On the Relationship Between Domestic Saving and the Current Account: Evidence and Theory for Developing Countries*

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Abstract: We examine the relationship between domestic saving and the current account in developing countries. Our three main findings are that: (i) domestic saving has a small effect on the current account; (ii) domestic saving has a significant positive effect on the trade balance – this effect is much larger than the effect that domestic saving has on the current account; (iii) domestic saving has a significant negative effect on net-current transfers. We use countries in the sub-Saharan African region as a laboratory for an instrumental variables approach. The IV approach enables to obtain estimates of causal effects. Underlying the IV approach is the significant positive first-stage response of domestic saving to plausibly exogenous annual rainfall: an unanticipated, transitory supply-side shock. We construct a small open-economy DSGE model with debt adjustment costs and endogenous current transfers to match the empirical findings. The model enables to examine the relationship between domestic saving and the current account for different types of shocks. An important message of our paper is that, for developing countries, estimates of the relationship between domestic saving and domestic investment are not informative for answering the question how domestic saving affects a country's accumulation of net foreign assets.

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1 Introduction

The relationship between domestic saving and the current account is an important topic in open economy macroeconomics. At least since Feldstein and Horioka (1980), there has been a large amount of research done on this topic. Already at the early stage of research, the question arose how to interpret and compare the empirical findings to the predictions from theoretical models (see e.g. Obstfeld, 1986). Results of least-squares regressions that the empirical literature documented are silent about what types of shocks are driving the variation in domestic saving. For example: are these permanent or transitory shocks; demand or supply-side shocks; anticipated or unanticipated? This is a key issue when relating empirical results to predictions from theoretical models. In all theoretical models, one has to specify the type of shock that is causing the variation in domestic saving. Another, separate issue is that estimation of a causal effect of domestic saving on the current account is complicated by the endogeneity of domestic saving. Identifying exogenous shocks to domestic saving in macroeconomic data is difficult.

Our contribution to the literature is threefold. First, we provide least squares estimates of the relationship between domestic saving and the current account for a large panel of developing countries that covers approximately half of the world's population and spans about half a century. We report least squares estimates separately for different regions in the world; regions are defined according to the World Bank classification. The relationships established from the least squares regressions are interesting, but interpreting them as causal or comparing them to a model is not straightforward. To enable causal interpretation we use an instrumental variables approach. This is our second contribution to the literature. The instrument for domestic saving is rainfall: an unanticipated, transitory supply-side shock. The IV analysis is confined to sub-Saharan African countries, for reasons described below. For the sub-Saharan African region we can compare least squares to IV estimates. We can compare least squares estimates for different regions, to see whether the least squares estimates are different between the sub-Saharan African region and other developing regions in the world. Our third contribution to the literature is to build a DSGE model with endogenous current transfers. The model delivers predictions of the relationship between domestic saving and the current account. For a transitory productivity shock like rainfall, we can compare the model's predictions to the instrumental variables estimates. Beyond comparison purposes, the theoretical model enables us to generate predictions of the relationship between domestic saving and the current account for other types of shocks, such as changes in interest rates on external debt or trend TFP, for which, at the current date of writing, there is no clearly exogenous, country-specific instrument available so that a causal relationship can be estimated.

There are three main results from the least squares regressions: (i) in developing countries the effect of domestic saving on the current account is small and, for some regions, statistically indistinguishable from zero; (ii) there is a significant positive and quantitatively sizable effect of domestic saving on the trade balance; (iii) a significant negative effect of domestic saving on net-current transfers. We show that these results hold in developing countries across different regions in the world. For developing countries, there is a substantial difference in the relationship between domestic saving and the current account, and domestic saving and the trade balance. We document that this difference is specific to developing economies. For developed economies, i.e. High Income Countries as defined by the World Bank, least squares regressions show that there is no substantial difference in the relationship between domestic saving and the current account, and domestic saving and the trade balance.

In the instrumental variables regressions, we use year-to-year variations in rainfall to study how a transitory, exogenous, and unanticipated supply-side shock to GDP affects the relationship between domestic saving and the current account. We construct instrumental variables estimates for a panel of 41 sub-Saharan African (SSA henceforth) countries during the period 1980-2009. The IV approach is specific to the group of SSA countries. In SSA the agricultural sector is relatively large: the average agricultural GDP share is about one-third, and over two-thirds of the population is employed in agriculture (World Bank, 2017). It is well documented that year-to-year variations in rainfall have a significant effect on SSA 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 GDP, the permanent income hypothesis predicts that domestic saving should respond significantly to this shock as well. Indeed our panel model estimates show a highly significant positive effect of rainfall on domestic saving. A ten percent above country-mean increase in the level of rainfall increases the domestic saving rate by around 1 percentage point.

The main finding from the instrumental variables analysis is that domestic saving has a quantitatively small and statistically insignificant effect on the current account. Controlling for country fixed effects, country-specific linear time trends, and year fixed effects the coefficient on domestic saving in the current account equation is around 0.0 with a standard error of around 0.2. In papers on the Feldstein-Horioka puzzle, see the discussion below, the dependent variable is domestic investment. When the dependent variable in the IV estimation is domestic investment, the estimated coefficient on domestic saving is around 0.5; significantly different from zero and significantly smaller than unity. That is: about half of domestic saving is channeled into domestic capital accumulation. If one would have focused, exclusively, on the relationship between domestic saving and domestic investment, as has been common practice in previous papers on the Feldstein-Horioka puzzle, then one might have reached the following conclusion: about half of domestic saving is used to increase net-claims on foreign assets. That would not have been the right conclusion for developing countries.

A direct approach to answering the question how domestic saving of developing countries affects their net claims on foreign assets is to have in the econometric model as dependent variable the current account (or the change in net foreign assets). Estimation of that model shows that domestic saving has a small, near-zero, effect on the current account. An important message is thus: for developing countries it is in general not true that, in any given period, when domestic saving exceeds domestic investment there will be an increase in net-claims on foreign assets.

When we look at the components of the current account, we find that the effect of domestic saving on net exports is significantly positive and quantitatively quite large. The instrumental variables regressions yield a coefficient in the net export equation on domestic saving that is around 0.5. For net current transfers, IV estimation yields a negative and significant coefficient on domestic saving of around -0.6. Hence, the significant positive response of net exports to domestic saving is in line with the prediction from the basic model of the intertemporal approach to the current account; however, the current account response is far off.

In order to gain a deeper understanding of the relationship between domestic saving and the current account, we develop a small open-economy DSGE model for a typical SSA country. The SSA country faces transitory and persistent domestic productivity shocks, foreign output shocks and interest rate shocks. The SSA country receives an endogenous transfer that we call aid. Following Carter et al. (2015) the dynamic aid allocation is an outcome of a maximization problem: the donor country allocates aid such that global welfare is maximized. The SSA country has access to international bond markets; however, it faces costs to adjusting its net foreign asset position as in Neumeyer and Perri (2005) and Uribe and Yue (2010). The SSA country can also invest in its domestic capital stock. There is, thus, a trade-off that the SSA country faces with regard to allocating domestic saving: diminishing returns to scale of investing in the domestic capital stock, and costs to adjusting external debt.

In the model, a transitory productivity shock in the SSA country increases output on impact. Consumption is smoothed. The consumption smoothing implies that the transitory productivity shock leads to an increase in domestic saving. Domestic saving is allocated between net exports and domestic investment. Net exports significantly increase; however, there is no similarly large increase of the current account. The reason for this is that foreign aid (i.e., net current transfers) reacts counter-cyclically to the domestic productivity shock.

In the model, the optimal aid policy of the rich donor country prescribes that aid flows to SSA countries increase when the SSA countries are hit by a negative productivity shock. The response of aid flows to positive and negative shocks is symmetric, i.e. aid flows decrease when the SSA economy is hit by a positive productivity shock. The response of aid flows is almost as large as the response of net exports. Hence, the response of the current account to a transitory productivity shock is negligibly small, as shown by the estimates of the econometric model. The theoretical model shows that if aid is exogenous, i.e. does not react to domestic productivity shocks, the current account becomes more pro-cyclical, and consumption is much more volatile.

