On the Relationship Between Domestic Savings and the Current Account in Poor Countries: Evidence and Theory*

Markus Brückner and Evi Pappa

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Abstract: This paper examines the relationship between domestic savings and the current account in poor sub-Saharan African countries. In order to uncover causal effects, we instrument domestic savings with plausibly exogenous year-to-year variations in rainfall. Our empirical analysis yields a quantitatively small and statistically insignificant effect of domestic savings on the current account, but a significant positive and quantitatively sizable effect on the trade balance. We show that the reason for the near zero correlation between domestic savings and the current account is a strong counter-cyclical response of net current transfers. We then analyze the role of transfers in a small open economy model with financial frictions.
Keywords: Feldstein-Horioka Puzzle, Domestic Savings, Current Account, Transitory Shocks, Net Current Transfers, Exports, Small Open Economy Model, Financial Frictions

*Department of Economics, National University of Singapore (Brückner); European University Institute, Universitat Autonoma de Barcelona, BGSE and CEPR (Pappa). Contact e-mail: ecsbm@nus.edu.sg; evi.pappa@eui.eu. Evi Pappa acknowledges the financial support from the Spanish Ministry of Science and Innovation through grant ECO2012-32392, the Generalitat of Catalonia through grant SGR2009-00350, and the Barcelona Graduate School Research Network. We would like to thank also Wojciech Paczos for excellent research assistance.

1 Introduction

The effect that changes in domestic savings have on the current account is an important topic in open economy macroeconomics. At least since Feldstein and Horioka (1980), there has been a vast amount of research done on this topic. Yet, despite the vast amount of both empirical and theoretical research, one of the key issues that the literature struggles with is how to interpret and compare the empirical findings to the predictions from macroeconomic models (see, for example, Obstfeld, 1985; Obstfeld and Rogoff, 1995). This is because empirical research based on correlations between domestic savings and the current account makes it difficult to distinguish what types of shocks are driving the change in domestic savings. For example, are these permanent or transitory shocks; demand or supply-side shocks; anticipated or unanticipated? Moreover, in the cross-section of countries, where over long time-periods cross-sectional differences reflect primarily permanent relationships, there could be third factors that lead to a large positive correlation between domestic savings and investment. For example, cross-country differences in home-country investment bias, taxation, or demographic factors; some of which are difficult to measure in the data.

The fact that correlations are silent about what types of shocks are driving the variation in domestic savings is a key problem for relating the empirical results to predictions from theoretical models. This is because, in all theoretical models, one has to make assumptions about the types of shocks that are causing the change in domestic savings. Another key problem, that is perhaps more obvious, but nevertheless equally important for estimation purposes, is that the variation in domestic savings is not necessarily driven by exogenous factors. For example, there could be changes in economic policies that induce changes in domestic savings – and these changes in economic policies may arise precisely because political leaders perceive it as beneficial to stimulate domestic investment or, say, reduce a current account imbalance.

To circumvent these problems, we use in this paper year-to-year variations in rainfall to study how a transitory, exogenous, and unanticipated shock to aggregate output affects the relationship between domestic savings and the current account. We do this for a panel of 41 sub-Saharan African countries during the period 1980-2009. We focus on the group of sub-Saharan African countries because agriculture constitutes an important sector in these economies: the average agricultural GDP share is about one-third, and over two-thirds of the population are employed in agriculture (WDI, 2011). It is well documented that year-to-year variations in rainfall have a significant positive effect on sub-Saharan African countries year-to-year GDP growth (e.g. Miguel et al. 2004, Brückner and Ciccone, 2011). The novelty in this paper is to realize that because rainfall is a transitory shock to output, the permanent income hypothesis predicts that domestic savings should respond significantly to this shock as well. Indeed our panel data estimates yield a highly significant and positive effect of year-to-year rainfall on the domestic savings rate. A one percent above country-mean increase in the level of rainfall increases the domestic savings rate by around 0.1 percentage points.

In the empirical part of our paper we pursue two complementary estimation strategies to study the relationship between a transitory shock to output that induces a significant change in domestic savings and the current account. The first estimation approach is an instrumental variables approach. In this estimation approach we use rainfall as an instrument for domestic savings. The main finding from the instrumental variables analysis is that changes in the domestic savings rate have a quantitatively small and statistically insignificant effect on the current account (also scaled by GDP). Controlling for country fixed effects, country-specific linear time trends, and year fixed effects the coefficient on the domestic savings rate in the current account equation is around 0.04 with a standard error of around 0.23.

An important economic feature of developing countries is the role of net current transfers as a source of external finance. For the average sub-Saharan African country during the 1980-2009 period net current transfers amounted to nearly 8 percent of GDP. In this context, it is useful to recall that the current account is the sum of net exports, net current transfers, and net factor income. During the 1980-2009 period the average sub-Saharan African country had a current account deficit of 5 percent, but the trade deficit was larger amounting to over 11 percent of GDP.

When we look at the components of the current account, we find that the net export response to the change in the domestic savings rate is positive and significant. The instrumental variables analysis yields a coefficient in the net export equation on the domestic savings rate that is around 0.54 (standard error 0.28). On the other hand, for the net current transfer equation IV estimation yields a negative and significant coefficient on the domestic savings rate of around -0.61 (standard error 0.28). Hence, the significant positive response of net exports to the change in the domestic savings rate gets closer to the predictions from basic models of the intertemporal approach to the current account; however, the overall current account response is far off.

In the theoretical part of the paper we construct a stochastic, small open economy general equilibrium model with three sectors to study the relationship between the current account and changes in domestic savings that are induced by rainfall shocks which we model as shocks to the agricultural sector. The model allows for significant financial market frictions. Following the business cycle literature (see, e.g., Neumeyer and Perri (2005) and Uribe and Yue (2010)), we introduce a reduced-form risk premium on external debt. This reduced-form risk premium can be rationalized by assuming that financial transactions between domestic and foreign residents require financial intermediation by domestic institutions and that financial intermediaries face operational costs that are increasing and convex in the volume of intermediation. Crucial for the predictions of the model are also the presence of adjustment costs in investment. The relative size of debt adjustment costs affects significantly the behavior of investment and net exports and, thus, the response of the current account to the transitory output shock. When investment cannot react due to heavy capital adjustment costs, the increase in domestic savings is used to reduce debt and net exports increase in equilibrium. Instead, when the opposite is true, the increase in domestic savings is absorbed by domestic investment and the reaction of net exports is much smaller in equilibrium.

