly significant. These country-specific time trends take into account that there are significant differences in sub-Saharan African countries' trends in rainfall and GDP per capita growth.

In columns (6) and (7) of Table 2 we show that rainfall's positive effect on GDP growth is robust to excluding extreme rainfall variations, i.e. severe droughts and floods. We do this by excluding (residual) rainfall observations that fall in the 5th and 95th percentiles of rainfall deviations from the country fixed effect, the country-specific linear time trend, and the year fixed effect. The main result is that excluding those extreme rainfall variations yields a slightly stronger first-stage fit. The estimated coefficient on year t rainfall is 0.06 and has a standard error of 0.02. The first-stage coefficient thus continues to be significantly different from zero at the 1 percent level when excluding large positive or negative rainfall observations.[10]

5.2 Response of Private Consumption

We now turn to discussing our instrumental variables estimates of the response of private consumption to transitory, rainfall induced GDP shocks. The IV estimates are reported in Panel A of Table 3. Column (1) shows estimates where the controls are country fixed effects only. The elasticity coefficient on GDP in this case is 0.5, significant at the 10 percent level. Columns (2) to (4) show estimates from a regression that includes year fixed effects and country-specific linear time trends as additional controls. The addition of these controls on

10 Appendix Table 1 in the supplementary online appendix documents that the first-stage estimates are robust to dynamic panel data estimation which controls for the lagged level of GDP per capita.

the right-hand side of the regression bears the result that the elasticity coefficient on GDP decreases; this result is consistent with the permanent income hypothesis since these controls capture trends and thus permanent variations in rainfall and GDP per capita growth.

In column (4), where the controls are country and year fixed effects as well as country-specific linear time trends, the estimated elasticity coefficient on GDP is 0.3. The 2SLS standard error is around 0.4, hence the 2SLS coefficient is not significant at the conventional significance levels. In column (5) we control for lagged consumption and this further decreases the elasticity coefficient on GDP to about 0.2. Given that the sample average share of consumption in GDP is 0.8, the implied marginal propensity to consume (MPC) out of transitory income is 0.14. We can reject the hypothesis that the MPC is equal to unity at the 1 percent significance level. However, we cannot reject the null hypothesis that the MPC is equal to zero (p-value 0.64). Columns (6) and (7) show that a similar result holds when we exclude large positive or negative rainfall shocks.

For comparison purposes, we report in Panel B of Table 3 the corresponding least squares estimates. These least squares estimates of the average elasticity response of consumption to GDP are positive and significant at the 1 percent level. Quantitatively, the least-squares coefficients range between 0.6 and 0.8. They are, therefore, quite a bit larger than the IV estimates.

The most likely reason for the difference between least squares and instrumental variables estimates is that the response of consumption to economic shocks depends on the shocks' persistence. This reason is in line with the permanent income hypothesis, according to which consumption should react little in response to transitory income shocks; in contrast, the consumption response to permanent shocks should be large. Because year-to-year variations in rainfall are highly transitory, the two-stage least squares estimates reflect the effect that a transitory GDP shock has on consumption. The least squares estimator captures on the other hand the average response of consumption to within-country GDP variations.

Variations in GDP contain both transitory and permanent shocks. Given this, the least squares estimates are smaller than the IV estimates because the least squares estimates reflect an average response of private consumption to permanent and transitory GDP shocks. This reasoning for why the least squares estimates of the consumption response are smaller is certainly not new. Aguiar and Gopinath (2007), for example, use a similar line of reasoning to identify the relative importance of permanent vs. transitory GDP shocks for emerging market business-cycles.[11]

In Table 4 we show that our finding of a quantitatively small and statistically insignificant private consumption response to transitory output shocks is robust to alternative measures of countries' national income. For our baseline estimates reported in Table 3, the measure of countries' aggregate output was PPP GDP per capita in constant US dollars. For the estimates reported in column (1) of Table 4 we substituted this variable with PPP GDP per capita in constant US dollars adjusted for the terms of trade (column (1)). The elasticity coefficient is in that case 0.2; the implied MPC is 0.16 and we can reject the hypothesis that the MPC is equal to unity at the 5 percent significance level. Hence, in comparison to the corresponding baseline estimates reported in column (5) of Table 3, using a measure of countries' national income that takes into account income effects arising from changes in the terms of trade yields very similar results.[12]

Related to the above point that changes in commodity prices might significantly affect sub-Saharan African countries' ability to smooth consumption, we report in column (2) instrumental variables estimates where the deflator for both GDP and private consumption is countries' consumer price index (CPI). For consumption the previous estimates were already based on deflating this series with the CPI. For GDP this is not the case, so we generated a

11 Another possible reason for why the least-squares estimates are larger than the instrumental variables estimates is reverse causality. If consumption has a positive effect on output, say, due to Keynesian effects (price rigidities), then the least squares estimates are upward biased.

12 We further examine the role that changes in countries' terms of trade play for consumption smoothing in Section 6.2.

CPI deflated GDP series by multiplying the PPP constant price GDP series with the PWT's GDP deflator and dividing by the CPI. The main result is that this adjustment is inconsequential. The elasticity coefficient on the CPI deflated GDP series is 0.15 and not significantly different from zero. If anything, using a CPI deflated GDP series suggests that consumption is smoothed even more than implied by our baseline estimates.

All the variables in our empirical analysis are in real terms, however, one issue is whether using a Laspeyres constant price series instead of a Chain-Series constant price series matters. In order to examine this, we report in column (3) of Table 4 instrumental variables estimates where we use the Chain-Series adjusted constant price PPP GDP per capita series. The main finding is that estimates are very similar with this alternative GDP series. The elasticity coefficient is 0.17. The implied MPC is 0.13. And we reject the hypothesis that the MPC is equal to unity at the 5 percent significance level. Hence, using a Chain-Series instead of a Laspeyres adjusted PPP GDP per capita series makes little difference. Column (4) of Table 4 also shows that results are very similar if we use the current $US PPP GDP and consumption data provided by the PWT.

Consumption smoothing is a test of the permanent income hypothesis and when testing consumption smoothing vis-a-vis GDP fluctuations, as we have done so far, we have only considered one component of countries' national income.[13] To examine the empirical implications of using a data series of countries' national income that accounts for net international factor payments we report in column (5) of Table 4 estimates that use countries' GNP. GNP includes in addition to GDP the net receipts of primary income from nonresident sources. Thus, GNP captures both the output produced within a country and net international factor payments. The main message of the estimates in column (5), however, is that using GNP instead of GDP makes little difference. The second-stage estimate on the log of GNP is 0.15 and implies an MPC of around 0.12 for which we can reject that it equals unity at the 1 percent significance level.

13 We are grateful to the editor for raising this point.

In column (6) of Table 4 we report instrumental variables estimates that have as dependent variable the change in the log of constant price consumption per capita and as explanatory variable the change in the log of constant price GDP per capita. Both of these variables are from WDI (2011). The first-stage relationship between rainfall and constant price GDP per capita is positive and highly significant: the coefficient on the log of rainfall is 0.06 and its standard error is 0.02. In the second-stage we find that within-country changes in constant price GDP per capita are not significantly related to within-country changes in constant price consumption per capita. The second-stage coefficient on the log of GDP per capita is 0.19 and its standard error is 0.35. The implied marginal propensity to consume out of transitory income is around 0.15, and we can reject that it is equal to unity at the 1 percent level. Using GDP and consumption data for the smaller sample for which constant price data are available from WDI yields hence similar results as in the larger sample that is based on PWT data.