Our model is minimalistic, in the sense, that the only friction assumed is a cost to adjusting external debt. This friction is important to replicate our empirical findings. The smaller the debt adjustment cost, the larger the correlation between the current account and domestic saving. The reason for this is that when the debt adjustment cost is small it is desirable to smooth consumption by adjusting debt. In that case foreign aid is, endogenously, almost acyclical. And the correlation between domestic saving and net current transfers is near zero. – There is a large positive correlation between domestic saving and the current account; and this correlation is nearly as large as the correlation between domestic saving and net exports. On the other hand, with very large debt adjustment costs, the correlation between domestic saving and the current account is close to zero; foreign aid is strongly countercyclical; the correlation between domestic saving and net exports is positive and nearly as large as for the case of small debt adjustment costs.

Identification of shocks is crucial. In the model, only transitory productivity shocks generate a near-zero correlation between domestic saving and the current account. Persistent domestic productivity and foreign output shocks generate a negative correlation between domestic saving and the current account. If the volatility of output in the small open economy is driven by TFP trend (87%) and transitory (13%) domestic output shocks, as suggested by Aguiar and Gopinath (2007), then according to our model domestic saving and the current account should be negatively correlated. For transitory shocks to the interest rate on external debt, as in Garcia-Cicco et al. (2010), our model predicts that the correlation between domestic saving and the current account should be positive. A key insight from the model is, thus, that the relationship between domestic saving and the current account critically depends on the types of shocks that the macroeconomy faces.

The remainder of the paper is organized as follows. In the next section we relate our work to the existing literature. Section 3 presents stylized facts, i.e. descriptive statistics and least squares estimates. Section 4 discusses results from instrumental variables regressions. Section 5 introduces the DSGE model. Calibration of the model is described in Section 6. Section 7 contains a discussion of the impulse responses to the different shocks. Section 8 concludes.

2 Related Literature

In a widely-cited paper, Lucas (1990) noted that there is not much private capital flowing from rich to poor countries.[1] Recent empirical papers have confirmed the Lucas paradox (e.g. Alfaro et al. 2008; Papaionnou, 2009). The most salient explanation are appropriative institutions: in poor countries private property is not secure. Thus, despite capital being relatively scarce the net (i.e. risk-adjusted) return to private capital is relatively low. If focus is exclusively on international flows of private capital then, indeed, it seems as if financial globalization is confined to developed countries (Mishkin, 2007).

However, while private capital flows to poor countries are small there are substantial current transfers to poor countries in form of foreign aid and workers' remittances. Current transfers are part of the current account. In the Ely Lecture entitled "Globalization and Its Challenges", Fischer (2003) noted the

[1] The flow of capital may even be in the other direction, i.e. there is capital flight, from poor to rich countries as pointed out by Tornell and Velasco (1992).

importance of current transfers for developing countries: in particular, at the time of writing, Fischer noted that aid flows are substantial when measured relative to developing countries' GDP; for the poorest countries, aid flows are much larger in volume than private capital flows.

Why does this matter? One of the main benefits of international trade is risk sharing. A poor country that is hit by a negative, exogenous shock to output may want to smooth consumption by increasing imports. By keeping consumption smooth in the presence of country-specific output shocks, vis-a-vis changes in the trade balance, welfare in the poor country is higher relative to the case of autarky.[2]

How can the increase in imports be financed? One way to finance the imports is through foreign aid or remittances.[3] Using year-to-year variation in rainfall as a transitory shock to output, Brueckner and Gradstein (2013) showed that for sub-Saharan African countries there is substantial consumption smoothing at the macro level.[4] The rainfall shock induces a significant positive correlation between output and the trade balance, and a significant negative correlation between output and net current transfers. The finding of significant consumption smoothing for poor countries is surprising: at the very least, the mechanism is different to the one described in the classic chapter on the intertemporal approach to the current account that can be found in the Handbook of International Economics (Obstfeld and Rogoff, 1995).[5]

The Handbook chapter model predicts that, a poor country hit by a negative transitory productivity shock smoothes consumption by increasing imports of goods produced in another (possibly rich) country. The increase in the poor country's trade deficit is financed by borrowing from the rich country, i.e. there is an increase in net financial liabilities. However, developing countries face risk premia on external debt in the international bond markets; and for many of the poorer countries, these risk premia can be excessive (see e.g. the discussion in Fisher (2003), or Mishkin (2007)). Thus, substantial consumption smoothing through the trade balance is unlikely to be financed vis-a-vis increases in external debt (or, more generally, as we will show, increases in net foreign liabilities).[6]

[2]In the presence of domestic financial frictions, which, as noted in the above cited papers are severe, the poor country would not be able to smooth consumption under autarky.

[3]Chinn and Prasad (2003, p.71) briefly noted the plausibility of foreign aid financing a trade deficit but did not explore further the implications that this has for the relationship between domestic saving and the current account.

[4]Brueckner and Gradstein do not present estimates of the relationship between domestic saving and the current account. They also do not provide a DSGE model that enables to study dynamic effects, and how other types of shocks (e.g. interest rate or trend productivity shocks) affect the relationship between domestic saving and the current account in developing countries when current transfers are countercyclical.

[5]Kraay and Ventura (2000) proposed a "new rule" to the current account: the change in the current account is equal to the change in domestic saving times the ratio of net foreign assets to wealth. Tille and Van Wincoop (2010) argue that this new rule only holds with one-way capital flows. The new rule is supported by cross-section evidence but not by the within-country evidence, as documented by Kraay and Ventura (2003). Tille and Van Wincoop (2010) write that "It [the cross-section evidence] is fundamentally distinct from the new rule, which is about the dynamic response to temporary income shocks".

[6]For many developing countries external debt is not countercyclical as predicted by the

The above matters for answering an important question in international finance: What is the effect of domestic saving on the change in net-claims on other countries' capital? Feldstein and Horioka (1980) were the first to empirically document that, for OECD countries, there is a strong positive correlation between domestic saving and domestic investment. Or alternatively by noting the definition of domestic saving, $S \equiv Y - C - G = I + NX$, that the relationship between domestic saving and the trade balance is not that strong. This would be consistent with home bias in investment for developed countries.

The seminal paper by Feldstein and Horioka (1980) focused on OECD countries. A decade later, Bacchetta and Feldstein (1991), and others, see e.g. Sinn (1990), Tesar (1991), Baxter and Crucini (1993) and references therein, confirmed the initial findings of Feldstein and Horioka: there is a strong positive correlation between domestic saving and domestic investment for OECD countries. Since the 1980s that correlation has been on the decline; for the 2000s it is close to zero, see e.g. Blanchard and Giavazzi (2002) or Giannone and Lenza (2010). The Feldstein-Horioka finding is one of the major puzzles in open economy macroeconomics (Obstfeld and Rogoff, 2000).[7]

For developing countries, estimating the relationship between domestic saving and domestic investment (or alternatively net exports) does not provide a satisfactory answer to the question how domestic saving affect changes in net-claims on other countries' capital. The current account comprises not only net exports but also net current transfers. If there is a negative correlation between domestic saving and net current transfers, then domestic saving and net exports may be substantially positively correlated; but there may not be a substantial positive correlation between domestic saving and the current account. As we will show in the following sections, for developing countries, greater domestic saving may not lead to significant increases in net claims on foreign assets – even when the effect of domestic saving on net exports is significantly greater than zero.

3 Stylized Facts

3.1 Descriptive Statistics

Table 1 provides means and medians of current accounts (as a share of GDP) in developing countries of different regions in the world. The data are from the World Bank's (2017) World Development Indicators. We call a country "developing" if in 2016 its GNI per capita was less than USD12000. This is the

basic version of the intertemporal approach to the current account. Arezki and Brueckner (2012a,b) documented this for the special case of international commodity price windfalls; which end up to a large extent in the hands of government, i.e. the fiscal sector. Tornell and Lane (1998) point to voracious rent-seeking in countries with weak legal-political institutions as an explanation for why a positive terms of trade shock may lead to a current account deterioration.