Many of the sub-Saharan African countries in our sample face significant barriers to private financial flows (as in the spirit of Alfaro et al., 2008; Papaionnou, 2009). In this regard, the finding of a near zero response of the current account to domestic savings in sub-Saharan African countries may not be surprising. However, as our empirical results and theoretical model make clear, a closer look into the components of the current account – (i) net exports, (ii) net current transfers, (iii) net factor income – reveals that the lack of financial integration of the sub-Saharan African region with the rest of the world would be too shallow of an explanation. This is because net exports do respond significantly positively to the rainfall shock. Net-current transfers respond significantly negatively, thus financing a significant part of the real international resource transfer: the change in net exports. Net current transfers, in contrast to private financial flows, are international capital flows without a quid pro quo. Our finding of a significant negative correlation between net current transfers and domestic savings therefore does not contradict the literature which argues for significant (institutional) barriers to private financial flows.

The significant positive response of net exports to a change in domestic savings is a common feature of even the most basic intertemporal models of the current account. As our model makes clear, however, it is the (countercyclical) net current transfers that enable the sub-Saharan African economies to smooth consumption. Output changes that are due to changes in rainfall are then, primarily, reflected in changes in net exports, which are mirrored by changes in net current transfers, so that the overall current account response is near zero. The bottom line of our research is that open economy models of poor countries – where net current transfers play an important role – need to incorporate both, financial frictions and a response of net current transfers to domestic output shocks.

The remainder of the paper is organized as follows. Section 2 discusses the related literature. Section 3 contains a description of the data. Section 4 presents the estimation strategy. Section 5 discusses the main empirical results. Section 6 introduces the dynamic stochastic general equilibrium model. Sections 7 and 8 discuss the calibration and the theoretical results. Section 9 concludes.

2 Related Literature

Our paper is related to literature on the response of the current account to economic shocks. The majority of papers in this literature, which have been both of empirical and theoretical nature, have focused on industrialized countries and emerging market economies. Examples include the classic paper by Feldstein and Horioka (1980), and the more recent papers by Blanchard and Giavazzi (2002), Kraay and Ventura (2000, 2003), Giannone and Lenza (2010), and Tille and Van Wincoop (2010). The typical empirical finding in these papers is that, on average, there is a high correlation between domestic savings and investment, and a close to zero correlation between domestic savings and the current account. This finding is commonly perceived as one of the major and empirically most robust puzzles in open economy macroeconomics (Obstfeld and Rogoff, 2000).

There are also a few papers that have focused exclusively on the group of developing countries. Focusing on African countries only, Calderon et al. (2007) find that the current account in these countries is positively linked to domestic savings. Extending their analysis to developing countries, Calderon et al. (2002) come to a similar conclusion. Similar to our work, Calderon et al. (2002, 2007) realize the importance of distinguishing in the data between transitory and permanent shocks. Calderon et al.'s approach is to argue that cross-country differences in saving rates mostly reflect permanent differences. Therefore, when country fixed effects are included in the econometric model, these permanent cross-country differences do not drive the estimated coefficient on domestic savings. In other words, when country fixed effects are controlled for the relationship between domestic savings and the current account is driven in the panel data by exclusively the time-series variation. However, as is also well understood, time-series variation in macroeconomic variables contains both very persistent and transitory shocks. Hence, even when controlling for country fixed effects, the panel fixed effects estimate on domestic savings captures an average effect of very persistent and transitory shocks to domestic savings. Moreover, such an estimate does not distinguish between demand and supply-side shocks and possible anticipatory effects of output changes.

Our paper is closest in spirit to the work of Aguiar and Gopinath (2007) who identify in the data permanent and transitory shocks by using information on the responses of consumption, net exports, and investment. Their work makes it clear that distinguishing transitory from permanents shocks is crucial for comparison of the empirical results to predictions from theoretical models, even when the empirical estimates are derived from the with-country variation of the data. The work by Aguiar and Gopinath (2007) also makes it clear that the persistence of the GDP process alone does not provide very useful information for this purpose. Our paper agrees with that position. It should be noted though that the approach taken in Aguiar and Gopinath (2007) is conditional on the validity of the permanent income hypothesis. The estimates in our paper that use year-to-year variations in rainfall as an exogenous, transitory shock to output do not depend on this assumption.

It is important to note that our paper's focus is on the group of sub-Saharan African countries. The empirical reason for this focus is that rainfall matters in the group of sub-Saharan African countries. The agricultural sector in the sub-Saharan African economies is large: over the past three decades agriculture's GDP share exceeded one-third on average; even today more than one-quarter of GDP comes from agriculture and over two-thirds of the population are employed in the agricultural sector (WDI, 2011). Therefore, year-to-year variations in rainfall can have large effects on aggregate output in these economies. As empirical work by Barrios et al. (2010) makes clear, the significant effects of rainfall on GDP are limited to the group of sub-Saharan African countries.

The limited effect of rainfall to the group of sub-Saharan African countries is the main reason why we focus in our paper on this particular group of poor countries.

Beyond the above empirical reason for using rainfall in the group of sub-Saharan countries, there is also a more substantive reason for our focus on these countries: sub-Saharan Africa is a focal point of economic development policy. This focal point is reflected, for example, in the World Development Millennium Goals. It is also reflected in recent reports by the World Bank, the European Commission, and the IMF. Understanding how sub-Saharan economies respond to economic shocks should be helpful in identifying which ingredients are essential for the macroeconomic modeling of these economies.

3 Data

3.1 Rainfall

Our data on year-to-year variations 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 2.5x2.5 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 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.

3.2 Macroeconomic Variables

We obtain data on the relevant macroeconomic variables for the group of sub-Saharan African countries from two sources. Our first data source of domestic savings, investment, and net exports is the Penn World Table, version 7.0 (Heston et al., 2011). The PWT provides data on PPP GDP, private consumption, government consumption expenditures, and total investment. Based on the PWT data, and following common practices, we compute domestic savings as GDP less private and government consumption expenditures. We then calculate net exports as the difference between domestic savings and total investment. Table 1 shows the relevant descriptive statistics. According to PWT, the domestic savings rate for the group of sub-Saharan African countries is 0.10; the investment rate is 0.19; and the share of net exports in GDP is -0.09.