In Table 5 we examine whether the response of consumption differs if we use instead of GDP only the value added generated in the agricultural sector. Panel A reports the first stage and second-stage estimates based on agricultural output (value added) and, for comparison purposes, Panel B of Table 5 reports the corresponding estimates for aggregate output (GDP) in exactly the same sample for which we have data on agricultural output. The main findings are as follows. First, the effects of agricultural output on private consumption are statistically insignificant and quantitatively small. The elasticity coefficient on the log of agricultural output is around 0.04 (0.06 and 0.01 if we exclude very large negative and positive rainfall shocks, respectively). The implied marginal propensity to consume is around 0.12 (0.16 and 0.03 if we exclude very large negative and positive rainfall shocks, respectively). Second, the effects on private consumption of aggregate output are statistically insignificant and quantitatively small. The elasticity coefficient on the log of GDP is around 0.18 (0.23 and 0.04 if we exclude very large negative and positive rainfall shocks, respectively). The implied marginal propensity to consume is around 0.14 (0.19 and 0.03 if we exclude very large negative and positive rainfall shocks, respectively). Thus, the main message from the analysis in Table 5 is that the response of private consumption to a unit change in aggregate output is very similar to the response of consumption to a unit change in agricultural output. In other words, (indirect) effects of rainfall that extend to the non-agricultural sector, for example, due to inter-sectoral input-output linkages or general equilibrium effects that occur due to factor movements between sectors have a similar impact on private consumption as effects that directly result from changes in agricultural value added.

5.3 Response of Net Current Transfers and the Trade Balance

In light of the literature that has pointed to significant frictions to financial flows in developing countries (e.g., Alfaro et al., 2007, 2008, and Papaioannou, 2009) our finding of a small private consumption response to transitory, rainfall-induced GDP shocks may be surprising. Certainly, sub-Saharan African countries' level of financial development is low. For example, for the group of sub-Saharan African countries in our sample, the GDP share of domestic credit to the private sector is 17 percent.[14]

However, despite sub-Saharan African countries' lack of financial development, it is important to realize that net current transfer payments to sub-Saharan African countries are large: these transfers constitute nearly 4 percent when measured as a ratio of PPP GDP. In Table 6 we document that net current transfers are strongly counter-cyclical. Controlling for the full set of fixed effects, the IV estimates in column (1) show that net current transfers as a fraction of GDP decrease by around 0.2 percentage points due to a one percent transitory increase in GDP. This effect goes up to 0.4 percentage points when excluding droughts and

14 For comparison purposes, according to WDI (2011), the average GDP share of domestic credit to the private sector during 1981-2007 in South Asia was 27 percent; in the Middle East and North African countries it was 35 percent; in Latin America and the Caribbean it was 34 percent; and in East Asia and the Pacific it was 145 percent.

floods (column (4)). If we do not measure transfers as a fraction of GDP, but instead as a change in the log (where we lose some of the observations with zero or negative transfer payment values), the IV estimates yield that a one percent increase in GDP significantly reduced net current transfers by around 4 to 5 percent.

The estimates in Table 6 imply quite a substantial consumption smoothing effect of net current transfers. The average share of net current transfers in PPP GDP is 4 percent. Hence, the elasticities in columns (3) and (6) imply that a one dollar drop in sub-Saharan African countries' GDP leads to an increase in transfers of about 0.2 dollars. The estimated MPC (see column (5) of Table 3) is around 0.2. Thus, net current transfers financed nearly one-quarter of the consumption smoothing.

In the supplementary online appendix (see pages 1-3 there) we present a simple model to further motivate this result. The model shows that with altruistic rich countries' donors, endogenously determined transfers help smooth consumption in financially constrained poor countries.

We document in Appendix Table 2 that there is also a negative effect of transitory GDP shocks on net current transfers when excluding migrant remittances.[15] As an average over the 1980-2009 period, migrant remittances to sub-Saharan Africa comprised less than 15 percent of net current transfers. However, migrant remittances have become increasingly important in recent years, comprising over 20 percent of net current transfers for the post-2000 period. The instrumental variables estimates in Appendix Table 2 imply that on average a one percent increase in GDP reduces the GDP share of net current transfers that excludes migrant remittances by 0.2 percentage points; and this effect goes up to 0.4 percentage points when excluding large positive or negative rainfall shocks. Hence, excluding migrant remittances from net current transfers leads to similar results.

15 As in all other tables, the estimates in Appendix Table 2 are for the largest possible sample; the number of observations decreases relative to Table 6 because WDI (2011) does not provide for all country-years data on migrant remittances.

In sum: our instrumental variables regressions yield a significant negative response of net current transfers to transitory GDP shocks. This finding echoes the findings of prior empirical research on the economic determinants of foreign aid and migrant remittances in developing countries (e.g. Yang and Choi (2007), Yang (2008), Arezki and Brückner (2012), Brückner (2013)). The analysis in this section shows that there is a significant counter-cyclicality of overseas transfers when focusing on the entire flow of net current transfers (rather than just counter-cyclicality of a specific item). This is an important result precisely because, when studying aggregate consumption responses, it is the entire flow of net current transfers that matters for poor countries' ability to smooth consumption.

We document in Table 7 that there is indeed a real transfer of international resources in response to transitory GDP shocks. Table 7 reports instrumental variables estimates of the effects that rainfall-induced GDP shocks have on the trade balance. The main finding is that the effects on the trade balance are positive, quantitatively large, and highly statistically significant. This is true regardless of whether we control for the full set of fixed effects; control for the lagged trade balance; or exclude large positive or negative rainfall shocks. Quantitatively, the estimates in columns (4)-(7) imply that a one percent transitory increase in GDP increases the trade balance by around 0.8 percentage points. Hence, the instrumental variables estimates indicate a strong pro-cyclicality of the trade balance. Or put in a slightly different way: country-specific shocks to aggregate output are absorbed in sub-Saharan African countries by changes in net exports; about one-quarter of the change in net exports is financed by a change in net current transfers.

5.4 Alternative Mechanisms: Private Financial Flows and Population Movements

A natural question that arises from the above analysis is this: how does the significant negative response of net current transfers to transitory GDP shocks square with the recent international finance literature that argues for significant frictions to private financial flows, in particular, frictions that arise due to institutional risk (e.g. Alfaro et al. 2007, 2008)? To answer that question, it is important to realize that net current transfers are essentially gifts, i.e. they come without a quid pro quo. A private investor's plausible objective is profit maximization, implying that expected marginal returns equal expected marginal costs. Institutional risk, as manifested in the risk of expropriation and political corruption, is certainly high in the group of sub-Saharan African countries. An investor needs to take this risk of expropriation into account, because it affects expected marginal profits; and political corruption (bribes), because it affects expected costs. However, for an altruist who sends transfers with welfare objectives in mind such institutional risk should matter less, resulting in stabilizing income in order to keep consumption smooth in the presence of output shocks. Hence, we would expect that institutional risk creates a significant friction for private financial flows to sub-Saharan African countries, in line with existing evidence, but not necessarily for net current transfers.