[7] For a paper that points to a Feldstein-Horioka puzzle in emerging economies, see Chang and Smith (2014).

threshold above which, according to the World Bank, countries are classified as High Income Countries. The time period covered is 1960-2016, i.e. the longest possible period given available data from the World Bank.

From Table 1, one can see that on average developing countries: (i) ran current account deficits; (ii) trade deficits; (iii) and were net recipients of current transfers. Comparing the trade deficit (Panel A) to the current account deficit (Panel B) one can see that the former is quite a bit larger than the latter. For the average developing country, the current account deficit is about two to three times the size of the trade deficit. Net current transfers are an important part of developing countries' current accounts comprising around 5 to 10 percent of GDP. One can also see from the descriptive statistics in Table 1 that developing countries in the sub-Saharan African regions are not substantially different from developing countries of other regions with regard to the economic importance of net current transfers, the size of the trade deficit, and the current account deficit.

For the first three decades since the 1960s, foreign aid wa the most important component of net current transfers; however, in the past two decades workers' remittances have become increasingly important (Yang, 2013). In sub-Saharan Africa, the GDP share of aid received is about twice as large as the GDP share of remittances received, see Table 2. With regard to the composition of net current transfers, sub-Saharan African countries are somewhat different to other developing countries. In South Asia and Latin America migrant remittances are about as large as foreign aid; in North Africa and the Middle East migrant remittances as a share of GDP are about twice as large as the GDP share of foreign aid.

3.2 Least Squares Regressions

Table 3 reports least squares estimates. The right-hand-side variable is the gross domestic saving rate. The dependent variables are the GDP shares of the current account (column (1)), net-exports (column (2)), net current transfers (column (3)), aid received (column (4)), and remittances received (column (5)). The different panels show estimates for different developing regions: sub-Saharan Africa (panel A), South Asia (panel B), Latin America (panel C), East Asia and Pacific (panel D), and North Africa and Middle East (panel E).

The first main result is that there is only a weak relationship between domestic saving and the current account. In only two of the five developing regions is the coefficient on the domestic saving rate significantly positive. For those two regions, the coefficient is far from unity: around 0.2 for sub-Saharan Africa and around 0.4 in Latin America. In South Asia and the Middle East and North Africa the coefficient on the domestic saving rate is not significantly different from zero; while in East Asia and the Pacific it is significantly negative, around -0.2.

The second main result is that there is a strong positive relationship between domestic saving and the trade balance. When the dependent variable is the GDP share of net exports, the coefficient on the domestic saving rate is positive and significantly different from zero in all five developing regions. The largest coefficients on the domestic saving rate are in Latin America, the Middle East and North Africa, and sub-Saharan Africa; 0.7 and 0.6, respectively. This suggests that there is a substantial positive co-movement between the trade balance and the domestic saving rate in these developing regions. In other developing regions the co-movement is not as strong, but it is still positive and significantly different from zero. In East Asia and the Pacific the coefficient on the domestic saving rate is around 0.5, while in South Asia it is around 0.4. If one were to interpret these estimates in a causal way then one would say that, roughly, about half of domestic saving is used to increase the domestic capital stock (i.e. domestic investment); the other half of the domestically produced goods and services that are not consumed are exported.

The third stylized fact is that there is a substantial negative correlation between domestic saving and net current transfers. In all five developing regions, the coefficient on the domestic saving rate is significantly negative when the dependent variable is the GDP share of net current transfers. The largest coefficients (in absolute value) are obtained for sub-Saharan Africa, East Asia and the Pacific, and South Asia. In those regions, a one percentage increase in the domestic saving rate is associated with a decrease in the GDP share of net current transfers of around 0.4 to 0.5 percentage points. In Latin America, and North Africa and the Middle East, it's somewhat less; around 0.3 to 0.2 percentage points. Thus, when domestic saving in developing countries increases net current transfers to these countries decrease and vice versa. This is true for foreign aid and remittances. I.e. there is a significant negative correlation between domestic saving and foreign aid, see column (4), and a significant negative correlation between domestic saving and remittances received, see column (5). Looking at the size of the estimated coefficients, it appears that the negative relationship between domestic saving and foreign aid is slightly stronger than the relationship between domestic saving and remittances.

Table 4 shows that the relationship between domestic saving and the current account is not the same for developing and developed countries. From column (1) of Table 4 one can see that in developed countries the coefficient on the domestic saving rate is around 0.6. In developing countries the coefficient on the domestic saving rate is around 0.1, see column (3) of Table 4. One can reject the hypothesis that in columns (1) and (3) the coefficients on the domestic saving rate are equal to each other at the 1 percent significance level. In developed countries there is a strong positive co-movement between domestic saving and the current account; but not so in developing countries.

Table 4 also shows that the relationship between domestic saving and the trade balance is similar in developing and developed countries. From columns (2) and (4), one can see that the coefficient on the domestic saving rate is around 0.6. In developed countries, the co-movement between domestic saving and net-exports is similar to the co-movement between domestic saving and the current account. However, this is not the case for developing countries. Intuitively, the reason for why in developing countries there is no substantial difference in the co-movement between domestic saving and the current account and domestic saving and net-exports is that the current transfers that developed countries make to developing countries are small relative to developed countries' GDP (less than 1 percent).

There is a difference between domestic saving and gross saving. According to the World Bank's World Development Indicators: Gross Domestic Saving = GDP - Final Consumption Expenditure. This is the standard definition of domestic saving. The papers cited in Section 2 on the Feldstein-Horioka puzzle use domestic saving as the explanatory variable. The WDI has a variable called gross saving that includes net current transfers, i.e. gross saving = GNI – Final Consumption Expenditure + Net Current Transfers. When we use gross saving as the right-hand-side variable we find that the relationship between gross saving and the current account is positive and quantitatively sizable in developing countries. See column (3) of Appendix Table 1. However, the relationship between gross saving and net exports is virtually zero, see column (4).[8] This is because net exports and net current transfers are strongly negatively correlated in developing countries: when a developing country receives a transfer from abroad this finances imports, which are then consumed.

Table 5 documents that in developing countries there exists a significant negative relationship between net current transfers and net exports (Panel C); and a significant positive relationship between net current transfers and consumption, in particular, household consumption and to a smaller extent government consumption (Panels A and B).

4 Sub-Saharan Africa as a Laboratory

In this section we discuss results from an instrumental variables approach that exploits the significant response of domestic saving to year-to-year rainfall. The IV approach is suitable for the sub-Saharan African region: the average SSA economies' agricultural sector is large, over half of the workforce are currently employed in agriculture and about one-quarter of GDP is generated by the agricultural sector. Of the five developing regions covered in the previous section, sub-Sahara Africa is the region with the largest agricultural sector.[9] In what follows, we will first provide a discussion of the estimation framework, and then discuss the empirical results obtained by the instrumental variables approach.

4.1 Estimation Framework

As in Section 3, the estimating equation relates the GDP ratio of the current account, CA_{ct}, (and its components) to gross domestic saving scaled by GDP,

[8] In developed economies, the distinction between gross domestic saving and gross saving does not matter much when relating these variables to the current account and net exports, see columns (1) and (2) of Appendix Table 1.

[9] Barrios et al. (2010) show that the significant effect of rainfall on GDP is limited to the sub-Saharan African region; in no other developing region in the world is there a significant effect.

$DomesticSaving_{ct}$:

$$CA_{ct} = \alpha_c + \beta_c t + \gamma_t + \theta DomesticSaving_{ct} + u_{ct} \tag{1}$$

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.

It is important to note that because we control for country fixed effects we identify the effect of domestic saving 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 saving and the current account to identify the relationship. Average cross-country differences in domestic saving 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 saving and possibly the current account beyond saving. In addition to the econometric issue that using average cross-country differences to identify the relationship between domestic saving and the current account gives rise concerns regarding omitted variables bias, the DSGE models available do not readily allow to incorporate these deep country characteristics as key features for studying the relationship between domestic saving and the current account.

Given that in our estimating equation we identify the relationship between domestic saving and the current account from the within-country variation of the data, it is important to realize that (in the absence of endogeneity bias) the least squares estimate, θ^{LS}, in equation (1) reflects the average response of the current account to domestic saving. That is, least squares provides an estimate of the relationship between domestic saving and the current account based on an average of different types (e.g. persistent vs. transitory) shocks that are inducing the within-country variation in domestic saving. For comparison of the econometric estimates to theoretical models it is crucial to have a clear understanding of the type of shock that is inducing the variation in domestic saving.