While an advantage of the PWT is that for the group of sub-Saharan African countries it provides the largest number of observations on domestic savings, investment, and net exports (about one-third more than the World Development Indicators, 2011), a disadvantage is that the PWT does not provide data on the current account. We, therefore, use data on the current account and its components from WDI (2011). Table 1 shows that, according to WDI, the current account to GDP ratio is -0.05. The current account is defined as the sum of net exports, net current transfers, and net factor income. The ratio of net exports to GDP is -0.11; the ratio of net current transfer payments to GDP is 0.08; and the ratio of net factor income to GDP -0.02. The WDI data also show that the bulk of private capital flows to sub-Saharan African countries are in form of foreign direct investment which comprise about 2 percent of GDP on average. Sub-Saharan African countries' average external debt to GDP ratio is around 0.99.

4 Estimation Framework

The estimating equation relates the GDP ratio of the current account, CA_{ct}, (and its components) to domestic savings scaled by GDP, $Saving_{ct}$:

$$CA_{ct} = \alpha_c + \beta_c t + \gamma_t + \theta Saving_{ct} + u_{ct} \quad (1)$$

where α_c are country fixed effects; $\beta_c t$ are country-specific linear time trends; γ_t are year fixed effects; and u_{ct} is an error term that we cluster at the country level to allow for arbitrary within-country serial correlation. We note that the country fixed effects, α_c, account for time-invariant factors. Examples of these time-invariant factors are geography and history. These time-invariant factors could affect both, sub-Saharan African countries' average savings rates and the current account.

It is important to note that because we control for country fixed characteristics we identify the effects of domestic savings on the current account from the within-country variation of the data. In other words, we do not use average cross-country differences in domestic savings and the current account to identify the relationship. Average cross-country differences in domestic savings and the current account are likely to be a consequence of an array of factors, some of which are difficult to measure, such as ethnic divisions, social norms, and trust; all of these are likely to affect savings and possibly the current account beyond savings. In addition to the econometric issue that using average cross-country differences to identify the relationship between domestic savings and the current account gives rise to serious omitted variables concerns, the macroeconomic models available do not readily allow to incorporate these deep country characteristics as key features for studying the relationship between domestic savings and the current account.

Given that in our estimating equation we identify the relationship between domestic savings and the current account from the within-country variation of the data, it is important to realize that (leaving endogeneity issues aside for now) the least squares estimate, θ^{LS}, in equation (1) reflects the average response of the current account to domestic savings. That is, the least squares estimator reflects the relationship between domestic savings and the current account based on an average of very persistent and transitory shocks that are inducing the within-country fluctuations in domestic savings. For comparison of the empirical estimates to theoretical models it is crucial, however, to have a clear understanding of the types of shocks that are inducing the change in domestic savings (we will show this in Section 8).

In the group of sub-Saharan African countries, year-to-year variations in rainfall are known to have large effects on aggregate output (e.g. Miguel et al. 2004; Brückner and Ciccone, 2011). The large effect on aggregate output is not surprising: during the 1980-2009 period nearly one-third of GDP came from agriculture and more than two-thirds of the population was employed in agriculture (WDI, 2011). Given that the average sample AR(1) coefficient of year-to-year variations in rainfall is less than 0.1, we not only have an exogenous shock to aggregate output at hand; we also have a shock to output that is of highly transitory nature.

The permanent income hypothesis predicts that such a transitory output shock should have a large effect on domestic savings. In light of this hypothesis, Brückner and Gradstein (2013) document a quantitatively small and statistically insignificant response of private consumption to transitory, rainfall-induced aggregate output shocks.[1] These authors also provide a rationale based on a game-theoretic model of net current transfers why, despite the severe frictions to private financial flows, consumption does not respond significantly to transitory output shocks in sub-Saharan African countries. In our instrumental variables estimation framework we exploit that, in line with the small effect of rainfall on private consumption documented in Brückner and Gradstein (2013), rainfall has a significant positive effect on domestic savings.

Under the exclusion restriction that rainfall only affects the current account through its effect on domestic savings, instrumental variables estimation of equation (1) captures the causal effect that a transitory, output-induced change in domestic savings has on the current account. In the instrumental variables estimation, the second-stage equation is simply equation (1), while the first-stage equation is:

$$Saving_{ct} = a_c + b_c t + d_t + \eta Rainfall_{ct} + e_{ct} \tag{2}$$

where $Rainfall_{ct}$ is the log of annual rainfall precipitation in country c and year t. Note that we are using in the regression smooth variations in rainfall, and not an indicator variable for droughts or floods. In order to ensure that our results are not driven by extreme weather events, we will exclude the top and bottom 5th percentile of country-specific rainfall observations from all regressions.

We note that for the purpose of comparing the empirical results to the predictions from the theoretical model, it suffices to look at the reduced-form responses. That is, it suffices to look at the GDP-scaled net exports response as well as the investment, current account, net transfers and net factor income

[1] The authors findings are consistent with household data evidence on the response of savings to rainfall shocks; see, for example, Paxson (1992).

responses to rainfall – and compare the magnitude of the responses with each other. This is because, observing a large reduced-form effect of rainfall on net exports *relative* to the reduced-form effect of rainfall on, say, net current transfers is directly comparable with the size of the theoretical impulse response of net exports to a productivity shock *relative* to the theoretical impulse of net current transfers to that productivity shock. In other words, any scaling issues related to the size of the rainfall shock and how that rainfall shock affects individually the variables will not affect the magnitude of the relative responses.

In light of the above point, it is useful to recall that the IV estimator is simply the ratio of the reduced-form coefficient over the first-stage coefficient (see e.g. Wooldridge, 2002; this is, of course, only true for an exactly identified model as we are estimating). Formally, the IV estimator in equation (1) is:

$$\theta^{IV} = \frac{\lambda}{\eta}$$

where λ is the effect of rainfall on the current account that is obtained from the reduced-form regression:

$$CA_{ct} = f_c + g_c t + h_t + \lambda Rainfall_{ct} + w_{ct} \tag{3}$$

For comparison to the predictions from the model, the second-stage coefficient, θ^{IV}, should therefore be interpreted as the reduced-form effect of rainfall on the current account relative to the first-stage effect that rainfall has on domestic savings.

