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The Dynamic Implications of Foreign Aid and Its Variability

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Abstract

The paper examines the effects of aid and its volatility on consumption, investment, and the structure of production in the context of an intertemporal two-sector general equilibrium model. A permanent flow of aid finances mainly consumption, a result consistent with the historical failure of aid inflows to translate into sustained growth. Shocks to aid are reflected mainly in investment fluctuations, as a result of consumption smoothing. Aid shocks result in substantial welfare losses, suggesting that aid variability should be taken into account in designing aid architecture. These results are consistent with the evidence from cross-country regressions of manufactured exports.

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I. Introduction

Foreign aid remains an important fact of life for developing countries: many countries, especially the poorest, rely on aid as a major external source of income. It is particularly important to consider the macroeconomic implications of these inflows to the extent that they may either support or impede the efforts of low-income countries to foster their own sources of economic growth. These implications are expected to become all the more important as donors increase aid flows to support these countries' progress toward the Millennium Development Goals.

A starting point for considering the impact of aid inflows is the *transfer problem*: how is an international transfer effected through an adjustment of the external trade balance? This is an issue of real resource transfers that is related to, but quite distinct from, the availability of financing. Economic analysis of the transfer problem yields straightforward conclusions: effecting the transfer—that is, achieving the required trade deficit—generally entails a combination of higher imports and lower exports associated with a real exchange rate appreciation.[2]

Another application of the transfer problem is so-called "Dutch disease"—the adverse effect of natural resource revenues on the manufacturing sector, associated with a real appreciation, such as was experienced following the discovery of natural gas in the Netherlands (Corden, 1984 or Gelb, 1988). A number of observers have pointed out that the logic of Dutch disease applies equally to the effect of large aid inflows in low-income countries. Foreign aid increases the supply of tradable goods and, ceteris paribus, lowers their price, while—through the income effect of the transfer—increasing the demand for and price of nontradable goods. As a result, factors of production are redirected toward the sectors producing nontradable goods.[3] This theoretical observation has given rise to a literature examining the empirical significance of Dutch disease, i.e., examining the extent to which aid is effected via a decrease in exports rather than via an increase in imports (see a review in Bulíř and Lane, 2004).

A second question is how the basic logic of the transfer problem, usually developed in a static two-good model, carries over to the dynamic context in which transfers can also affect savings and capital accumulation. This question is related, in turn, to the empirical question of how aid affects investment: it has traditionally been argued that aid may boost growth

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[2] The transfer problem can be traced back to a discussion of Germany's war reparations by Keynes (1929) and Ohlin (1929). Samuelson (1952)—who was concerned with the implications of the Marshall plan—was the first to frame the problem in a neoclassical apparatus. For a recent review, see Yano and Nugent (1999).

[3] See, for example, Michaely (1981) and Laplagne, Treadgold, and Baldry (2001) for simple static models of this process. While the impact on investment is relatively trivial in these models, the impact on labor depends on labor mobility and migration, see Harris and Todaro (1970) and Corden and Findlay (1975).

because it supplements the limited supply of domestic saving available for investment; but although some empirical evidence suggests that investment increases with aid (for example, Hansen and Tarp, 2001 or Clemens, Radelet, and Bhavnani, 2004), this evidence is far from conclusive (Easterly, 1999).

A third question is why—or indeed, whether—Dutch disease matters: the transfer problem is generally analyzed in the context of models in which the resulting decline in production of tradables is an optimal adjustment to the transfer, so that Dutch disease is not really a disease at all. However, discussions of this phenomenon in the context of low-income countries and development usually refer to the importance of the export industries for growth (Michaely, 1981). Indeed, a number of theoretical studies have elaborated the idea that trade can be the engine of growth for developing countries through technological diffusion and learning by doing (Grossman and Helpman, 1991; Barro and Sala-i-Martin, 1997; Connolly, 1999; and Bigsten et al., 2002). Empirical papers have also found a positive relation between trade and growth (Levine and Renelt, 1993 or Sala-i-Martin, 1997). But such analyses—with the exception of Adam and Bevan (2003)—have not generally been integrated into the analysis of the decline in the tradables sector in response to sustained aid inflows.