In the group of sub-Saharan African countries, year-to-year variations in rainfall are known to have significant effects on aggregate output (e.g. Miguel et al. 2004; Brückner and Ciccone, 2011).[10] The AR(1) coefficient of year-to-year variations in rainfall is less than 0.1. Thus, not only do we have an exogenous shock to aggregate output at hand; we also have a shock to output that is of transitory nature.

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

[10] 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). All other data are from the World Bank's World Development Indicators (2017).

equation is:

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

where $Rainfall_{ct}$ is the log of annual rainfall in country c and year t. Note that we are using in the regression 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 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 current account, net transfers, and domestic saving 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 saving.

4.2 Empirical Results

4.2.1 Two-Stage Least Squares Estimates

In this section we discuss two-stage least squares estimates of the relationship between the current account and domestic saving. The current account response to domestic saving is quantitatively much smaller than the net export response. This can be seen from the estimates in columns (1) and (2) of Table 6. Column (1) of Table 6 shows that in sub-Saharan African countries domestic saving has an insignificant effect on the current account. The second-stage coefficient on the domestic saving rate is 0.04 and its standard error is 0.23. In column (1) one cannot reject the hypothesis that the second-stage coefficient on domestic saving is equal to zero at the conventional significance levels (p-value 0.86). One can reject the hypothesis that it is equal to unity a the 1 percent level (p-value 0.00). In column (2), where the dependent variable is net-exports, two-stage least squares estimation yields a coefficient on the domestic saving rate that is around 0.54 with a standard error of around 0.28. One can reject the hypothesis that the second-stage coefficient is equal to zero (unity) at the 5 (10) percent level. Quantitatively, the estimated coefficient suggests that, on average, a one percentage point increase in the domestic saving rate leads to an increase in the net exports to GDP ratio of about half a percentage point. The difference in coefficients between columns (1) and (2) is around 0.5. Thus, if one would have focused on the current account only one might have mistakenly concluded that there is no significant relationship between domestic saving and net trade of goods and services.

The reason why the current account response to domestic saving is quantitatively much smaller than the net-export response is that there is a statistically significant and quantitatively large negative response of net current transfers to domestic saving. This can be seen from the estimates reported in column (3) of Table 6. The second-stage coefficient on the domestic saving rate is -0.61 and has a standard error of 0.25. Quantitatively, the estimated coefficient implies that, on average, a one percentage point increase in the domestic saving 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 negatively affected by domestic saving. From columns (5) and (6) one can see that domestic saving has a significant negative effect on receipts of foreign aid; there is no significant effect on receipts of migrants remittances.[11]

To complete the picture, Table 7 reports the effect that domestic saving has on asset accumulation. The main message from Table 7 is that domestic saving leads to accumulation of domestic capital, and there are no significant effects on private or official assets held in the rest of the world. Column (1) of Table 7 reports two-stage least squares estimates of the effect that domestic saving has on gross fixed capital formation. The second-stage coefficient on the domestic saving rate is around 0.4. One can reject the hypothesis that the estimated coefficient is equal to zero at the 5 percent significance level (p-value 0.05); the hypothesis that it is equal to unity one can reject at the 1 percent significance level (p-value 0.01). Quantitatively, the interpretation is that a one percentage points increase in the domestic saving rate increases the ratio of gross fixed capital formation over GDP by around 0.4 percentage points; i.e. about half of

[11]This is consistent with the finding in Arezki and Brueckner (2012c) that, on average, rainfall has no significant effect on receipt of remittances in sub-Saharan Africa. Arezki and Brueckner show that the effect depends on the development of domestic financial markets, i.e. the GDP share of domestic credit to the private sector. In countries where domestic credit to the private sector is extremely scarce remittances are procyclical, consistent with an investment motive; i.e. remittances exploit high returns to capital. In countries where domestic credit to the private sector is relatively abundant, remittances are countercylical, consistent with a consumption smoothing motive.

domestic saving is used to build up the domestic capital stock.

There are no significant effects of domestic saving on accumulation of net-foreign assets. This is the case if one considers only FDI, see column (2) of Table 7; or the total net flows of private capital, i.e. the sum of net foreign direct investment plus portfolio investment, see column (3) of Table 7. Domestic saving has no significant effect on official reserve assets, see column (4). And there are no significant effects of domestic saving on the sum of gross bond issuance, bank lending and new equity placement (i.e. gross inflows of finance from international capital markets), see column (5). Column (6) shows that domestic saving has no significant effect on the year t-1 to t change in the total external debt stock. Resonating the results for the current account, column (7) shows that the coefficient on domestic saving is quantitatively small and statistically indistinguishable from zero when the dependent variable is the year t-1 to t change in net foreign assets.

4.2.2 Impulse Responses

Figure 1 plots the impulse responses of the different macroeconomic variables to a rainfall shock. The impulse responses are obtained from a dynamic panel model that includes the lagged dependent variable on the right-hand side of the estimating equation. Control variables are country fixed effects, country-specific time trends, and year fixed effects.

The rainfall shock is transitory. This can be seen from the impulse response plotted in the bottom-right panel of Figure 1. After one year the impulse response is right back to zero: of the initial positive shock in year t=0 (set equal to 1 percent of rainfall) the following year's rainfall is only 0.07 percent higher.

The rainfall shock significantly increases GDP on impact and effects are visible for only a few years after. Specifically, the impulse response function shows that a one percent increase in rainfall increases GDP in the same year by around 0.06 percent. After about three years, the effect is still positive and significantly different from zero; around 0.03 percent. That is, the half-life of the rainfall shock on GDP is around three years. Not all of the initial increase in GDP is consumed. The confidence bands for the impulse response of household consumption to the rainfall shock include zero in all periods. Domestic saving significantly increases on impact, and the effects of the rainfall shock on domestic saving are visible a few years thereafter. The half life of domestic saving is slightly less than that of GDP, though after rounding, there is no substantial difference, i.e. it's about three years.

Part of the domestic saving is used to increase the domestic capital stock. From the impulse response function, one can see that there is an increase in domestic investment in response to the rainfall shock. The rainfall shock's effect on domestic investment has a relatively short half-life of about one year. The impact increase in domestic investment is about half the size of the impact increase in domestic saving.

The dynamic effects of the rainfall shock on the current account are quantitatively small and statistically indistinguishable from zero. The confidence bands around the impulse response function for the current account include zero in all periods. Net exports significantly increase on impact – by about as much, as net current transfers decrease. The rainfall shock has only a small positive effect on net factor income. The effect of rainfall on net factor income is about one-quarter of the effect that rainfall has (in absolute value) on any of the two other components of the current account, i.e. the trade balance or net current transfers.

In terms of dynamics, the impulse responses converge back to zero relatively quickly. After about five years, the effect of the initial rainfall shock on the components of the current account is near zero, i.e. less than 5 percent of the impact effect. The half-life of the response of the current account and its components to a rainfall shock is quite short. After about one year (t=1) half of the rainfall shock's impact on the current account and its components dissipated.

The dynamic effects of the rainfall shock on the change in external debt are quantitatively small and statistically indistinguishable from zero. The confidence bands around the impulse response function for the change in external debt include zero in all periods. Qualitatively, the rainfall shock leads to a decrease in external debt. Quantitatively, the effect is very small – less than one-fifth (in absolute value) of the effect that the rainfall shock has on impact on net-exports. From the impulse response function, one can see that after about one year (t=1) the effect of the initial rainfall shock on external debt is near zero. The period t=1 effect is less than 20 percent of the period t=0 effect. Thus, not only is the effect of the rainfall shock on external debt quantitatively small, the effect is also very short lived.