Consistent with this argument, we document in Table 8 that there are no significant effects of transitory GDP shocks on private financial flows. This is true when we focus more narrowly on foreign direct investment; use data on the entire flow of private capital (which includes also portfolio investment); or exclude large positive or negative rainfall shocks. In addition to being statistically insignificant, the effects of transitory GDP shocks on private capital flows are also quantitatively small. For example, the estimates in column (1) imply that at most a 1 percent increase in GDP leads to an increase in the FDI GDP share of 0.06 percentage points. In absolute magnitude, this effect is less than one-third of the estimated effect that transitory GDP shocks have on net current transfers. Thus, in quantitative terms, the response of private capital flows to sub-Saharan African countries is in absolute magnitude much smaller than the response of net current transfers.

Yet another alternative mechanism for keeping consumption smooth in the presence of country specific and transitory aggregate output shocks is related to changes in population size. With decreasing returns to scale in labor, if there is a positive response of population size to transitory output shocks, say, due to migration flows or changes in birth or mortality rates, this would help stabilize income per capita and, thus, consumption. Columns (1) and (2) of Table 9 show that the effect of transitory GDP shocks on the population size of sub-Saharan African countries is indeed positive; however, statistically the estimated coefficient on GDP is not significant. Quantitatively, the IV estimate in column (2) suggests that a transitory one percent increase in GDP per capita increases the population size by less than 0.04 percent.

It is noteworthy that the effect of GDP on population size becomes statistically weaker when severe droughts are excluded (column (3)). One possible reason for the absence of a strong positive response of population size to output is that migration is typically risky, hence, costly. It would, thus, take an extreme drop in output for a significant migration movement to show up in the data. Indeed, as has been documented in Bruckner (2010), only sufficiently severe droughts have a significant negative effect on the sub-Saharan African population size. That in turn explains why on average GDP, when instrumented by year-to-year rainfall, has a positive but only marginally significant effect on sub-Saharan African countries' population size.

Finally we document in columns (5)-(8) of Table 9 that transitory GDP shocks do not have a significant effect on the labor force participation rate of sub-Saharan African countries. The estimated labor force participation effects of GDP shocks are quantitatively small: the coefficient of -0.01 implies that, at most, a one percent transitory increase in GDP reduces the labor force participation rate by 0.01 percentage points. This result also holds when we exclude large positive or negative rainfall shocks (columns (7) and (8)). Hence, the aggregate labor force participation rate only barely responds to transitory GDP shocks, which reconfirms micro data evidence that labor supply in developing countries is quite inelastic (e.g. Jayachandran, 2006).

6. Further Empirical Analysis

6.1 Examination of Instrument Quality

Our instrumental variables estimates use rainfall as an exogenous, unanticipated and transitory shock to sub-Saharan African countries' GDP. In terms of first-stage fit, rainfall is a reasonable instrument. In all specifications it has a positive and highly significant effect on GDP. The positive effects on GDP are not surprising given that the size of the agricultural sector in many of the sub-Saharan African countries is large. According to WDI (2011) agriculture constitutes more than one-third of GDP; and over two-thirds of the sub-Saharan African population work in the agricultural sector.

In statistical terms, the Kleibergen Paap F-statistic usually exceeds 10. Thus, it passes the Staiger and Stock (1997) rule-of-thumb value for instruments to be declared weak. We also report in the tables the Anderson-Rubin test on the significance of the second-stage coefficient. This test has correct size even when instruments are weak (e.g. Andrews and Stock, 2005). In all cases, when the asymptotic t-value on the 2SLS coefficient was significant, the Anderson-Rubin p-value also indicated significance. Conversely, in all cases when the asymptotic t-value on the 2SLS coefficient was insignificant, the Anderson-Rubin p-value was also insignificant. Hence, the Anderson-Rubin test is always in agreement with the asymptotic 2SLS tests, which is reassuring evidence that weak instruments are unlikely to be a major concern in our regressions.

Beyond the first-stage fit between the endogenous regressor and instrument, a further necessary condition for instrumental variables estimation to provide consistent estimates is that the instruments fulfill the exclusion restriction. Previous research, such as Miguel et al. (2004) and Brückner and Ciccone (2011), has used rainfall as an instrumental variable for GDP to examine the effects of economic shocks on civil conflict and democracy. In their context, the exclusion restriction was that rainfall should only affect civil conflict and democracy through GDP. With respect to civil conflict, this exclusion restriction would be violated, for example, if flooding affected troop mobility, which in turn affects the incidence of civil conflict.

In our context, the exclusion restriction is that rainfall should only affect consumption through its effect on GDP. In a sense, this is a weaker exclusion restriction than in the context of civil conflict or democracy: unless these variables affect consumption, we do not have to be concerned about whether rainfall, through, for example, flooding has a direct effect on conflict and democratic change. Moreover, as shown in the previous tables the results are robust to excluding large positive or negative rainfall shocks. In Appendix Table 4 we also show that our main findings continue to hold when controlling on the right-hand side of the regression for the incidence of civil conflict and political institutions.

Still, one could also imagine other channels through which rainfall might have direct effects on consumption, such as by affecting income distribution. Unfortunately, the sparse data on income distribution for sub-Saharan African countries prohibits us from examining this channel. However, if changes in the income distribution matter for consumption, then this might also be reflected in interest rates (or interest rate spreads). With this in mind, we show in Appendix Table 3 that there are no significant reduced-form effects of rainfall on domestic interest rates. This is true regardless of whether we consider the real interest rate (columns (1) and (2)), the lending rate (columns (3) and (4)), or the interest rate spread (columns (5) and (6)). Not only are the reduced-form effects statistically insignificant, they are also quantitatively small. For example, the estimate in column (1) implies that at most a ten percent increase in rainfall decreases the real interest rate by 0.1 percentage points. Given that the estimates in Table 2 showed that a ten percent increase in rainfall increases GDP growth on average by around 0.5 percentage points, the 0.1 percentage points decrease in the real interest rate is, indeed, a small effect.

To provide further evidence on the validity of our identifying assumption that rainfall's effect on consumption goes primarily through aggregate output, and not through income distribution, we report in Appendix Table 5 estimates that control for the (relative) size of the agricultural sector. Rainfall's first-order effect is on agricultural output, however, it is likely that in general equilibrium there are also (second-order) effects on the output of other sectors. One issue is therefore whether rainfall, through the relative size of the agricultural sector, has independent effects on private consumption (as well as transfers and net exports). In order to explore the importance of this channel, we report in Appendix Table 5 instrumental variables estimates that control for the agricultural GDP share. By controlling for the agricultural GDP share, we shut down the effects that rainfall may have on private consumption through the relative size of the agricultural sector. The main finding in Appendix Table 5 is that transitory GDP, instrumented by rainfall, has a quantitatively small and statistically insignificant effect on private consumption with an elasticity coefficient of around 0.1. On the other hand, the effect on net current transfers is negative and significant, with a coefficient of around -0.3, while the effect on the trade balance is positive and significant, with a coefficient of around 1.0. In addition, we note that the conditional effects of the agricultural GDP share on private consumption, net current transfers, and the trade balance are all insignificant. Hence, the estimates in Appendix Table 5 suggest that the relative distribution of output between the agricultural and non-agricultural sector is not a significant omitted variable and, in particular, that there are no significant direct effects of rainfall on private consumption that go through the agricultural GDP share.