5 Empirical Results

5.1 Two-Stage Least Squares Estimates

In this section we present and discuss our two-stage least squares estimates of the effect that a shock to domestic savings has on the current account. Before discussing the estimates, it is useful to recall that the current account is equal to the sum of net exports, net current transfers, and net factor income. Net exports are the difference between all exports of goods and services minus all imports of goods and services. According to WDI (2011), 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) as well as migrants' remittances. Net factor income represents earnings on foreign loans and investments minus payments made to foreign investors. As the descriptive statistics in Table 1 show, net exports make up an important part of the current account. We thus begin the discussion of our empirical results with the response of net exports to domestic savings.

Columns (1) and (2) of Panel A in Table 2 show two-stage least squares estimates that use rainfall as an instrumental variable for the domestic savings rate. In column (1) data on the domestic savings rate and the net exports to

GDP ratio are from the PWT. The estimated second-stage coefficient on the domestic savings rate is in that case around 0.67 and has a standard error of around 0.15. We can reject the hypothesis that the second-stage coefficient is equal to zero (unity) at the 1 (5) percent significance level. In column (2) the data on the domestic savings rate and the net exports to GDP ratio are from the WDI. Two-stage least squares estimation yields in that case a coefficient on the domestic savings rate that is around 0.54 with a standard error of around 0.28. We can reject the hypothesis that the second-stage coefficient is equal to zero (unity) at the 5 (10) percent level. Quantitatively, these estimates imply that, on average, a one percentage point increase in the domestic savings rate leads to an increase in the net exports to GDP ratio of over 0.5 percent points.

Despite the highly significant positive relationship between net exports and domestic savings, column (3) in Panel A of Table 2 shows that the relationship between the current account and domestic savings is insignificant. The second-stage coefficient on the domestic savings rate in column (3) is 0.04 and its standard error is 0.23. We cannot reject the hypothesis that the second-stage coefficient in column (3) is equal to zero at the conventional significance levels. We can however reject the hypothesis that it is equal to unity a the 1 percent level. The current account response to domestic savings is thus quantitatively much smaller than the net export response. A corollary of this is that if we would have focused in our empirical analysis on the current account only we would have (mistakenly) concluded that shocks to domestic savings have no substantial effects on net trade of goods and services.

The reason why the current account response to domestic savings is quantitatively smaller than the net-export response is that there is a statistically significant and quantitatively large negative response of net current transfers to domestic savings. This can be seen from the estimates reported in column (4) of Panel A in Table 2. The second-stage coefficient on the domestic savings rate is -0.61 and has a standard error of 0.28. Quantitatively, the estimate implies that, on average, a one percentage point increase in the domestic savings rate is associated with a roughly 0.6 percentage points decrease in the GDP ratio of net current transfers. In other words, net current transfers are strongly counter-cyclical.

For purposes of studying sub-Saharan African countries' trade responses to a transitory shock to domestic savings, the significant negative response of net current transfer is an important result for two main reasons. First, from an empirical perspective, the significant negative response of net current transfers to domestic savings implies that the response of the current account to domestic savings differs from the response of net exports. Second, from a theoretical perspective, understanding correctly the relationship between the current account and domestic savings calls for incorporating the behavior of net current transfers in theoretical models. In other words, even though a basic intertemporal approach to the current account contains the necessary ingredients, it may not be rich enough to correctly predict the response of the current account to domestic savings. We will demonstrate this point in Section 8.

For completeness column (5) in Panel A of Table 2 shows that the response of net factor income is positive, but not significantly different from zero. The second-stage coefficient on the domestic savings rate in column (5) is 0.11 and has a standard error of 0.14. Hence, we conclude that the main reason why the current account response to domestic savings is different from the net export response is the quantitatively large offsetting response of net current transfers.

Regarding the quality of our instrumental variables estimates, we note that the first-stage effect of rainfall on the domestic savings rate is positive and significant at the 1 percent level. The first-stage estimates, which we report at the bottom of Panel A, imply that a ten percent increase in rainfall increases the domestic savings rate by around 1 percentage point. The Anderson-Rubin test indicates significance of the second-stage coefficient in columns (1), (2), and (4) but not in columns (3) and (5).[2] The Anderson-Rubin test results are thus always in agreement with the test results obtained from the 2SLS based t-values.

For comparison to the instrumental variables estimates, we report in Panel B of Table 2 least squares estimates. The least squares coefficient for the net export equation is 0.73 in column (1) and 0.33 in column (2). For the current account the least squares coefficient is 0.20 while for net current transfers and net factor income it is -0.08 and -0.06, respectively (see columns (3)-(5)). Thus, similar to the instrumental variables estimates, the least squares estimates also indicate a large effect of domestic savings on net exports and a smaller, though significant positive effect on the current account. However, as discussed in detail in Section 4, estimates from least squares regressions are only of limited use for comparison to predictions from theoretical models.

The assumption in our two-stage least squares regressions is that rainfall only affects the current account and its components through its effect on domestic savings, i.e. rainfall is uncorrelated with the error term in equation (1). In Table 3 we examine this exclusion restriction by using temperature as an additional instrument for domestic savings. Temperature like rainfall is plausibly exogenous to economic conditions in sub-Saharan African countries. With the two instruments in hand we can compute the p-value of the Hansen J-test. The Hansen J-test is a joint test that the instruments are uncorrelated with the second-stage error term. Table 3 shows that the p-value from the Hansen J-test is always in excess of 0.1. Hence, the Hansen J-test does not provide evidence that the instruments are correlated with the second stage error term.

To complete the picture, we report in columns (1) and (2) of Table 4 two-stage least squares estimates of the effects that domestic savings have on investment. The second-stage coefficient on the domestic savings rate is around 0.33 if we use PWT data and around 0.42 if we use WDI data. Both coefficients are significantly different from zero and unity at the conventional significance level. On the other hand, there is no significant effect of domestic savings on private capital flows. This is true if we consider only FDI (column (3)) or the total net flow of private capital to sub-Saharan African countries (column (4)).