Fourth, a salient aspect of aid, which has recently been receiving increasing attention, is its variability. Evidence indicates that aid flows are volatile, reflecting the vagaries of donors' budget allocations, donor conditionality, and other factors (Pallage and Robe, 2001; Bulíř and Hamann, 2003; and Bulíř and Lane, 2004). This evidence makes it important to examine how aid volatility affects both the level and variability of key macroeconomic variables. Little is known, however, about long-term output and welfare effects of aid and its volatility (Pallage and Robe, 2003, and Turnovsky and Chattopadhyay, 2003).

This paper examines the dynamic implications of aid and its variability in the context of a simple intertemporal two-sector optimizing model, akin to those used in the literature on real business cycles (RBC). The simplifying assumptions of the model leave aside three important issues: first, the composition of aid and its fungibility, as well as any associated conditionality; second, any aid-driven learning-by-doing effects, and, third, any domestic political economy effects associated with rent-seeking behavior of aid recipients. The model is calibrated based on plausible parameter values, comparable to those used in previous literature.

The results suggest, first of all, that the "Dutch disease" effects indeed carry over to a dynamic setting, with some differences. Second, the model characterizes the response of aid on consumption and investment: a constant, predictable stream of aid is reflected primarily in consumption, while the effects of shocks to aid are distributed between consumption and investment in proportions that depend on the shape of the underlying utility and production functions. Third, aid variability of the magnitude found in previous literature may have substantial detrimental welfare effects, albeit not large enough to wipe out the welfare benefits of the aid itself.

The paper also presents empirical results on the relationship between foreign aid and the production of goods for export. Cross-country regressions for 73 aid-dependent countries indicate that manufactured good exports, as predicted by the theoretical model, are negatively related to the level of aid. The results are significant after controlling for initial endowments, transaction costs, the level of development, and a host other variables.

The paper is organized as follows: Section II develops the model and presents results for the numerical simulations, Section III presents regression results on the aid-to-exports nexus, Section IV summarizes issues for further research, and Section V concludes.

II. The Theoretical Model

The model used in this paper is a neoclassical dynamic general equilibrium model of a small economy that has two productive sectors: tradable and nontradable goods. The model displays transitional growth driven by the accumulation of capital, but it is simplified in several important respects. First, aid is assumed to be provided unconditionally in the form of a grant.[4] Second, the recipient country is assumed to have no access to international capital markets, so that investment in capital goods is the only available store of value. Third, the model assumes simplified consumption behavior, with a representative household maximizing an intertemporal utility function characterized by constant elasticity of substitution. Fourth, it does not model productivity spillovers associated with the expansion of the tradable goods sector. Fifth, the model also ignores the political economy effects of aid (Bauer, 1979 or Tornell and Lane, 1999), absorption-capacity constraints, or aid-related costs of investment (Asilis and Ghosh, 2002). This simplified model nonetheless yields interesting analytical results, which may provide a benchmark for other analyses that would move the model beyond these limits.

Households in the economy maximize their expected lifetime utility and have preferences over tradable and nontradable goods:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma}}{1-\sigma} \quad , \qquad (1)$$

where σ is the coefficient of risk aversion and the consumption function is of constant elasticity of substitution (CES) form

$$C_t = \left[\omega\left(C_t^T\right)^{-\mu} + (1-\omega)\left(C_t^N\right)^{-\mu}\right]^{-\frac{1}{\mu}}, \qquad (2)$$

where ω is the weight households place on tradable consumption (C^T) and (1- ω) is the weight on nontradable consumption (C^N). The elasticity of substitution of consumption between tradables and nontradables is $1/(1+\mu)$. It could be argued, however, that

[4] This means ignoring a large literature on the implications of aid conditionality (Killick, 1997, Svensson, 2000, and Mayer and Mourmouras, 2002).

consumption in poor countries may be inflexible at the subsistence level and that constant relative risk aversion (CRRA) preference used in this paper may underestimate the welfare losses. This is one of the issues left for further research.