5 Model

The goal of this section is to develop a simple, small-open-economy DSGE model that can match the empirical findings of the previous section. Our model includes a Sub-Saharan African (SSA) economy that engages in agricultural production. This economy receives aid transfers from a Donor economy (developed country); these transfers are decided endogenously. The Donor country solves a dynamic aid allocation problem as in Carter et al. (2015). The SSA economy also has access to international bond markets, where it issues a one-period bond at a risk premium. The model, even though minimalistic in design, will deliver a rich set of insights regarding the relationship between domestic saving and the current account.[12]

[12]An alternative to the minimalistic model present here would be to build a model of a two-sector economy with traded and non-traded sectors, where shocks to agriculture are modeled as shocks to the traded sector. An even richer framework would include three sectors: traded agriculture, traded manufacturing and non-traded services. We have tried both alternative approaches. The results are qualitatively the same and are available upon request. We would like to thank two anonymous referees for suggesting the minimalistic approach.

5.1 SSA Economy

Households in the SSA economy are infinitely lived and maximize the discounted stream of future utilities from consumption:

$$\max_{\{C_t, I_t, D_{t+1}\}_{t=1}^{\infty}} E_0 \sum_{t=1}^{\infty} \beta^{t-1} \frac{C_t^{1-\sigma} - 1}{1-\sigma}$$

where C_t denotes consumption in period t. Households have access to two types of assets, physical capital and an internationally traded bond. To ease exposition we assume that the capital stock is owned entirely by domestic residents. Households have three sources of income: wages, capital rents, and interest income on financial asset holdings. Each period, the household allocates wealth to purchases of the consumption good, purchases of the investment good, and purchases of financial assets. The period-by-period budget constraint in terms of traded goods is:

$$C_t + I_t + D_t(1 + r_t) + \Psi(D_{t+1}) = W_t\overline{L} - U_t K_t + D_{t+1} - \frac{X_t}{L_s} \quad D_1 \text{ given}, \quad (4)$$

where budget outflows stand on the left-hand-side and budget inflows stand on the right-hand-side. D_t denotes the household's maturing debt in period t, r_t denotes the net interest rate faced by domestic residents in financial markets which is exogenous to the domestic agents and D_{t+1} is a new foreign debt taken out in period t. I_t denotes gross domestic investment in the stock of physical capital K_t, U_t denotes the rental rate of capital and W_t denotes the wage rate. Labor is supplied inelastically, and without a loss of generality we normalize $\overline{L} = 1$. X_t is the net current aid transfer from the Donor economy, expressed in per capita terms; and L_s is the population of SSA relative to Donor.

Following Neumeyer and Perri (2005) and Uribe and Yue (2010), households face costs of adjusting external debt.[13] Debt adjustment costs eliminate the unit root in the dynamics of standard formulations of the small open economy model.[14] 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:

$$\Psi(D_t) = \frac{\psi}{2}(D_t - \overline{D})^2.$$

[13]These authors develop models in which country risk spreads are stochastic and interact with financial imperfections.The debt adjustment cost can be decentralized as follows. Suppose that financial transactions between domestic and foreign residents require financial intermediation by domestic, competitive banks. 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. The problem of domestic banks is then to choose the volume D_t so as to maximize profits, which are given by $r_t^d[D_t - \Psi(D_t)] - r_t D_t$, taking as given r_t^d and r_t. It follows that the interest rate charged to domestic residents is given by $r_t^d = \frac{r_t}{1-\Psi'(D_t)}$. Bank profits are assumed to be distributed to domestic households in a lump-sum fashion.

[14]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.

The adopted functional form ensures stationarity of the external debt level in a log-linear approximation of the model and also rules out Ponzi-scheme optimal debt paths. Capital accumulates according to the standard law of motion:

$$K_{t+1} = I_t + (1-\delta)K_t \quad K_1 \text{ given}, \tag{5}$$

where δ is the rate of depreciation of physical capital. The first-order conditions with respect to consumption, tomorrow's capital and tomorrow's debt yield respectively:

$$C_t^{-\sigma} - \lambda_t = 0 \tag{6}$$

$$\beta E_t[\lambda_{t+1}(1-\delta+U_{t+1})] - \lambda_t = 0 \tag{7}$$

$$\lambda_t[1-\psi(D_{t+1}-\bar{D})] - \beta E_t[\lambda_{t+1}(1+r_{t+1})] = 0, \tag{8}$$

where λ is a Lagrange multiplier associated with the budget constraint 4 and represents the shadow price of consumption. Firms operate under perfect competition. They employ immobile labor and hire capital to maximize profits, and produce output with a Cobb-Douglas, constant returns to scale technology:

$$Y_t = \varepsilon_t^Y K_t^\alpha, \tag{9}$$

where ε_t^Y is a productivity shock to the SSA output. The optimal allocation of the factors labor and capital will be such that the wage rate equals the marginal product of labor and the rental rate of capital equals the marginal product of capital:

$$W_t = (1-\alpha)\varepsilon_t^Y (K_t)^\alpha \tag{10}$$

$$U_t = \alpha\varepsilon_t^Y (K_t)^{\alpha-1}. \tag{11}$$

5.2 Donor economy

We follow the benchmark version of the model by Carter et al. (2015) where dynamic aid allocation is postulated as a problem of weighted global welfare maximization. In particular, a utilitarian, forward-looking social planner seeks to maximize a weighted average of welfare in the Donor economy and in the SSA economy. The planner decides on an optimal path of current transfers, anticipating that consumption and investment decisions in the SSA economy will be made by an optimizing household.

The planer of the Donor economy maximizes the following objective function:

$$\underset{\{C_t^D, X_t\}_{t=1}^\infty}{max} E_o \sum_{t=1}^{\infty} \beta^{t-1} \left(\frac{(C_t^D)^{1-\sigma} - 1}{1-\sigma} + \phi L_s \frac{(C_t)^{1-\sigma} - 1}{1-\sigma} \right),$$

subject to SSA's budget constraint 4, SSA's Euler equation derived from 6, 7 and Donor's resource constraint:

$$C_t^D + X_t = \varepsilon_t^D, \tag{12}$$

where C_t^D is per capita consumption of the Donor household, X_t is the international aid flow introduced earlier in equation 4, ϕ is the relative weight that the Donor places on SSA household's utility. For simplicity, we assume the same risk aversion σ and time preferences β in SSA and Donor economies and that the relative population L_s does not change over time. To isolate dynamic endogenous responses of aid subject to shocks in the SSA economy we shut down dynamic capital accumulation in the Donor economy and assume instead, for simplicity, that the household in the Donor economy receives stochastic, i.i.d. endowments ε_t^D. It is straightforward to relax these assumptions, but it is beyond the scope of this paper.

The choice of aid will matter through intertemporal budget constraints, reducing consumption in the Donor economy and relaxing the budget constraint of the SSA economy. The Donor's problem is postulated as a weighted global average maximization, which allows us to study how optimal aid policies arise endogenously, in particular, how those policies respond to shocks in SSA. This formulation also provides a mapping between generosity ϕ and optimal capital accumulation and production decisions in SSA. Aid is distributed to SSA households, who are too small to internalize the effects of their actions on the optimal aid policies, and, hence, take X_t as given.