[2] The Anderson-Rubin test has correct size even when instruments are weak (see Andrews and Stock, 2005).

This latter result is consistent with the literature that has pointed to significant frictions to private capital flows in developing countries (Alfaro et al., 2008; Papaionnou, 2009).

5.2 Reduced Form Estimates

We now leave the instrumental variables analysis and turn to the reduced-form estimates reported in Table 5. Columns (1) and (2) of Table 5 show that rainfall has a significant positive effect on the net exports to GDP ratio. The coefficient (standard error) on the log of rainfall is 0.08 (0.02) in column (1) where the data on the net export to GDP ratio are from the PWT. In column (2), where the data on the net export to GDP ratio are from WDI, the coefficient on the log of rainfall is 0.05 (0.02). Rainfall also has a significant positive effect on the investment to GDP ratio, see columns (3) and (4). The coefficient (standard error) on the log of rainfall is 0.04 (0.02) in column (3) where the data on investment are from the PWT. In column (4), where the data on investment are from the WDI, the coefficient (standard error) on the log of rainfall is 0.04 (0.02). Quantitatively, the response of net exports to the rainfall shock is thus larger than the response of investment.

Moving to the current account and its components, columns (5)-(7) of Table 5 show the following: (i) the overall current account response to rainfall is insignificant; (ii) the net current transfer response to rainfall is negative and significant at the 1 percent level; (iii) the net factor income response is insignificant. In quantitative terms, the (absolute) net current transfers response is of almost similar magnitude as the net exports response. The net factor income response to rainfall is, on the other hand, quantitatively small.

For comparison to the predictions from the theoretical model presented in the next section, it is useful to consider also the empirical responses of other key macroeconomic variables. Column (8) of Table 5 documents the well-known positive effect of year-to-year rainfall on sub-Saharan African countries' GDP per capita. The estimates imply that, on average, a one percent increase in rainfall increases GDP per capita in that year by around 0.07 percent. Column (9) shows that, despite this increase in GDP per capita, private consumption does not increase significantly. Columns (10) and (11) document that increases in year-to-year rainfall lead to a significant decrease in the real exchange rate and the external debt-to-GDP ratio.

In Figure 1 we plot the impulse responses of the different macroeconomic variables to the rainfall shock. On impact the rainfall shock significantly increases output, domestic savings, net exports, and investment; it significantly decreases external debt and leads to a real exchange rate depreciation; the effects on consumption and net factor income while positive, are quantitatively small. After about five years the dynamic effects are zero for the majority of variables. External debt and the real exchange rate display the most persistent dynamics; for these variables the impulse responses are zero after about 10 years.

6 Model

The model is a neoclassical dynamic general equilibrium model of a small open economy that has three productive sectors: agricultural and manufacturing goods which are tradable and services which are non-tradable goods. The economy receives net current transfers in form of a transfer of manufacturing goods from the rest of the world; crucially, these transfers depend on the level of total production in the recipient country. The recipient country also has access to international capital markets, but faces there a significant risk premium. Preferences are assumed to feature external habit formation, or catching up with the Joneses as in Abel (1990). Habit formation has been shown to help explain asset prices and business fluctuations in both developed economies (e.g., Boldrin et al., 2001) and emerging countries (e.g., Uribe, 2002). Finally, there are costs to the adjustment of aggregate capital. Adjustments costs have been extensively used in modeling the dynamics of small open economies as they represent a convenient and plausible way to avoid excessive investment volatility in response to changes in the interest rate faced by the country in international markets. Finally, labor is inelastically supplied.

6.1 Households

Consider a small open economy populated by a large number of infinitely lived households with preferences described by the following utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(C_t - \varphi \widetilde{C}_{t-1}\right)^{1-\sigma} - 1}{1-\sigma} \tag{4}$$

where C_t denotes the individual consumption aggregator in period t, and $\widetilde{C}_t$ denotes the cross-sectional average level of consumption in period $t-1$. The single-period utility is assumed to be increasing, concave, and smooth. The parameter $\beta \in (0,1)$ denotes the subjective discount factor. The parameter φ measures the degree of external habit formation. The case $\varphi = 0$ corresponds to time separability in preferences. The larger is φ, the stronger is the degree of external habit formation and the parameter σ is the relative risk aversion coefficient.

The consumption aggregator is of constant elasticity of substitution (CES) form:

$$C_t = \left[\omega_A \left(C_t^A\right)^{-\mu} + \omega_S (C_t^S)^{-\mu} + \omega_M (C_t^M)^{-\mu}\right]^{-\frac{1}{\mu}} \tag{5}$$

where $\mu, \omega_A, \omega_s, \omega_M > 0$ with $\omega_A + \omega_s + \omega_M = 1$, and the elasticity of substitution across sectoral goods $\frac{1}{1+\mu}$.

Labor is supplied inelastically in the economy and is perfectly homogenous and mobile across sectors so that:

$$\overline{L} = L_t^A + L_t^S + L_t^M$$

Households have access to two types of assets, physical capital and an internationally traded bond. The capital stock is assumed to be owned entirely by domestic residents. Households have three sources of income: wages, capital rents, and interest income on financial asset holdings. Each period, households allocate their wealth to purchases of consumption goods, purchases of investment goods, and purchases of financial assets. The manufactured goods contribute to the economy's stock of capital with any excess supply or demand traded in international markets at price p_t^M that we normalize to one. In addition, the economy receives net current transfers, which we model here as a transfer of traded-manufacturing goods, X_t, from the rest of the world. The household's period-by-period budget constraint in terms of traded goods is then given by:

$$d_t = (1 + R_{t-1})d_{t-1} + \Psi(d_t) + C_t P_t + I_t - w_t \overline{L} - u_t K_t - X_t \tag{6}$$