Households receive labor income, rent capital to firms, and make investment decisions. In addition, the economy receives a stochastic transfer of tradable goods, *X*, that is, aid. The budget constraint—in tradable good terms—is as follows:

$$C_t^T + p_t^N C_t^N = r_t K_t + w_t L_t - i_t + X_t, \tag{3}$$

where p_t^N is the relative price of nontradables in terms of tradables (i.e., the real exchange rate), K_t is the economy's capital stock, i_t is investment (which, for the sake of simplicity, we assume is in the form of tradable goods only), w_t is the real wage rate paid to labor input, L_t is the labor endowment set to 1, r_t is the real domestic interest paid on capital, and $X_t = X\exp\left(\varepsilon_t^x\right)$ is a stochastic amount of aid inflows given to the economy. Here, an important underlying assumption is that the country has no access to international capital markets, so that the only mechanism for saving is investing in the domestic capital stock.

Capital follows the usual accumulation process:

$$K_{t+1} = i_t + (1-\delta)K_t \tag{4}$$

and depreciates at rate δ.

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

$$Y_t^T = A^T \exp(\varepsilon_t^T) K_t^{T\alpha} L_t^{T1-\alpha}, \tag{5}$$

$$Y_t^N = A^N \exp(\varepsilon_t^N) K_t^{N\eta} L_t^{N1-\eta}. \tag{6}$$

Both sectors are subject to productivity shocks, $\varepsilon_t^T, \varepsilon_t^N$. Firms and households have the same information set: they know the distribution of both the productivity and aid shocks. However, households cannot insure perfectly against negative shocks because asset markets are incomplete and the only asset available for intertemporal smoothing is domestic capital.

Labor is perfectly homogenous and mobile across sectors:

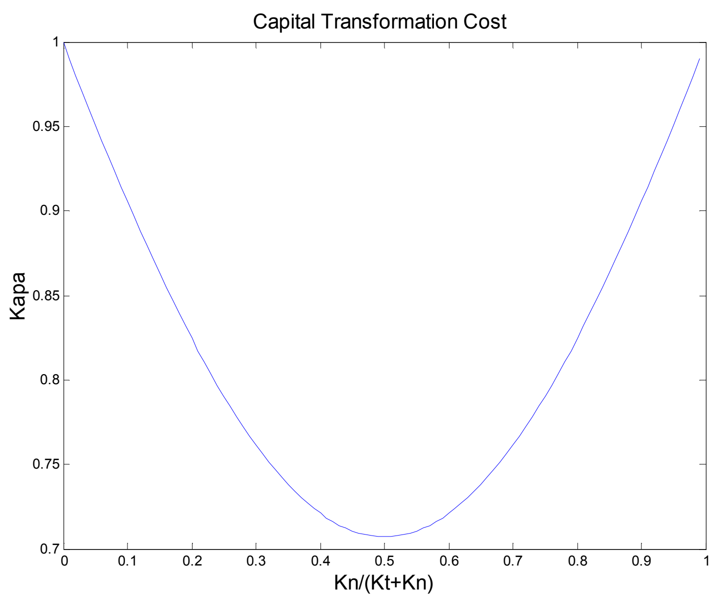
$$L_t = L_t^N + L_t^T = 1. \tag{7}$$

Capital, however, is assumed to be somewhat 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):

$$K_t = \kappa(K_t^T, K_t^N), \tag{8}$$

where $\kappa(\cdot)$ is assumed to be a CES function, $K = \left[K^{T^{-\nu}} + K^{N^{-\nu}}\right]^{-\frac{1}{\nu}}$, with the elasticity of substitution between K^T and K^N being $\xi = 1/(1+\nu)$ with $\nu \leq 1$. Perfectly homogenous capital is the special case where $\nu = -1$. Figure 1 shows the cost $\kappa(\cdot)$ for a given level of $K^T + K^N$ (which for simplicity is set to 1) as a function of the relative allocation of capital to the nontradable goods sector. The production possibility frontier is concave, owing to differences in factor intensities in the two sectors as well as to the curvature of the aggregate capital stock as given by $\kappa(\cdot)$. In equilibrium, the slope of the production possibility frontier is equal to the relative price of nontradables, which in turn is equal to the marginal rate of substitution between tradables and nontradables.