The second issue related to the importance of the agricultural sector is that rainfall should have particularly large effects on GDP in countries where the agricultural sector is large. If, indeed, our identifying assumption is correct, we should also find in those countries where rainfall has a large and significant effect on GDP a large and significant effect on net current transfers and the trade balance. On the other hand, in sub-Saharan African countries with relatively small agricultural sectors, rainfall should have smaller effects on GDP, as well as smaller effects on net current transfers and the trade balance. Panel A of Table 8 shows precisely this: rainfall has a quantitatively small and statistically insignificant effect on GDP in countries with below median agricultural GDP shares (column (1)); and there are also no significant effects on private consumption, net current transfers, or the trade balance (columns (2)-(4)). On the other hand, Panel B of Table 8 shows that in those sub-Saharan African countries where rainfall had a large effect on GDP because the agricultural sector is large, rainfall also had a significant effect on net current transfers and the trade balance, but not on private consumption, which is consistent with our main finding of significant consumption smoothing in the sub-Saharan African countries.

6.2 Additional Robustness Checks

We have carried out a number of additional robustness checks. One issue with regard to consumption smoothing is whether variations in international commodity prices can provide a buffer against output shocks on consumption. If, say, the international price of exported agricultural commodities increases as a consequence of a bad rainfall year then this would provide a buffer against the effects of rainfall shocks on countries' income. However, the majority of sub-Saharan African countries are commonly viewed as price takers on the international commodity market (e.g. Deaton, 1999, Bruckner and Ciccone, 2010). A typical justification for this view is that the majority of these countries produce individually only a small fraction of the global output of a particular agricultural commodity. Rainfall driven output shocks in sub-Saharan African economies are, therefore, likely to have immaterial effects on world commodity prices.

In order to provide further support for the above view we have carried out the following robustness checks. First, we have examined in Appendix Table 6 the effects that rainfall has on countries' terms of trade. The main finding is that the effects of rainfall on the terms of trade of sub-Saharan African countries are statistically insignificant. Quantitatively the estimated effects are also small. For example, the coefficient of -0.02 in column (1) suggests that a ten percent increase in rainfall reduces the terms of trade by 0.2 percent. The second exercise that we carried out is to examine the effects that GDP has on private consumption, net current transfers, and the trade balance when excluding the handful of sub-Saharan African countries that produce more than 3 percent of world commodity exports. According to Bruckner and Ciccone (2010), these countries are Cameroon (cocoa), Ivory Coast (cocoa, coffee), Ghana (cocoa), and Kenya (tea). Appendix Table 7 shows that when excluding these potentially large agricultural commodity exporters that the effects of rainfall on GDP, net current transfers and the trade balance continue to be significant, and of sizable magnitude; rainfall's effect on private consumption, while positive, is insignificant and quantitatively small.

Another issue is whether the effects of rainfall on these macroeconomic variables are specific to particular time periods, such as the Cold War or the recent crisis. To explore this possibility, we report in Panel A of Appendix Table 8 estimates that exclude the post-2007 period; i.e. those years when the recent financial and debt crisis occurred. The main result is that excluding this period leaves our main findings intact: rainfall has a positive and significant effect on GDP, with an elasticity coefficient of around 0.05; it has a significant negative effect on net current transfers, with an elasticity coefficient of around -0.3; a positive, albeit, insignificant effect on private consumption; and a significant positive effect on the trade balance, with a coefficient of around 0.04. In Panel B of Appendix Table 8 we also show that similar results are obtained when excluding the pre-1990 period; i.e. those years when the Cold War was still ongoing. The only difference is that, in this case, the coefficient on the response of the trade balance to rainfall drops somewhat; it is still, however, positive, quantitatively sizable, and we cannot reject the hypothesis that the effect of rainfall on net exports when excluding the pre-1990 period is the same as the effect when including this period (p-value 0.78).

In Appendix Table 9 we document that our results are also robust to controlling for the within-country variance of year-to-year rainfall. The estimated coefficients on the 5-year standard deviation of rainfall are all insignificant. The sign of the coefficient on the standard deviation of rainfall is negative for the consumption equation. While the standard error on the estimated coefficient is large, the sign of the estimate on rainfall volatility could be interpreted as weak evidence that greater uncertainty leads to a drop in consumption growth. More importantly, Appendix Table 9 shows that when controlling for the second rainfall moment, the effects of year-to-year rainfall continue to be significant for GDP growth, net current transfers and the trade balance; while for private consumption it is insignificant and quantitatively small.

In Appendix Table 10 we document that there is no evidence of significant asymmetry between negative and positive shocks. In Panel A we report instrumental variables estimates when we split the GDP per capita growth series into positive and negative shocks. The main finding is that both the coefficient on positive and negative shocks is positive and insignificant. Importantly, the p-value on the test that the coefficient on positive shocks is equal to the coefficient on negative shocks is always in excess of 0.1. In Panel B of Table 10 we document that the reduced form effects of positive and negative rainfall shocks on consumption growth are also insignificant. On the other hand, in Panel C the estimates of positive and negative rainfall shocks on economic growth are significant. Neither in Panel B nor in Panel C can we reject the hypothesis that the coefficients on positive shocks are equal to the coefficients on negative shocks. Hence, the data do not reject our baseline assumption of symmetry between negative and positive shocks.[16]

We have also checked the robustness of our results to using GDP, consumption, and net export data from the WDI (2011). Appendix Table 11 presents the results. Panel A shows the estimates for private consumption and Panel B shows the estimates for the net-export to GDP ratio. Our two main findings are as follows. First, GDP per capita as instrumented by

16 In the standard consumption model with liquidity constraints, there is an asymmetric response of consumption to positive and negative shocks. However, in the presence of (counter-cyclical) transfers, this asymmetry disappears; see the model in Appendix A of the supplementary online appendix for a formal proof. Intuitively, altruistically motivated transfers increase in the presence of a negative shock, thus, even if countries cannot borrow their consumption will not respond to an adverse transitory shock.

rainfall has an insignificant effect on private consumption. Quantitatively the estimated elasticity coefficient is small. For example, when we control for country fixed effects, country-specific linear time trends, and year fixed effects the estimated elasticity coefficient on GDP per capita is around 0.2. The second finding is that within-country variations in GDP per capita as instrumented by rainfall have a significant positive and quantitatively large effect on the net-export to GDP ratio. For example, when we control for country fixed effects, country-specific linear time trends, and year fixed effects the estimated elasticity coefficient on log GDP per capita is around 0.9. In sum, the results are very similar if we use data from WDI instead of PWT.

7. Conclusion

By how much does private consumption respond to a transitory shock to aggregate output in countries where there exist significant frictions to private financial flows? To answer this question we focused on poor and largely agrarian sub-Saharan African countries. We used year-to-year variations in rainfall as an exogenous, unanticipated, and transitory shock to aggregate output. Our main finding from instrumental variables regressions that employed rainfall as an instrument for countries' real GDP per capita is a quantitatively small response of private consumption. Controlling for country and year fixed effects as well as country-specific linear time trends, the estimated marginal propensity to consume out of transitory output is around 0.2. This finding may seem surprising. At least, it calls for an explanation as our focus is on a sample of poor countries, where according to common wisdom institutional rigidities constitute a major obstacle to private financial flows (e.g. Alfaro et al., 2008, Papaioannou, 2009). Thus, a priori, one would not have expected such a small response of private consumption to a transitory shock to aggregate output.