where d_t denotes the household's debt position in period t, R_{t-1} denotes the net interest rate faced by domestic residents in financial markets which is exogenous to the domestic agents, w_t denotes the wage rate, u_t denotes the rental rate of capital, K_t denotes the stock of physical capital, and I_t denotes gross domestic investment. The household consumes a composite good C_t at a price P_t. Her expenditure is defined as $P_t C_t = C_t^M + p_t^S C_t^S + p_t^A C_t^A$, where p_t^S is the relative price of services in terms of traded manufactured goods and p_t^A is the relative price of agricultural goods in terms of traded manufactured goods that we assume is exogenous in the context of our small open economy and X_t is the net current transfers in terms of traded manufacturing goods given to the economy. We assume investment is in the form of traded manufactured goods, so that net current transfers can be used directly for investment (see also Arellano et al., 2009). We introduce financial frictions in the model by assuming that households face costs of adjusting their foreign asset position following the spirit of Neumeyer and Perri (2005) and Uribe and Yue (2010) who develop models in which country risk spreads are stochastic and interact with financial imperfections. Debt adjustment costs also eliminate the familiar unit root built in the dynamics of standard formulations of the small open economy model.[3] The debt-adjustment cost function $\Psi(d)$ is assumed to be convex and to satisfy $\Psi(\overline{d}) = \Psi'(\overline{d}) = 0$, for some $\overline{d} > 0$. In particular, we assume the quadratic costs of adjustment of the form: $\Psi(d) = \frac{\psi}{2}(d_t - \overline{d})^2$.

The debt adjustment cost can be decentralized as follows. Suppose that financial transactions between domestic and foreign residents require financial intermediation by domestic institutions (banks). Suppose there is a continuum of banks of measure one that behave competitively. They capture funds from foreign investors at the country rate R_t and lend to domestic agents at the rate R_t^d. In addition, banks face operational costs, $\Psi(d_t)$, that are increasing and convex in the volume of intermediation, d_t. The problem of domestic banks is then to choose the volume d_t so as to maximize profits, which are given by

[3] Schmitt-Grohe and Uribe (2003) compare a number of standard alternative ways to induce stationarity in the small open economy framework and conclude that they all produce virtually identical implications for business-cycle fluctuations.

$R_t^d[d_t - \Psi(d_t)] - R_t d_t$, taking as given R_t^d and R_t. It follows from the first-order condition associated with this problem that the interest rate charged to domestic residents is given by:

$$R_t^d = \frac{R_t}{1 - \Psi'(d_t)} \tag{7}$$

Bank profits are assumed to be distributed to domestic households in a lump-sum fashion. The expenditure minimization problem of the household yields:

$$C_t^i = \omega_i^{\frac{1}{1+\mu}} \left(\frac{P_t^i}{P_t}\right)^{-\frac{1}{1+\mu}} C_t, \text{ for } i = A, M, S$$

The household is assumed to own physical capital, K_t. The process of capital accumulation displays adjustment costs in the form of quadratic costs of installing new capital goods, where parameter ξ determines the size of these costs. Capital accumulates according to the following law of motion:

$$K_{t+1} = I_t + (1-\delta)K_t - \frac{\xi}{2}\left(\frac{K_{t+1}}{K_t} - 1\right)^2 K_t \tag{8}$$

where δ is the rate of depreciation of physical capital.

In addition, consumers are subject to a borrowing constraint that prevents them from engaging in Ponzi financing:

$$\lim_{j\to\infty} E_t \frac{d_{t+j+1}}{\prod\limits_{s=0} R_{t+s}} \tag{9}$$

6.2 Firms

Firms in all sectors are competitive, choose labor and capital to maximize profits, and produce output with a Cobb-Douglas, constant returns to scale technology:

$$Y_t^A = Z^A \exp(\varepsilon_t^A) \left(K_t^A\right)^{\alpha_A} \left(L_t^A\right)^{1-\alpha_A} \tag{10}$$

$$Y_t^S = Z^S \exp(\varepsilon_t^S) \left(K_t^S\right)^{\alpha_S} \left(L_t^S\right)^{1-\alpha_S} \tag{11}$$

$$Y_t^M = Z^M \exp(\varepsilon_t^M) \left(K_t^M\right)^{\alpha_M} \left(L_t^M\right)^{1-\alpha_M} \tag{12}$$

All sectors are subject to productivity shocks, $\varepsilon_t^A, \varepsilon_t^S$ and ε_t^M. Shocks to rainfalls are modeled as ε_t^A disturbances. Firms and households have the same information set: they know the distribution of the productivity and net current transfer shocks. However, households cannot insure perfectly against shocks because asset markets are incomplete.

Although we have assumed perfect labor mobility, capital, however, is assumed to be sector-specific, in the sense that capital becomes less effective as more of the existing capital stock is allocated to one sector. This assumption is captured by the factor transformation curve (Mendoza and Uribe, 2000):

$$K_t = \left[K_t^{A-\nu} + K_t^{S-\nu} + K_t^{M-\nu}\right]^{-\frac{1}{\nu}} \tag{13}$$

where $1/1+\nu$ denotes the elasticity of substitution between the two types of capital, so that if $\nu = -1$, we can nest the case of perfectly homogeneous capital.

Firms operate under perfect competition. The first-order conditions for the firms in the different sectors are defined by:

$$F_L^i = w_t \qquad \text{for } i = A, M, S \tag{14}$$

$$F_k^i = u_t \qquad \text{for } i = A, M, S \tag{15}$$

Firms in each sector hire labor and rent capital from the households so that in equilibrium the wage rate equals the marginal productivity of labor and the rate of return equals the marginal productivity of capital. Since capital is sector-specific, the effective rate of return in each sector incorporates the degree of factor substitutability between the three sectors given by the derivative of total capital, K, with respect to the sectoral capital. In equilibrium, marginal productivities across sectors are equalized.

6.3 Net Current Transfers

A key empirical finding in the development economics literature is that foreign aid and migrant remittances are a significant function of shocks to developing countries' national income (e.g. Yang and Choi (2007), Yang (2008), Arezki and Brückner (2012), Brückner (2013), Brückner and Gradstein (2013)). In particular, this literature finds significant counter-cyclicality of net current transfers to transitory income shocks. Following this literature we model net current transfers as dependent on the economy's GDP. The economy's GDP in terms of manufactured goods is determined by:

$$Y_t = Y_t^M + p_t^A Y_t^A + p_t^S Y_t^S$$

And net current transfers follow:

$$X_t = \chi + \theta Y_t$$

6.4 Definitions

The trade balance or net exports in the small open economy in terns of manufactured traded goods is defined as:

$$NX_t = Y_t - p_t C_t - I_t - \Psi(d_t) \tag{16}$$

while the current account is the sum of net exports, net factor income and net current transfers:

$$CA_t = NX_t + X_t - R_{t-1}d_{t-1} \tag{17}$$

Total savings in the economy are defined by:

$$S_t = Y_t - p_t C_t - \Psi(d_t)$$

The real exchange rate in the economy can be represented in terms of the relative price of non-traded goods. The price index of traded goods in the economy is given by:

$$P_t^T = \frac{\omega_A}{\omega_A + \omega_M} p_t^A + \frac{\omega_M}{\omega_A + \omega_M} p_t^M$$

and the real exchange rate is defined as the ratio of p_t^S / p_t^T.