Figure 1. Capital Transformation Curve 1/



1/ The cost of reallocating capital from one sector to another, $\kappa(.)$, is shown as a function of the relative allocation of capital to the nontradable sector.

The relative price of nontradables is determined by relative technologies and the relative sectoral capital stocks. Firms in the two sectors 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 two sectors given by the derivative of κ with respect to the sectoral capital. In equilibrium, marginal productivities across sectors are equalized:

$$w_t = A^T \exp(\varepsilon_t^T)(1-\alpha)(K_t^T / L_t^T)^\alpha = p_t^N A^N \exp(\varepsilon_t^N)(1-\eta)(K_t^N / L_t^N)^\eta, \qquad (9)$$

$$r_t = \frac{A^T \exp(\varepsilon_t^T)\alpha(K_t^T / L_t^T)^{\alpha-1}}{\kappa_1(K_t^T, K_t^N)} = p_t^N \frac{A^N \exp(\varepsilon_t^N)\eta(K_t^N / L_t^N)^{\eta-1}}{\kappa_2(K_t^T, K_t^N)}. \qquad (10)$$

In this setting, aid affects the wage rate and the rate of return on capital by affecting the relative levels of labor and capital used in the two sectors. The effects depend on the relative factor intensities of the two sectors, as reflected in the parameters α and η (the Stolper-Samuelson effect). Here, we focus on the case in which tradables are relatively labor-intensive ($\alpha < \eta$): increased aid raises the demand for capital-intensive nontradables, raising the economy-wide return to capital, that is, the equilibrium real rate of interest, r.

The market clearing conditions for the two sectors are:

$$C_t^N = Y_t^N \qquad (11)$$

and

$$C_t^T + i_t = Y_t^T + X_t. \qquad (12)$$

The first order conditions of the maximization problems of households and firms can be combined in the following set of equilibrium conditions:

$$p_t^N = \left(\frac{1-\omega}{\omega}\right)\left(\frac{C_t^N}{C_t^T}\right)^{-(1+\eta)} \qquad (13)$$

and

$$\frac{C_t^{-\sigma}}{p_t^C} = \beta E_t \frac{C_{t+1}^{-\sigma}}{p_{t+1}^C}\left(\frac{A^T \exp(\varepsilon_{t+1}^T)\alpha(K_{t+1}^T / L_{t+1}^T)^{\alpha-1}}{\kappa_1(K_{t+1}^T, K_{t+1}^N)} + 1 - \delta\right), \qquad (14)$$

where p_t^C is the CES price index for aggregate consumption:

$$p^C = \left(\omega^{\frac{1}{1+\eta}} + (1-\omega)^{\frac{1}{1+\eta}}\left(p^N\right)^{\frac{\eta}{1+\eta}}\right)^{\frac{1+\eta}{\eta}} \qquad (15)$$

Equation (13) equates the marginal rate of substitution between the consumption of tradable and nontradable goods to the relative price, p^N, and equation (14) corresponds to the Euler equation that equalizes the marginal cost of sacrificing a unit of current consumption with the marginal benefit of allocating the resulting extra savings into the aggregate capital.

The competitive equilibrium of this model is defined as the state contingent sequences of allocations and prices $\{C_t^T, C_t^N, K_t^N, K_t^T, K_{t+1}, L_t^T, L_t^N, p_t^N, r_t, w_t\}_{t=0}^{\infty}$ such that (i) households maximize utility subject to their budget and time constraints taking prices as given, (ii) firms maximize profits subject to their technology taking input prices as given, and (iii) markets clear.

The sequence of decisions in the economy is as follows. At time t households and firms realize the productivity and aid shocks, make investment decisions, and choose consumption and capital and labor in each sector. Prices are determined at this time. The investment decisions are based on the expected rate of return that households foresee for the next period. At $t+1$ the uncertainty is resolved and the rate of return on the previous period's investment is realized. It is worth noting that although the actual rate of return is equalized across sectors, the level at which it is equalized was uncertain when investment was allocated.