We suggested that counter-cyclical net current transfers could be an explanation for the quantitatively small response of private consumption to transitory output shocks. Indeed, the magnitude of such transfers is significant, comprising over four percent of PPP GDP in our sample. In the framework of the intertemporal approach to the current account, consumption smoothing of country-specific aggregate output shocks is predicted to occur vis-a-vis net exports. If net current transfers are counter-cyclical, then consumption smoothing can occur however vis-a-vis net exports without large changes in a countries' net foreign asset position. In other words, imports and exports *within* a single period enable consumption to be smoothed -- and there need not be a large change in a country's trade obligations (claims) over time if net current transfers are counter-cyclical.

Our findings help to gauge the extent to which consumption smoothing is helped by net current transfers. As our instrumental variables estimates revealed that a one percent transitory GDP increase is associated with an approximately four to five percent decrease in transfers, this amounts to a roughly 0.2 dollar increase in net current transfers for a one dollar decrease in output. Under the assumption that all of the net current transfers are used for consumption, the estimates imply that about one-quarter of the consumption smoothing is financed by net current transfers.

We also documented an economically large and statistically significant positive effect of transitory GDP shocks on the trade balance. Our instrumental variables estimates showed that a one percent transitory GDP increase is associated with an up to 0.8 percentage points increase in the ratio of net export over GDP. This significant pro-cyclicality of the trade balance, in turn, suggests that international goods trade ensured significant intertemporal smoothing of consumption in the presence of aggregate output shocks.

It is interesting to note that in line with our empirical results, basic models of the intertemporal approach to the current account predict pro-cyclical behavior of the trade balance (e.g. Obstfeld and Rogoff, 1995). The underlying assumption in these models -- frictionless markets -- is unlikely to be fulfilled though in the context of poor sub-Saharan African countries. Nevertheless, as pointed out in Obstfeld and Rogoff, 1995, financial frictions do not imply necessarily zero consumption smoothing. Standard intertemporal models also do not consider the consumption smoothing role of counter-cyclical net current transfers. One interesting avenue for future theoretical work that seeks to model developing countries' macroeconomies could, therefore, be constructing stochastic general equilibrium models that contain both financial frictions and net current transfers.

References

Adler, R.F., G.J. Huffman, A. Chang, R. Ferraro, P. Xie, J. Janowiak, B. Rudolf, U. Schneider, S. Curtis, D. Bolvin, A. Gruber, J. Susskind, P. Arkin, and E. Nelkin, 2003, The Version 2 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979-Present). Journal of Hydrometeorology 4, 1147-1167.

Aguiar, M. and G. Gopinath, 2007, Emerging Market Business Cycles: The Cycle is the Trend. Journal of Political Economy 115, 69-102.

Alcala, F. and A. Ciccone, 2004, Trade and Productivity. Quarterly Journal of Economics 119, 612-645.

Alfaro, L. S. Kalemli, and V. Volosovych, 2007, Capital Flow in a Globalized World: The Role of Policies and Institutions. in: Capital Controls and Capital Flows in Emerging Economies: Policies, Practices and Consequences, Sebastian Edwards (ed.), NBER.

Alfaro, L. S. Kalemli, and V. Volosovych, 2008, Why doesn't capital flow from rich to poor countries? An empirical investigation. Review of Economics and Statistics 90, 347-368.

Arezki, R. and M. Brückner, 2012, Rainfall, Financial Development, and Remittances: Evidence from sub-Saharan Africa, Journal of International Economics 87, 377-385.

Attanasio, O. and G. Weber, 1993, Consumption growth, the interest rate, and aggregation. Review of Economic Studies 60, 631-649.

Attanasio, O. and G. Weber, 2010, Consumption and saving: Models of intertemporal allocation and their implications for public policy. Journal of Economic Literature 48, 693-751.

Brückner, M., 2013, On the Simultaneity Problem in the Aid and Growth Debate. Journal of Applied Econometrics 28, 102-125.

Brückner, M., 2010, Population Size and Civil Conflict Risk: Is There a Causal Link? Economic Journal 120, 535-550.

Brückner, M. and A. Ciccone, 2010, International Commodity Price Shocks, Growth, and the Outbreak of Civil War in sub-Saharan Africa. Economic Journal 120, 519-534.

Brückner, M. and A. Ciccone, 2011, Rain and the Democratic Window of Opportunity. Econometrica 79, 923-947.

Ciccone, A., 2011, Economic Shocks and Civil Conflict: A Comment. American Economic Journal: Applied Economics 3, 215-227.

Deaton, A., 1991, Saving and liquidity constraints. Econometrica 59, 1221-1248.

Deaton, A., 1992, Household Saving in LDC's: Credit Markets, Insurance, and Welfare. Scandinavian Journal of Economics 94, 253-273.

Deaton, A., 1999, Commodity Prices and Growth in Africa. Journal of Economic Perspectives 13, 23-40.

Deaton, A. and A. Heston, 2010, Understanding PPPs and PPP-Based National Accounts. American Economic Journal Macroeconomics 2, 1-35.

Dercon, S., 2004, Growth and shocks: evidence from rural Ethiopia. Journal of Development Economics 74, 309-329.

Edwards, S., 1996, Why Are Latin America's Savings Rates So Low? An International Comparative Analysis. Journal of Development Economics 51, 5-44.

Fafchamps, M. and S. Lund, 2003, Risk Sharing Networks in Rural Philippines. Journal of Development Economics 71, 261-87.

FAO, 2011, Climate Change and Food Systems Resilience in sub-Saharan Africa. Online document available at http://www.fao.org/docrep/014/i2230e/i2230e.pdf.

Feldstein, M. and C. Horioka, 1980, Domestic saving and international capital flows. Economic Journal 90, 314-329.

Feenstra, R., A. Heston, M. Timmer and H. Deng, 2009, Estimating Real Production and Expenditures across Nations: A Proposal for Improving the Penn World Tables. Review of Economics and Statistics 91, 201-212.

Foster, A. and M. Rosenzweig, 2001, Imperfect Commitment, Altruism and the Family: Evidence from Transfer Behavior in Low-Income Rural Areas. Review of Economics and Statistics 83, 389-407.

Friedman, M., 1957, A Theory of the Consumption Function. Princeton, NJ.

Ghosh, A., 1995, Capital mobility among the major industrialized countries: Too little or too much? Economic Journal, 107-128.

Hall, R., 1978, Stochastic implications of the life cycle permanent income hypothesis: theory and evidence. Journal of Political Economy 86, 971-987.

Heston, A., Summers, R., and B. Aten, 2011, Penn World Table Version 7.0. Center for International Comparisons of Production, Income and Prices, University of Pennsylvania, May 2011.

Im, K.S., Pesaran, M. H. and Shin, Y., 2003, Testing for unit roots in heterogeneous panels. Journal of Econometrics 115, 53-75.

Japelli, T. and M. Pagano, 1989, Consumption and capital market imperfections: an international comparison. American Economic Review 79, 1088-1105.

Japelli, T. and M. Pagano, 1994, Saving, Growth, and Liquidity Constraints. Quarterly Journal of Economics 106, 83-109.

Japelli, T. and L. Pistaferri, 2010, The consumption response to income changes. Annual Review of Economics 2, 479-506.