6.5 Market Clearing Conditions

In equilibrium all households consume identical quantities. Thus, individual consumption equals average consumption across households, or

$$C_t = \widetilde{C}_t$$

and services which are non-traded are consumed in the home economy:

$$Y_t^S = C_t^S$$

7 Calibration

The parameters in the benchmark model are calibrated to mimic a typical sub-Saharan African country and are presented in Table 6. In calibrating the model, the time unit is meant to be one year. For the preference parameters, we set the steady-state real interest rate faced by the small economy in international financial markets at 11 percent per year. This value is consistent with an average US interest rate of about 4 percent and an average risk premium of 7 percent, both of which are in line with actual data. We set $\sigma = 2$ following other studies on developing economies (see e.g., Arellano et al., 2009). Following Uribe and Yue (2006) we set the habit formation parameter, φ, equal to 0.2. We set the depreciation rate at 14.5 percent per year to match an investment to output ratio of 0.19. The elasticity of substitution between capital used in the tradable and non-tradable sectors, $1/\ (1{+}\nu)$, is set to -0.1 following Mendoza and Uribe (2000). Capital adjustment costs are set to $\xi = 0.2$, while the adjustment costs on debt are similarly set equal to $\psi = 0.1$. Uribe and Yue (2006) estimate a much lower value for ψ in emerging market economies; according to their estimation $\psi = 0.00045$. In what follows, we investigate the sensitivity of our results to changes in the cost of adjusting external debt. We normalize the productivity of all sectors $Z^i, i = A, M, S$ to one. The elasticity of substitution between the different goods, $1/(1+\mu)$ is set equal to 0.7. In the spirit of Herrendorf and Valentinyi (2008) we parameterize the three productions functions as follows: we set the capital share of the tradable manufacturing sector α_M to 0.36 and the capital share of the tradable agricultural sector, $\alpha_A = 0.35$, and the capital share of the nontradable sector, α_S= 0.3**.** In order to obtain labor shares in agriculture, manufacturing and services similar to the ones we observe in the data we have set $\omega_M = 0.2$, $\omega_S = 0.1$, and $\omega_A = 0.7$. Parameter χ is set so that net current transfers to GDP at the steady state equal 0.15, while net exports to GDP are calibrated to equal -0.11 at the steady state. The current account to GDP ratio in the steady state is zero while the debt to GDP ratio is equal to 36 percent and savings to GDP equal 8 percent. Finally, we set $\theta = -0.6$ to match the dollar response of net current transfers to changes in GDP in sub-Saharan countries, which equals -0.1 in our model, and is estimated in the (-0.1, -0.2) interval by Brückner and Gradstein (2013).

We set the persistence of the stochastic structure of productivity in the agricultural sector to 0.07. The persistence thus corresponds to the AR(1) coefficient on year-to-year rainfall in the sub-Saharan African region. We assume that shocks are uncorrelated across sectors. Finally, the process for the world interest rate is calibrated fitting an AR(1) into the evolution of the 3-month treasury bill rate in the US and the autocorrelation coefficient for the interest rates shock is set equal to 0.83.

8 Results

In Figure 2 we present the impulse responses of the economy to a productivity shock in the agricultural sector. The patterns in Figure 2 replicate qualitatively the responses depicted in Figure 1. The productivity shock increases output and employment in agriculture. Since overall labor supply is inelastic the increase in hours in the agricultural sector crowds out the hours in the services and manufacturing sector, leading to a fall of output in these sectors. Overall, total output increases in equilibrium and net current transfers fall. The real wage increases and agents decrease the demand for services and increase the consumption of tradable goods. There is a decrease in the relative price of non-tradables.[4] The increase in domestic savings reduces the amount of foreign debt; this in turn leads to increases in net factor income. The increase in domestic savings coupled with the moderate increase in investment leads to an increase in net exports. Finally, the current account increases in the impact period but by much less than net exports. Hence, the impact responses of the model reflect the picture we see in the data: domestic savings as a percentage of GDP increase on impact and net exports react much more to the shock relative to the current account and investment.

[4] Depending on the size of the demand and the supply shifts from manufacturing and service goods and their relative movements, the real exchange rate can fall or increase after a shock in the agricultural sector. For our calibration the real exchange rate depreciates inducing a boost in the demand for agricultural goods from foreigners.

In what follows we try to isolate the features of the model that are crucial for generating these results. The first row of Table 7 presents the impact responses of the variables of interest in the benchmark model, i.e., using the parameterization of Table 6. The consecutive rows of Table 7 present the sensitivity of these results to different parameter choices and shocks considered.

Endogeneity of Net Current Transfers

In the benchmark model we assumed that net current transfers are endogenous and had calibrated θ so that the impact response of transfers relative to output matches the data. In what follows we analyze how the assumption of endogeneity of net current transfers affects the transmission of rainfall shocks on domestic savings, the current account and net exports.

First, we consider the case of $\theta = 0$; see the second row of Table 7 for the results. The absence of a reaction of transfers to the rainfall shock implies that the current account and net exports responses coincide on impact. This is because net factor income, which depends only on interest payments for debt, does not react contemporaneously to the shock. However, the absence of a response in net current transfers should affect the behavior of households and the allocation between traded and non-traded goods and hours worked. When net current transfers do not react to changes in GDP, agents will try to smooth consumption after the productivity shock by their own means. They can do so by either increasing investment or net exports. Note that, in the absence of net current transfer, changes in net exports have to be fully financed by changes in the external debt position – which is costly. The increase in net exports in the absence of net current transfers is therefore lower relative to the benchmark model while the response of investment is larger. Also, there is less consumption smoothing when $\theta = 0$.