The first order conditions of the Donor's maximization problem read:

$$(C_t^D:) \quad (C_t^D)^{-\sigma} - \xi_t^D = 0$$

$$(X_t:) \quad -\xi_t^D + \xi_t^S = 0$$

$$(C_t^D:) \quad \phi C_t^{-\sigma} - \xi_t^S + \sigma C_t^{-\sigma-1}[\zeta_t - \zeta_{t-1}(1-\delta+U_{t-1})] = 0 \quad \forall_{t>1}$$

$$\zeta_{-1} = 0,$$

where $\beta^t\xi_t^D$, $\beta^t\xi_t^S$ and $\beta^{t-1}\zeta_t$ are Lagrange multipliers associated with the Donor resource constraint, the SSA budget constraint and the SSA Euler equation, respectively. The dynamics of the problem are governed by two mechanisms. The first one is the convergence to the steady-state from some arbitrary initial conditions. The second one are the dynamics inside the stochastic steady-state in response to exogenous shocks. Carter et al. (2015) study the first mechanism without considering stochastic disturbances. We, on the other hand, focus on the second, and so we assume away initial convergence dynamics. Donor and SSA economies are in their respective stochastic steady states, which implies that $\zeta_t = \zeta_{t-1}\forall_t$. In the stochastic steady state the optimal aid is governed by the following intratemporal condition:

$$(C_t^D)^{-\sigma} = \phi(C_t)^{-\sigma}. \quad (13)$$

The above framework is also suitable to study the problem of endogenous remittances from abroad. In such context, the Donor country can be interpreted as domestic residents living abroad that care about the utility of the family left behind with ϕ representing the intensity of domestic ties.[15]

5.3 Definitions

We now define the remaining model counterparts in the following way: domestic saving is:

$$S_t = Y_t - C_t, \quad (14)$$

the trade balance is

$$NX_t = Y_t - C_t - I_t - \Psi(D_{t+1}), \quad (15)$$

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

$$CA_t = NX_t - r_t D_t + \frac{X_t}{L_s}. \quad (16)$$

5.4 Exogenous shocks

The model is a dynamic system of 13 variables $(C_t, I_t, W_t, U_t, X_t, Y_t, \lambda_t, C_t^D, D_t, K_t, S_t, NX_t, CA_t)$ governed by 13 equations 4-16, subject to three exogenous shocks: a productivity shock in SSA ε_t^Y, an endowment shock in Donor ε_t^D, and an interest rate shock ε_t^R. We assume that the interest rate evolves according to:

$$r_{t+1} = \bar{r} + \rho^R r_t + \varepsilon_t^R,$$

where ρ^R is the parametrized persistence of the interest rate shock and $\bar{r}$is calculated to match the average steady-state level of interest rate paid by SSA economies on their external debt.

6 Calibration

The parameters in the benchmark model are calibrated to mimic a typical sub-Saharan African country and are presented in Table 8. For the calibration of the model the time unit is one year. We use standard values in the literature for the relative risk aversion $\sigma = 2$ and the capital share in production $\alpha = 0.3$.

[15]An alternative to studying endogenous remittances would be to develop a model where each household has members living domestically and members that can decide to live abroad along the lines of Mandelman and Zlate (2012). Since empirically in SSA aid is larger than remittances, we decided to pursue the above framework, that can flexibly incorporate both narratives.

Using Penn World Tables 9.0 (Feenstra et.al., 2015) we set the depreciation rate at 7 percent per year and relative output in SSA to USA at 6 percent, while the steady-state productivity in SSA economy is normalized to one. We fix the relative population L_s to 1.1 using the population of 996 million in Sub-Saharan Africa (World Population Prospects) and the population of 901 million in developed countries (see also Carter et.al. (2015)), although it should be noted that this parameter could be normalized to one without a loss of generality, since what matters is the relative size of ϕ/L_s. We set $\phi = 0.0038$ to match the average aid inflow of 12% of SSA output as reported in Table 2.

The time discount factor β is set to 0.8, which is lower than usual values of above 0.9 used in the calibrated models of developed economies. Aguiar and Gopinath (2007) argue that for studies of developing economies with risky debt significantly lower values should be used, and use an even lower value of $\beta = 0.8$ for quarterly time units. Our calibration results in a risk-adjusted interest rate of 25%.

We use equation 16 and grand ratios of current account to output $\frac{CA}{Y} = -0.07$, net exports to output $\frac{NX}{Y} = -0.15$ reported in Table 1 and aid to output $\frac{X/L_s}{Y} = 0.12$ reported in Table 2. Using this, we calibrate $\bar{D} = 0.1556$ to be consistent with $r = 25\%$. This leaves us with one free parameter, the adjustment costs of debt. We set $\psi = 0.2$ so that the implied marginal propensity to consume equals 0.3 when the aid channel is shut off. Higher values of ψ do not increase the MPC much further, while lower values of ψ induce slow, counterfactual convergence of foreign debt, which motivates households to counterfactually save big proportions out of transitory income. Schmitt-Grohe and Uribe (2003) use much lower values of ψ (i.e., 0.00074 to 0.001). However, it should be noted that: i) their framework includes a richer set of frictions, while in our model ψ by construction approximates for all frictions faced by households, and ii) their calibration targets developed economies, while frictions in developing economies are widely believed to be much more severe. Also, empirically we observe that external debt does not react to rainfall induced variations in output and domestic saving (see Table 7), which is a manifestation of severe frictions in the SSA economies. Hence, we find a value of $\psi = 0.2$ a reasonable fit for the model. In what follows, we assess robustness of the model's predictions to variations in ψ.

We set the AR(1) coefficient for a transitory productivity shock equal to 0.1. We additionally study the responses of the SSA economy to other transitory shocks: to output in the Donor economy and to the interest rate; the AR(1) coefficient for these shocks is also set to 0.1. For persistent productivity shocks to SSA output we set the AR(1) coefficient equal to 0.9. Since shocks are modeled as unexpected, one off disturbances, their volatilities do not need to be calibrated as they do not enter into households' expectations. To ensure convergence of the interest rate back to its steady-state, given the above persistence, we calculate $\bar{r} = (1 - \rho^r)r = 0.225$. To facilitate comparison between empirics and theory, we calibrate the size of each shock to give a 0.07 percent increase in output on impact (i.e. the estimated effect that rainfall has on GDP on impact).

7 Results

In Figure 2 we present the impulse responses of the SSA economy to a transitory productivity shock. The responses of output and consumption are measured in percent deviation from the steady-state, while responses of all other variables are measured in percentage points of GDP deviations from the steady-state. Solid lines show responses of variables in the model with endogenous foreign aid. The patterns in Figure 2 replicate the empirical responses depicted in Figure 1 both qualitatively and quantitatively. The theoretical responses of domestic saving, the current account, net current transfers, net exports and net factor income closely mimic their data counterparts.

In terms of dynamics, the productivity shock increases output on impact and domestic agents increase saving to smooth consumption. Domestic investment increases temporarily due to the short-lived nature of the shock.[16] The increase in the domestic saving rate leads to an increase in net exports. However, the increase in net exports does not lead to a similar increase in the current account balance. The model shows that this occurs due to the reaction of net current transfers (or, equivalently for the SSA economy, foreign aid). In the data we see that foreign aid decreases after a positive, transitory positive shock to output induced by increased rainfall. In the model aid is decided by a benevolent planner located in the rich Donor economy. The optimal aid policy prescribes that aid flows to the SSA increase after a transitory negative productivity shock, and that they decrease after a positive, transitory shock to productivity. The response of aid flows is, in absolute value, almost as large as the response of net exports; as a result, the response of the current account is negligible, as in the data. Similarly to the data, the increase in domestic saving reduces only slightly the amount of foreign debt. This in turn leads to negligible increases in net factor income, while consumption, remains almost unchanged.

According to the benchmark DSGE model, a 1 percentage points increase in the domestic saving rate – due to a transitory productivity shock – increases the GDP ratio of the current account by around 0.1 percentage points. This is very close to the estimated effect shown in column (1) of Table 6. Hence, the benchmark DSGE model replicates the main empirical finding qualitatively and quantitatively.

7.1 Endogenous vs. Exogenous Foreign Aid

In this section we discuss the role that the endogenous response of foreign aid to domestic shocks in the aid-recipient country has for the key macro variables of interest. In Figure 2 we plot, using dashed lines, impulse responses of an identically calibrated model, albeit with fixed (i.e. exogenous) foreign aid.[17] The change, and only change, we make to the benchmark model is to switch

[16] Note that the investment response reverses quickly. This is because we have not assumed capital or investment adjustment costs to smooth out the investment responses as we opted for minimizing the frictions assumed in the model.

[17]

off the Donor economy block; we calibrate aid to be equal to 12% of domestic output. One can see from the impulse response that in this version of the model aid does not respond to shocks in the aid-recipient country, i.e. aid is "exogenous" or "fixed"; alternatively, one can say that foreign aid is acylical, that is, foreign aid does not respond to shocks which affect output in the aid-recipient country.