Jayachandran, S., 2006, Selling Labor Low: Wage Responses to Productivity Shocks in Developing Countries. Journal of Political Economy 114, 538-575.

Johnson, S., W. Larson, C. Papageorgiou and A. Subramanian, 2013, Is newer better? Penn World Table Revisions and their impact on growth estimates. Journal of Monetary Economics 60, 255-274.

Kalemli-Ozcan, S., Sorensen, B., and O. Yosha, 2003, Risk Sharing and Industrial Specialization: Regional and International Evidence. American Economic Review 93, 903-918.

Kaufmann, D., A. Kraay and M. Mastruzzi, 2008, Governance matters VII. World Bank Policy Research Paper, no. 4654, Washington DC.

Kazianga, H. and C. Udry, 2006, Consumption smoothing? Livestock, insurance and drought in rural Burkina Faso. Journal of Development Economics 79, 413-446.

Loayza, N., K. Schmidt-Hebbel, and L. Serven, 2000, What drives private savings across the world? Review of Economics and Statistics 82, 165-181.

Medard, J., 2002, Corruption in the neo-patrimonial states of Sub-Saharan Africa. Chapter 22 in Arnold J. Heidenheimer and Michael Johnston (eds.), Political Corruption, Concepts and Contexts, 3, New Brunswick: Transaction Publishers.

Miguel, E., S. Satyanath, and E. Sergenti, 2004, Economic Shocks and Civil Conflict: An Instrumental Variables Approach. Journal of Political Economy 112, 725-753.

Obstfeld, M. and K. Rogoff, 1995, The intertemporal approach to the current account. in Grossman, G. and K. Rogoff, Handbook of International Economics, vol. 3, North Holland.

Obstfeld, M. and K. Rogoff, 1996, Foundations of International Macroeconomics. MIT Press.

Papaioannou, E., 2009, What Drives International Financial Flows? Politics, Institutions and Other Determinants. Journal of Development Economics 88, 269-281.

Paxson, C., 1992, Using Weather Variability to Estimate the Response of Savings to Transitory Income in Thailand. American Economic Review 82, 15-33.

Polity IV, 2010, Political Regime Characteristics and Transitions, 1800-2010. Online Database.

Reinikka, R. and J. Svensson, 2004, Local capture: evidence from a central government transfer program in Uganda. Quarterly Journal of Economics 119, 679-705.

Rosenzweig, M., 1988, Risk, Implicit Contracts and the Family in Rural Areas of Low-Income Countries. Economic Journal 98, 1148-1170.

Staiger, D. and J. Stock, 1997, Instrumental Variables Regression with Weak Instruments. Econometrica 65, 557-586.

PRIO, 2010, Armed Conflict Dataset v4-2009. Online Database.

WDI, 2011, World Development Indicators. Online Database.

Wooldridge, J., 2002, Econometric Analysis of Cross Section and Panel Data. Cambridge, MIT Press.

Yang, D. and H. Choi, 2007, Are Remittances Insurance? Evidence from Rainfall Shocks in the Philippines. World Bank Economic Review 21, 219-48.

Yang, D., 2008, Coping with Disaster: The Impact of Hurricanes on International Financial Flows, 1970-2002. The B.E. Journal of Economic Analysis & Policy 8 (Advances), Article 13.

Table 1. Descriptive Statistics

Variable	Source	Mean	Stdv.	Obs
		Panel A: Income Growth		
PPP GDP p.c. constant $US, Laspeyres (Baseline, ΔLn(*GDP p.c.*))	PWT	0.008	0.074	976
PPP GDP p.c. constant $US, Chain-Series	PWT	0.008	0.074	976
PPP GDP p.c. constant $US, ToT Adjusted	PWT	0.007	0.090	976
PPP GDP p.c. current $US	PWT	0.035	0.091	976
PPP GNP p.c. current $US	PWT	0.032	0.097	976
PPP GDP p.c. current $US	WDI	0.033	0.054	911
PPP GNP p.c. current $US	WDI	0.032	0.064	874
GDP p.c. constant LCU	WDI	0.032	0.056	932
Agricultural VA p.c. current $US	WDI	0.036	0.202	914
		Panel B: Private Consumption Growth		
PPP Private Consumption p.c. constant $US, Laspeyres (Baseline, ΔLn(*Cons p.c.*))	PWT	0.005	0.106	976
PPP Private Consumption p.c. current $US	PWT	0.034	0.106	976
PPP Private Consumption p.c. current $US	WDI	0.040	0.122	718
Private Consumption p.c. constant LCU	WDI	0.028	0.094	773
		Panel C: Other Variables		
Domestic Savings Rate	PWT	0.097	0.203	976
PPP Private Consumption/PPP GDP	PWT	0.807	0.257	976
NX/PPP GDP	PWT	-0.092	0.192	976
(EXP+IMP)/PPP GDP	PWT	0.660	0.372	976
GNP/GDP	PWT	0.974	0.118	976
Net Current Transfers/PPP GDP	WDI/PWT	0.040	0.077	976
FDI/PPP GDP	WDI/PWT	0.010	0.024	964
FDI+Portfolio Inv/PPP GDP	WDI/PWT	0.009	0.026	964
ΔLn(Net Current Transfers) in current $US	WDI	0.065	0.557	778
Real Interest Rate	WDI	0.058	0.146	728
ΔReal Interest Rate	WDI	0.005	0.129	691
Lending Interest Rate	WDI	0.196	0.148	738
ΔLending Interest Rate	WDI	-0.001	0.086	701
Interest Rate Spread	WDI	0.093	0.083	714
ΔInterest Rate Spread	WDI	0.001	0.054	677
Labor Force Participation Rate	WDI	0.729	0.109	976
Population Growth Rate	WDI	0.026	0.011	976
Terms of Trade Growth	WDI	-0.005	0.149	895
Ln(Rainfall)	GPCP V2.1	6.733	0.622	976
ΔLn(Rainfall)	GPCP V2.1	-0.009	0.215	976
Polity2 Score	Polity IV	-1.627	5.889	976
Civil Conflict Incidence	PRIO	0.252	0.434	976

Table 2. First-Stage Effects of Rainfall on GDP Growth

	ΔLn(GDP P.C.)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
						Excluding Severe	
						Drought	Flood
Ln(Rainfall), t	0.05***	0.05***	0.04***	0.07***	0.05***	0.06***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Ln(Rainfall), t-1	0.01						
	(0.02)						
Ln(Rainfall), t-2	0.00						
	(0.01)						
Ln(Rainfall), t-3	-0.01						
	(0.01)						
Ln(Rainfall), t-4	-0.03**						
	(0.01)						
Ln(Rainfall), t-5	-0.02						
	(0.02)						
Cumulative Effect, t to t-5	-0.01						
	(0.03)						
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	No	Yes	Yes	Yes
Country Trends	No	No	No	Yes	Yes	Yes	Yes
Observations	837	976	976	976	976	927	927

Note: The method of estimation is least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. The dependent variable is the change in the log of real GDP per capita. Column (6) excludes the bottom 5th percentile of rainfall observations. Column (7) excludes the top 5th percentile of rainfall observations. *Significantly different from zero at the 10 percent significance level, ** 5 percent significance level, *** 1 percent significance level.