The importance of the endogeneity of net current transfers can also be seen when we increase the size of capital adjustment costs in the economy. The means for intertemporal consumption smoothing are net exports and investment. In the benchmark model agents use both investment and net exports as a mean of adjustment to the transitory shock. However, when capital is costly to adjust, the agents depend more on adjustments through net exports. In this case the increase in investment after the shock is much smaller and the increase in net exports higher relative to the benchmark case. On the other hand, if transfers are not endogenous, agents utilize relatively more investment even though it is costly to adjust the capital stock to smooth consumption.

Next we consider the case when debt adjustment costs are assumed to be low, ψ=0.00045, as estimated in Uribe and Yue (2006) for emerging market economies.[5] We present the impact responses of the model economy in the fifth row of Table 7. In this case agents smooth consumption more through net exports

[5] Note that our model differs in many aspects from the model of Uribe and Yue (2006). For that reason we take the estimated value for parameter ψ that they offer as indicative, since the implied value for ψ in our model with both traded agricultural and manufacturing goods and non-traded goods and endogenous net current transfers could be very different.

than through investment. The increase in savings is allocated to increase net exports. Again, the endogeneity of transfers matters for consumption smoothing and savings behavior (see the sixth row of the table where we consider the case of $\theta = 0$ and $\psi = 0.0045$) – but less so than in the benchmark economy where debt adjustment costs are larger.

Consumption Smoothing

Relative risk aversion determines the degree of sensitivity of consumption to interest rate changes and, as a result, will affect the behavior of savings after the shock in agriculture. In the seventh row of Table 7 we show that decreases in the relative risk aversion parameter, σ, do not affect significantly our benchmark results. The response of savings and the response of investment are slightly larger on impact but so is the net-export response, resulting in a slight increase in the impact coefficient for the current account and net exports

Elasticity of Substitution Across Goods

In the benchmark calibration we have assumed, by setting $\mu = 0.43$, that goods are substitutes in consumption. This is in line with Ostry and Reinhart (1992) where the estimated elasticity of substitution between traded and non-traded goods is around 0.32 for a panel of developing countries. One might rightly ask though what are the implications if we assume complementarity? We investigate this case in the eight row of Table 7, where we set $\mu = 8$, implying an elasticity of substitution between traded and non-traded goods of 0.11. Higher complementary between goods implies a decrease in the consumption bundle on impact and a lower increase in output and investment after the shock. Domestic savings increase more moderately after the shock relative to the benchmark case and, although absolute responses are not comparable with the benchmark case, the relative responses of investment, the current account and net-exports to savings do not look strikingly different.

Persistence of the Productivity Shock

The distinction between transitory and persistent shocks is crucial for understanding the relationship between domestic savings and the current account. In our empirical analysis, we used plausibly exogenous variations in year-to-year rainfall to provide an estimate of the causal relationship between domestic savings and the current account that emerges from a transitory productivity shock. We then compared the empirical responses to the predictions from a dynamic stochastic general equilibrium model. The theoretical model also permits us to investigate the relationship between the current account and domestics savings when the shock is of more permanent nature. In the ninth row of Table 7 we report the impact responses of the various variables of interest to a productivity shock that is very persistent ($\rho_a = 0.99$). Similarly to the temporary shock, the (positive) persistent shock increases domestic savings, output, investment and net exports. However, the current account becomes countercyclical after a permanent shock in agriculture. This results from the smaller increase in net exports relative to the case of temporary shocks combined with the countercyclical change in net current transfers. Net exports change less relative to the benchmark case since they are crowded out by investment as the persistent higher returns to capital and the capital adjustment costs make investment more attractive on impact.[6]

Demand Shocks

Since the behavior of the current account depends crucially on the nature of the shocks considered in this subsection we examine the impact responses of the model economy to a demand shock, modeled as a shock to the relative price of agricultural goods. According to Cashin et al. (2000) such shocks are quite persistent; for that reason we assume an autocorrelation coefficient of the shock equal to 0.8. The impact responses to the shock in the relative price of agricultural goods are reported in the last row of Table 7. Again the joint behavior of the current account and domestic savings is very different from the transitory productivity shock. The increase in savings is smaller in size and it is mostly allocated to investment in order to increase production in agriculture. Consumption, in particular of agricultural goods, is crowded out by the price shock. Again, the countercyclical net current transfers combined with the smaller increase in investment lead to a negative current account in the impact period. Yet, even in the absence of endogenous transfers the response of the current account would be negative since in this case the increase in the demand for investment to satisfy the increased output demand in the impact period of the shock would lead to a fall in net exports and a negative current account.

9 Conclusion

This paper examined the relationship between domestic savings and the current account in poor countries. In contrast to advanced economies, net current transfers are an important component of poor countries' current accounts. The basic model of the intertemporal approach to the current account focuses on net exports only. It, therefore, misses out on an important component of the current account of poor countries.

The missing out of the basic intertemporal model of the net-current-transfer component of the current account matters, in particular, in terms of the model's predictive power of how the current account reacts to a change in domestic savings. According to the basic model, a transitory output shock that leads to a significant increase in domestic savings should be accompanied by a substantial

[6] Note that the returns to investment after a permanent shock are such that in the absence of foreign transfers, i.e., if we set $\theta = 0$ in this exercise, net exports become negative and the current account continues to behave countercyclicaly in response to the shock.

increase in the current account. In the empirical part of the paper, we showed that there is a near zero correlation between domestic savings and the current account. We instrumented domestic savings with year-to-year variations in rainfall to ensure that this correlation reflects a causal effect of domestic savings on the current account. The empirical findings are thus inconsistent with the prediction from the basic intertemporal model of the current account.

In the theoretical part of the paper we extended the intertemporal model of the current account to include net current transfers. We showed that with an endogenous response of net current transfers to poor countries' output shocks, the intertemporal model's predictive power of the current account response to a change in domestic savings substantially improves. Consistent with the literature on frictions to financial flows, we also allowed in the model for a risk premium on poor countries' external debt. The presence of financial frictions and their interaction with the endogenous transfers mechanism is crucial for replicating the empirical results.

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