Output responds in the same manner to a productivity shock when foreign aid is assumed to be fixed as in the benchmark model with endogenous aid. What behaves very differently though, is private consumption. In the absence of countercyclical foreign aid, and subject to frictions in the international asset markets, consumption smoothing is less pronounced: i.e., consumption increases more on impact due to a transitory productivity shock when aid is acyclical than when aid is countercylical; and when foreign aid is acyclical the response of consumption to the productivity shock is more persistent than when aid is counteryclical. Thus, countercylical foreign aid enables significant consumption smoothing in the developing economy.

The response of domestic saving to a transitory productivity shock is less pronounced in the model when foreign aid is exogenous. This is because consumption responds more strongly when aid is acyclical. There is a larger adjustment of external debt. That is, a positive transitory productivity shock leads to a larger decrease in external debt when foreign aid is acyclical then when foreign aid is countercylical. Due to the presence of adjustment costs of external debt, there is a smaller increase in net-exports. Net factor income increases slightly more.

Overall, in the model where foreign aid is exogenous the effect of domestic saving on the current account is larger than when aid is endogenous. For the case of exogenous aid, the model predicts that a 1 percentage point increase in the domestic saving rate increases the GDP ratio of the current account by around 0.4 percentage points. This effect is about four times larger than in the model where foreign aid, endogenously, responds countercylically to the transitory productivity shock.

7.2 Debt Adjustment Costs

In this section we assess the implications that debt adjustment costs have for the relationship between domestic saving and the current account. Figure 3 shows impulse response functions for two alternative scenarios: high and low debt adjustment costs, i.e. $\psi = 0.99$ and $\psi = 0.001$.

The behavior of output and domestic saving is unaffected by the choice of ψ. Not surprisingly, the most affected variable is external debt. When there are large debt adjustment costs, the response of external debt to a transitory productivity shock is very small. On the other hand, when debt adjustment costs are small external debt is strongly countercylical; and convergence back to the steady-state is much slower: – both of these features are at odds with the data. The empirical impulse responses show that the response of external debt to a rainfall shock is very small and that the impulse response converges back to zero very quickly.

The response of external debt affects the response of net factor income. The larger the debt adjustment cost the smaller is the response of net factor income to a transitory productivity shock. Foreign aid counteracts the debt (and hence net factor income) responses: When households cannot intertemporarily substitute through debt, due to high debt adjustment costs, optimal behavior of the Donor country entails a stronger countercyclical reaction of transfers in order to enable consumption smoothing in the developing economy. Instead, when debt adjustment costs are low, the increase in domestic saving that follows as a response to the transitory productivity shock has only a small effect on domestic investment; intertemporal substitution is achieved through adjusting debt; and foreign aid moves little, as it is redundant in enabling consumption smoothing. It is the different responses of net factor income and foreign aid in the counterfactual scenario drives the difference in the response of the current account.

In sum: With high debt adjustment costs, variations in domestic saving that are induced by a transitory productivty shock have only a small effect on the current account. When debt adjustment costs are small, there is a substantial effect of domestic saving on the current account. Specifically, for $\psi = 0.001$, the model predicts that on impact (t=0), for a transitory productivity shock, a 1 percentage point increase in the domestic saving rate increases the current account to GDP ratio by around 0.04 percentage points. For $\psi = 0.99$ this effect is around 0.62 percentage points.

7.3 Persistence of the Productivity Shock

The distinction between transitory and persistent shocks is crucial for understanding the relationship between domestic saving 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 saving and the current account that emerges from a transitory productivity shock.

In Figure 4 we depict impulse responses delivered by the model when the productivity shock is persistent. Specifically, the impulse responses are generated for a productivity shock that follows an AR(1) process; the AR(1) coefficient is set equal to 0.9.

Expecting long-lasting increases in productivity, households in SSA substantially invest in domestic capital. The persistent productivity shock has a positive effect on domestic saving. The key takeaway for the case of endogenous aid is this: the persistent productivity shock induces a near one-to-one relationship between domestic saving and domestic investment; however, there is a negative relationship beween domestic saving and the current account. The reason why the current account deteriorates following a positive productivity shock is that foreign aid decreases. Consumption in the model with endogenous (i.e. countercylical) foreign aid is smooth.

When foreign aid is exogenous (i.e. acyclical), a persistent productivity shock induces a positive response of consumption, i.e. there is less consumption smoothing relative to the case of endogenous aid. Consequently, the response of domestic saving is smaller when foreign aid is exogenous. When aid is exogenous, a persistent productivity shock induces, on impact, an increase in domestic investment that is larger than the increase in domestic saving; the impact effect on the current account is negative, as is the effect on net exports. In contrast when aid is endogenous net exports increase on impact while the current account deteriorates. This shows that, even qualitatively, in terms of the sign of the effect, the current account response can be different from the trade balance response when foreign aid is endogenous.

7.4 Other Shocks

The discussion in the previous section highlighted the importance of shock identification. The relationship between domestic saving and the current account depends not only on the institutional design (in this case: the endogeneity of aid flows) but also on the nature of the shock that is responsible for the variation in domestic saving. In the model with endogenous aid, a transitory productivity shock generates a near-zero correlation between domestic saving and the current account, in line with the empirical findings. Contrary to the empirical findings, the same shock with exogenous aid would produce a positive correlation. A permanent shock however, would result in a negative correlation: domestic saving goes up and the current account goes down, both with endogenous and exogenous aid. In what follows, we study how other shocks affect the relationship between domestic saving and the current account.

In Figure 5 we plot impulse responses to a positive shock to the endowment of the Donor economy. The shock is passed to the SSA economy through increases in foreign aid. On impact consumption in the SSA economy increases, there is no effect on ouput; thus domestic saving falls. Given the high debt adjustment costs, consumption smoothing cannot be achieved completely through changes in external debt. External debt decreases in reaction to the shock, while domestic capital accumulation increases which leads to increases in output in the following periods. The shock has a positive effect on the current account on impact, – even though net exports fall on impact. The shock, hence, induces opposite movements in net exports and the current account. As can be seen from the figure, the shock generates a negative relationship between domestic saving and the current account. Quantitatively, the model predicts that – when driven by a transitory increase in the endowment of the Donor economy – a 1 percentage point decrease in domestic saving increases the current account of the SSA economy by nearly 5 percentage points on impact.

In Figure 6 we plot impulse responses to a negative shock to the interest rate that the SSA economy pays on its external debt. As the interest rate drops, households unexpectedly save on debt service -- net factor income increases on impact. Since the SSA economy now has more resources, foreign aid drops on impact; consumption is smoothed. Domestic investment increases on impact and then quickly reverses due to the transitory nature of the shock. With increased domestic absorption net exports drop. Driven by the drops in net exports and foreign aid, the current account drops on impact. Newly invested capital becomes productive in the following period and this is when output and domestic saving increase. In the second period the interest rate reverts back to its steady-state level and we see reversals in most macroeconomic aggregates: net factor income, domestic investment, foreign aid, and, consequently, also net exports and the current account reverse. Both with endogenous and exogenous aid, the current account moves more than domestic saving. The interest rate shock generates a positive relationship between domestic saving and the current account. Quantitatively, the model predicts that – when driven by a transitory decrease in the interest on external debt – a 1 percentage point decrease in domestic saving decreases, on impact, the current account of the SSA economy by nearly 17 percentage points when aid is endogenous; the effect is smaller when aid is exogenous, around 3 percentage points.

The above analysis reveals that it is essential to identify the source of variation in the economy in order to be able to investigate the relation between domestic saving and the current account. According to our simple model, if the major source of fluctuations in the small open economy is persistent TFP shocks, the relationship between domestic saving and the current account would be very different than in the case in which transitory shocks move the cycle. The sources of business cycle fluctuations in developing economies are not yet clearly identified. To illustrate, if we take the view by Aguiar and Gopinath (2007) that volatility in developing countries is explained mostly by trend TFP shocks (87%), and transitory TFP shocks explain only 13% of variations in output, then our model would predict a negative correlation between domestic saving and the current account. Instead, Garcia-Cicco et.al (2010) suggest that persistent shocks explain only 2.5% of TFP volatility and that most cyclical variations in those countries are explained by stationary TFP shocks and country premium shocks. In this case our model predicts that the correlation between domestic saving and the current account is positive.