Table 3. Response of Private Consumption to Transitory GDP

	ΔLn(Cons P.C.)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
						Excluding Severe	
						Drought	Flood
				Panel A: 2SLS			
ΔLn(GDP P.C.), t	0.54*	0.50	0.57**	0.34	0.18	0.25	0.05
	(0.29)	(0.41)	(0.23)	(0.39)	(0.38)	(0.40)	(0.44)
Ln(Cons P.C.), t-1					-0.30***	-0.29***	-0.32***
					(0.06)	(0.06)	(0.07)
Implied MPC	0.43	0.40	0.46	0.27	0.14	0.20	0.04
[P-Value: MPC=1]	[0.02]	[0.08]	[0.00]	[0.02]	[0.01]	[0.01]	[0.01]
Kleibergen Paap F-Stat	19.20	9.11	35.69	11.44	10.87	9.24	9.75
Anderson-Rubin, p-value	0.11	0.28	0.02	0.41	0.65	0.56	0.91
				First Stage for ΔLn(GDP P.C.)			
Ln(Rainfall), t	0.05***	0.04***	0.07***	0.05***	0.05***	0.06***	0.06***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
				Panel B: LS			
ΔLn(GDP P.C.), t	0.77***	0.74***	0.75***	0.73***	0.65***	0.66***	0.66***
	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)	(0.08)
Ln(Cons P.C.), t-1					-0.26***	-0.25***	-0.26***
					(0.04)	(0.04)	(0.04)
Implied MPC	0.62	0.59	0.60	0.58	0.52	0.53	0.53
[P-Value: MPC=1]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	Yes	Yes	Yes
Country Trends	No	No	Yes	Yes	Yes	Yes	Yes
Observations	976	976	976	976	976	927	927

Note: The method of estimation in Panel A is two-stage least squares; Panel B least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. The dependent variable is the change in the log of real consumption per capita. In Panel A, the excluded instrumental variable is the log of rainfall. Column (6) excludes the bottom 5th percentile of rainfall observations. Column (7) excludes the top 5th percentile of rainfall observations. *Significantly different from zero at the 10 percent significance level, ** 5 percent significance level, *** 1 percent significance level.

Table 4. Private Consumption Response to Alternative Measures of National Income

	ΔLn(Cons p.c.)					
	(1)	(2)	(3)	(4)	(5)	(6)
Income Variable is:	PPP GDP Constant Price Terms of Trade Adjusted	PPP GDP Constant Price CPI Deflator	PPP GDP Constant Price Chain Series	PPP GDP Current US Dollar	PPP GNP Current US Dollar	GDP Constant LCU
ΔLn(Income p.c.), t	0.20	0.15	0.17	0.19	0.15	0.19
	(0.49)	(0.37)	(0.41)	(0.46)	(0.37)	(0.35)
Ln(Cons p.c.), t-1	-0.30***	-0.31***	-0.31***	-0.30***	-0.30***	-0.35***
	(0.09)	(0.06)	(0.07)	(0.09)	(0.08)	(0.08)
Implied MPC	0.16	0.12	0.13	0.15	0.12	0.15
[P-Value: MPC=1]	[0.03]	[0.00]	[0.01]	[0.02]	[0.00]	[0.00]
	First Stage for ΔLn(Income p.c.), t					
Ln(Rainfall), t	0.04**	0.05**	0.05***	0.04**	0.05***	0.06***
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)
R-Squared	0.158	0.153	0.175	0.172	0.173	0.258
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	Yes	Yes	Yes	Yes	Yes	Yes
Observations	976	976	976	976	976	742

Note: The method of estimation is two-stage least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. The dependent variable is the change in the log of real consumption per capita. The explanatory variable in column (1) is PPP constant price GDP per capita adjusted for the terms of trade; column (2) PPP constant price GDP per capita where the deflator is the consumer price index instead of the GDP price index; column (3) PPP chain-series constant price GDP per capita; column (4) PPP GDP per capita in current $US; column (5) PPP GNP per capita in current US$; column (6) constant price GDP per capita in local currency units. The excluded instrumental variable is the log of rainfall. *Significantly different from zero at the 10 percent significance level, ** 5 percent significance level, *** 1 percent significance level.

Table 5. Response of Private Consumption: GDP vs. Agricultural Value Added

	ΔLn(Cons P.C.)					
	(1)	(2)	(3)	(4)	(5)	(6)
			Excluding Drought		Excluding Flood	
			Panel A: Agricultural Value Added			
ΔLn(Agricultural VA p.c.), t	0.04	0.04	0.09	0.06	0.03	0.01
	(0.12)	(0.10)	(0.13)	(0.12)	(0.14)	(0.12)
Ln(Cons p.c.), t-1		-0.36***		-0.37***		-0.35***
		(0.06)		(0.07)		(0.07)
Implied MPC	0.10	0.12	0.24	0.16	0.07	0.03
[P-Value: MPC=1]	[0.00]	[0.00]	[0.03]	[0.01]	[0.01]	[0.00]
Kleibergen Paap F-Stat	10.19	10.99	8.40	9.95	9.77	11.16
Anderson-Rubin, p-value	0.76	0.68	0.50	0.61	0.86	0.94
			First Stage for ΔLn(Agricultural VA p.c.)			
Ln(Rainfall), t	0.18***	0.18***	0.21***	0.22***	0.21***	0.21***
	(0.06)	(0.05)	(0.07)	(0.07)	(0.07)	(0.06)
			Panel B: GDP			
ΔLn(GDP p.c.), t	0.15	0.18	0.33	0.23	0.10	0.04
	(0.45)	(0.40)	(0.45)	(0.43)	(0.52)	(0.48)
Ln(Cons p.c.), t-1		-0.32***		-0.32***		-0.34***
		(0.07)		(0.07)		(0.07)
Implied MPC	0.12	0.14	0.26	0.19	0.08	0.03
[P-Value: MPC=1]	[0.01]	[0.01]	[0.04]	[0.02]	[0.03]	[0.01]
Kleibergen Paap F-Stat	9.21	9.55	8.44	8.17	8.22	8.08
Anderson-Rubin, p-value	0.76	0.68	0.50	0.61	0.85	0.94
			First Stage for ΔLn(GDP p.c.)			
Ln(Rainfall), t	0.05***	0.05***	0.06***	0.06***	0.05***	0.05***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	Yes	Yes	Yes	Yes	Yes	Yes
Observations	914	914	869	869	869	869

Note: The method of estimation is two-stage least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. The dependent variable is the change in the log of real consumption per capita. The excluded instrumental variable is the log of rainfall. Columns (3) and (4) exclude the bottom 5th percentile of rainfall observations. Columns (5) and (6) exclude the top 5th percentile of rainfall observations. *Significantly different from zero at the 10 percent significance level, ** 5 percent significance level, *** 1 percent significance level.

Table 6. Response of Net Current Transfers

	Transfer/GDP		ΔLn(Transfer)	Transfer/GDP		ΔLn(Transfer)
	(1)	(2)	(3)	(4)	(5)	(6)
				Excluding Extreme Rainfall Observations		
ΔLn(GDP P.C.), t	-0.22*	-0.12	-4.56**	-0.35**	-0.20**	-5.35**
	(0.13)	(0.09)	(2.30)	(0.16)	(0.10)	(2.32)
Net Current Transfer Payments/GDP, t-1		0.58***			0.72***	
		(0.09)			(0.08)	
Ln(Transfer), t-1			-0.50***			-0.49***
			(0.06)			(0.07)
Kleibergen Paap F-Stat	11.44	12.62	9.61	9.98	12.68	10.81
Anderson-Rubin, p-value	0.05	0.18	0.02	0.00	0.02	0.00
			First Stage for ΔLn(GDP P.C.)			
Ln(Rainfall), t	0.05***	0.06***	0.05***	0.08***	0.09***	0.09***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	Yes	Yes	Yes	Yes	Yes	Yes
Observations	976	976	778	874	874	690

Note: The method of estimation is two-stage least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. The dependent variable in columns (1), (2), (4), and (5) is net current transfers scaled by GDP; columns (3) and (6) the change in the log of net current transfers. The excluded instrumental variable is the log of rainfall. Columns (4)-(6) exclude the top and bottom 5th percentile of rainfall observations. *Significantly different from zero at the 10 percent significance level, ** 5 percent significance level, *** 1 percent significance level.

Table 7. Response of the Trade Balance

	NX/GDP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
						Excluding Severe	
						Drought	Flood
ΔLn(GDP P.C.), t	1.40***	2.01**	0.67***	1.07**	0.73**	0.89**	0.78**
	(0.58)	(0.85)	(0.22)	(0.43)	(0.35)	(0.39)	(0.33)
NX/GDP, t-1					0.57***	0.58***	0.57***
					(0.07)	(0.07)	(0.07)
Kleibergen Paap F-Stat	19.20	9.11	35.69	11.44	11.86	11.09	11.37
Anderson-Rubin, p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	First Stage for ΔLn(GDP P.C.)						
Ln(Rainfall), t	0.05***	0.04***	0.07***	0.05***	0.05***	0.06***	0.06***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	Yes	Yes	Yes
Country Trends	No	No	Yes	Yes	Yes	Yes	Yes
Observations	976	976	976	976	976	927	927

Note: The method of estimation is two-stage least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. The dependent variable is net exports scaled by GDP. Column (6) excludes the bottom 5th percentile of rainfall observations. Column (7) excludes the top 5th percentile of rainfall observations. *Significantly different from zero at the 10 percent significance level, ** 5 percent significance level, *** 1 percent significance level.

Table 8. Response of Private Financial Flows

	FDI/GDP				(FDI+PI)/GDP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Excluding Severe				Excluding Severe	
			Drought	Flood			Drought	Flood
ΔLn(GDP P.C.), t	0.06	0.01	0.04	0.05	0.10	0.04	0.01	0.08
	(0.09)	(0.08)	(0.08)	(0.08)	(0.10)	(0.08)	(0.09)	(0.09)
FDI/GDP, t-1		0.51***	0.53***	0.51***				
		(0.13)	(0.13)	(0.13)				
(FDI+Portfolio)/GDP, t-1						0.54***	0.55***	0.49***
						(0.12)	(0.12)	(0.13)
Kleibergen Paap F-Stat	10.72	10.07	9.30	9.23	10.72	10.26	9.39	9.48
Anderson-Rubin, p-value	0.43	0.88	0.67	0.58	0.29	0.66	0.89	0.37
	First Stage for ΔLn(GDP P.C.)							
Ln(Rainfall), t	0.05***	0.05***	0.06***	0.06***	0.05***	0.05***	0.06***	0.06***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	964	919	872	872	964	919	872	872

Note: The method of estimation is two-stage least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. The dependent variable in columns (1)-(4) is net foreign direct investment scaled by GDP; columns (5)-(8) net foreign direct investment plus portfolio investment scaled by GDP. The instrumental variable is the log of rainfall. Columns (3) and (7) exclude the bottom 5th percentile of rainfall observations. Columns (4) and (8) exclude the top 5th percentile of rainfall observations. *Significantly different from zero at the 10 percent significance level, ** 5 percent significance level, *** 1 percent significance level.

Table 9. Response of Population Size and Labor Force Participation Rate

	ΔLn(Pop)				LFPR			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Excluding Severe				Excluding Severe	
			Drought	Flood			Drought	Flood
ΔLn(GDP P.C.), t	0.05	0.04	0.03	0.07	0.00	-0.01	-0.00	-0.01
	(0.04)	(0.04)	(0.09)	(0.09)	(0.03)	(0.01)	(0.01)	(0.01)
Ln(Pop), t-1		-0.27***	-0.26***	-0.27***				
		(0.05)	(0.05)	(0.05)				
LFPR, t-1						0.91***	0.92***	0.91***
						(0.04)	(0.04)	(0.04)
Kleibergen Paap F-Stat	10.74	11.47	10.80	11.05	10.74	10.62	10.53	9.65
Anderson-Rubin, p-value	0.15	0.65	0.73	0.45	0.97	0.36	0.75	0.17
	First Stage for ΔLn(GDP P.C.)							
Ln(Rainfall), t	0.05***	0.05***	0.07***	0.06***	0.05***	0.05***	0.06***	0.06***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	976	976	976	976	976	976	976	976

Note: The method of estimation is two-stage least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. The dependent variable in columns (1)-(4) is the change in the log of population size; columns (5)-(8) the labor force participation rate. The instrumental variable is the log of rainfall. Columns (3) and (7) exclude the bottom 5th percentile of rainfall observations. Columns (4) and (8) exclude the top 5th percentile of rainfall observations. *Significantly different from zero at the 10 percent significance level, ** 5 percent significance level, *** 1 percent significance level.

Table 10. Falsification Check: Sample Split by Size of the Agricultural Sector

	Δln(GDP P.C.)	Δln(Cons P.C.)	Transfer/GDP	NX/GDP
	(1)	(2)	(3)	(4)
	LS	LS	LS	LS
	Panel A: Below Median Agricultural GDP Share			
Ln(Rainfall), t	0.01	0.00	-0.00	0.03
	(0.02)	(0.02)	(0.01)	(0.02)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country Trends	Yes	Yes	Yes	Yes
Observations	480	480	480	480
Countries	19	19	19	19
	Panel B: Above Median Agricultural GDP Share			
Ln(Rainfall), t	0.10***	0.04	-0.02**	0.07**
	(0.03)	(0.04)	(0.01)	(0.03)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country Trends	Yes	Yes	Yes	Yes
Observations	496	496	496	496
Countries	20	20	20	20

Note: The method of estimation is least squares. Huber robust standard errors (shown in parentheses) are clustered at the country level. *Significantly different from zero at the 10 percent significance level, ** 5 percent significance level, *** 1 percent significance level.

Data Appendix Table 1. List of Countries and Observations

Country	Observations	Country	Observations	Country	Observations
Angola	25	Ghana	29	Nigeria	29
Benin	28	Guinea	24	Rwanda	29
Botswana	29	Guinea-Bissau	24	Senegal	28
Burkina Faso	23	Kenya	29	Sierra Leone	29
Burundi	25	Lesotho	29	Somalia	9
Cameroon	29	Liberia	13	South Africa	29
Central Afr. Rep.	14	Madagascar	25	Sudan	29
Chad	14	Malawi	22	Swaziland	29
Congo, Rep. of	27	Mali	29	Tanzania	29
Cote d'Ivoire	29	Mauritania	18	Togo	29
Ethiopia	29	Mozambique	29	Uganda	29
Gabon	25	Namibia	20	Zambia	24
Gambia, The	24	Niger	28	Zimbabwe	14