8 Conclusion

In the 5th edition of the balance of payment manual of the International Monetary Fund (1993) that is harmonized with the System of National Accounts 1993, one can find the following statement in Chapter V on Selected Issues in Balance of Payments Analysis:

> "Thus, to the extent that domestic saving is not matched by an increase in domestic capital accumulation, there will be an increase in private or official assets held in the rest of the world." (IMF, 1993, page 160)

According to the results in this paper, for developing countries, the above statement does not always hold.[18]

[18] The statement is correct for gross saving. By the accounting identity gross saving is equal to domestic investment plus the current account.

Instrumental variables estimation showed that, in a panel of 41 sub-Saharan African countries during 1981-2009, domestic saving has a statistically insignificant and quantitatively near zero effect on the current account. When the dependent variable is gross domestic capital formation (domestic investment), the estimated coefficient on domestic saving is positive, though significantly smaller than unity. Hence domestic saving is not matched one-to-one by an increase in domestic capital accumulation. – But contrary to what is suggested by the statement in the IMF's (1993) balance of payment manual: there is no significant increase in net foreign assets. Domestic saving leads to an increase in net-exports; i.e. there is a significant positive effect on the trade balance. Yet domestic saving has no significant effect on the current account.

For developing countries in general, least squares estimation shows that the effect of domestic saving on net-exports is much larger than the effect of domestic saving on the current account. For three out of the five developing regions in the world, the least squares estimate of the impact that domestic saving has on the current account is not significantly positive. For all five regions, the least squares estimate of the impact that domestic saving has on the trade balance is positive and significantly different from zero at the conventional significance levels.

We argued that the significant negative correlation between domestic saving and net-current transfers explains why, even when domestic saving is not matched one-to-one by an increase in domestic capital accumulation, an increase in domestic saving may not lead to a significant increase in the current account.

We provided a DSGE model with endogenously derived current transfers to gain a deeper understanding of the relationship between domestic saving and the current account in developing countries. The model enables to study the relationship between domestic saving and the current account for different types of shocks. Not all of the shocks considered produce a positive correlation between domestic saving and the current account, or net exports. The model does predict a positive correlation between domestic saving – triggered by transitory productivity shocks, like rainfall, as in the IV estimation – and net exports, though a much smaller effect on the current account that can be near zero for large costs to external debt adjustment. A key take away from the model is that identification of shocks is crucial: the relationship between domestic saving and the current account critically depends on the type of shock that induces the variation in domestic saving.

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.

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. Bruckner (2012a). "Commodity Windfalls, Polarization, and Net Foreign Assets: Panel Data Evidence on the Voracity Effect." Journal of International Economics 86: 318-326.

Arezki, R. and M. Bruckner (2012b). "Commodity Windfalls, Democracy, and External Debt." Economic Journal 122 (2012) pp. 848-866.

Bacchetta, P. and M. Feldstein (1991). "National Saving and International Investment." in D. Bernheim and J. Shoven (eds.), National Saving and Economic Performance, University of Chicago Press, 1991

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

Barrios, S., L. Bertinelli, and E. Strobl (2010). "Trends in Rainfall and Economic Growth in Africa: A Neglected Cause of the African Growth Tragedy." Review of Economics and Statistics 92: 350-366.

Baxter, M. and M. Crucini. "Explaining Saving-Investment Correlations." American Economic Review 1993: 416-436.

Blanchard, O. and F. Giavazzi (2002). "Current Account Deficits in the Euro Area: The End of the Feldstein-Horioka Puzzle? " Brookings Papers on Economic Activity 2: 147-210.

Brückner, M. and A. Ciccone (2011). "Rainfall and the Democratic Window of Opportunity." Econometrica 79: 923-947.

Brückner, M. and M. Gradstein (2013). "Effects of Transitory Shocks to Output on Consumption in Poor Countries." Journal of International Economics 91: 343-357.

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

Carter, P., Postel-Vinay, F., & Temple, J. (2015). "Dynamic aid allocation." Journal of International Economics 95: 291-304.

Chang, Y. and T. Smith (2014). "Feldstein-Horioka Puzzles." European Economic Review 72: 98-112.

Chinn, M. and E. Prasad (2003). "Medium-term Determinants of Current Accounts in Industrial and Developing Countries: An Empirical Exploration." Journal of International Economics 59: 47-76.

Feenstra, R. C., R. Inklaar and M. P. Timmer (2015), "The Next Generation of the Penn World Table" American Economic Review, 105: 3150-3182, available for download at www.ggdc.net/pwt.

Feldstein, M., and C. Horioka (1980). "Domestic Saving and International Capital Flows." Economic Journal 90:314-332.

Fischer, S. (2003). “Globalization and Its Challenges.” American Economic Review 93 (2): 1-30.

Garcia-Cicco, J., R. Pancrazi, and M. Uribe (2010), "Real business cycles in emerging countries?" American Economic Review 100: 2510-2531.

Giannone, D. and M. Lenza (2010). "The Feldstein-Horioka Fact." NBER International Seminar on Macroeconomics, University of Chicago Press, vol. 6(1), pages 103-117.

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.

International Monetary Fund (1993). “Balance of Payments Manual.” Available for download at https://www.imf.org/external/pubs/ft/bopman

Kraay, A. and J. Ventura. (2000). "Current Accounts in Debtor and Creditor Countries." Quarterly Journal of Economics 95: 1137-1166.

Kraay, A. and J. Ventura. (2003). "Current Accounts in the Long and Short Run." NBER Macroeconomics Annual 2002, 17: 65-94.

Lane, P. and G. Milesi-Ferretti (2007). "The External Wealth of Nations Mark II." Journal of International Economics 73: 223-250.

Lucas, R. (1990). “Why Doesn’t Capital Flow from Rich to Poor Countries?” American Economic Review 80 (2): 92-96.

Mandelman, F. S., & Zlate, A. (2012). “Immigration, remittances and business cycles.” Journal of Monetary Economics 59: 196-213.

Mishkin, F. (2007). “Is Financial Globalization Beneficial?” Journal of Money Credit and Banking 39: 259-294.

Neumeyer, P. and F. Perri (2005). "Business cycles in emerging economies: the role of interest rates." Journal of Monetary Economics 52: 345-380.

Obstfeld, M. (1986). “Capital Mobility in the World Economy: Theory and Measurement”. Carnegie-Rochester Conference Series on Public Policy, Journal of Monetary Economics 24 (1): 55-103.

Obstfeld, M. and K. Rogoff (1995). "The intertemporal approach to the current account. In Handbook of International Economics." vol. 3, G. Grossman and K. Rogoff (eds.). Amsterdam: Elsevier.

Obstfeld, M. and K. Rogoff (2000). "Six Major Puzzles in International Macroeconomics: Is there a Common Cause?" NBER Macroeconomics Annual 2000, ed. B. Bernanke and K. Rogoff, Cambridge: NBER and MIT Press.

Schmitt-Grohe, S. and M. Uribe (2003). "Closing small open economy models." Journal of International Economics 61: 163-185.

Sinn, S. (1990). "Saving-Investment Correlations and Capital Mobility: On the Evidence from Annual Data." Economic Journal 102: 1162-1170.

Tesar, L. (1991). "Saving, investment and international capital flows." Journal of International Economics 31: 55-78.

Tille, C. and E. van Wincoop (2010). "A New Perspective on “The New Rule” of the Current Account." Journal of International Economics 80: 89-99.

Tornell, A. and P. Lane (1998). "Are Windfalls a Curse? A Non-Representative Agent Model of the Current Account." Journal of International Economics 44: 83-112.

Tornell, A. and A. Velasco (1992). “The Tragedy of the Commons and Economic Growth: Why Does Capital Flow From Poor to Rich Countries?" Journal of Political Economy 100: 1208-1231

Uribe, M. and V. Yue (2006). "Country spreads and emerging countries: Who drives whom?" Journal of International Economics 69: 6-36

Yang, D. (2013). "Migrant Remittances." Journal of Economic Perspectives 25: 129-152.

World Bank (2012). "World Development Indicators." Available for download at https://data.worldbank.org/products/wdi

World Bank (2017). "World Development Indicators." Available for download at https://data.worldbank.org/products/wdi