The equilibrium real exchange rate (16) is a function of the relative technologies of the two sectors, as well as of the sectoral allocations of capital.[5] The model incorporates the Balassa-Samuelson hypothesis that variations in the real exchange rate come from labor productivity differentials, modified for the possibility of sector-specific capital:

$$\ln p_t^N = (\alpha - \eta)\ln\left(\frac{K_t^N}{L_t^N}\right) + \ln\left[\left(\frac{A^T}{A^N}\right)\left(\frac{1-\alpha}{1-\eta}\right)^{1-\alpha}\left(\frac{\alpha}{\eta}\right)^{\alpha}\right] - \frac{\alpha}{\xi}\ln\left(\frac{K_t^N}{K_t^T}\right). \qquad (16)$$

In addition to equation (16), which is essentially a "supply side" condition coming from equalization of marginal productivities in the two sectors, the real exchange rate is subject to a "demand side" condition, equation (13), coming from equalization of the marginal rate of substitution between consumption of the two goods.

Aid affects the real exchange rate through the level of tradable consumption as well as through the ratio of the capital stock of the two sectors.[6] An increase in aid increases tradables consumption, lowering the relative price of tradable goods, however, the resulting appreciation of the real exchange rate is attenuated by the increase in the relative share of capital used in the nontradable sector. The solution of the model predicts what portions of aid are consumed and invested, and how the outcome is affected by aid volatility. The results depend, in part, on the elasticity of substitution of capital in the two sectors.

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[5] We combine equations (9) and (10) and take logs.

[6] Permanently higher aid would increases consumption permanently—with constant aid the agents would need no additional (or reduced) investment. Shocks to aid affect investment, but only to the extent that the resulting diminishing marginal rate of transformation of capital interacts with the increasing marginal rate of substitution of consumption. Thus, the magnitude of the effect depends on the specifications of the model, such as aversion to intertemporal variations of consumption or the scope for fungibility of capital across sectors.

III. Simulations and Results

A. Calibration for the Benchmark Model

The numerical analysis starts from a baseline scenario in which the model's parameters are calibrated to mimic some of the characteristics of poor, aid-dependent countries, or taken from other developing-country business cycle studies. The model is solved numerically by value function iteration. The long-run solution is described in the Annex, and Table A1 summarizes the parameters used in the baseline simulations.

For the preference parameters, the elasticity of substitution between tradable and nontradable consumption, $1/(1+\mu)$, is taken from Ostry and Reinhart (1992), where their estimate for μ is equal to 0.316. The risk aversion coefficient σ is set to 5 (Reinhart and Vegh, 1995), and the time-preference parameter is set to 0.95 which is a standard value in RBC studies in developing countries. The weight of tradable consumption ω is taken from the weights of tradable goods in the CPI indexes, where we found the share of tradable goods to be roughly equal to 0.5. The nontradable sector is assumed to be more capital intensive that the tradable sector: the capital shares in the tradable and nontradable sectors, α and η, are equal to 0.3 and 0.4, respectively. Two stylized facts support our choice of calibration parameters: first, exporters in developing countries specialize typically in labor-intensive, low-skill technologies (footwear, apparel, and so on) and, second, most nontradable infrastructure projects in those countries are highly capital intensive (electricity, telecommunications, and so on), see, for example, Brock and Turnovsky (1994) and Goldstein and Lardy (2005) for this argument. The elasticity of substitution between capital used in the tradable and nontradable sectors, $1/(1+\nu)$ is set to –10. The rate of depreciation of capital δ is set to 0.09 so that in steady state the investment rate is equivalent to 18 percent of GDP, an average of long-term investment rates taken from the *World Economic Outlook*.

The shocks are set to replicate broadly the stochastic structure of productivity and aid in aid-dependent countries. First, in our baseline model we assume that productivity shocks affect the tradables and nontradables sectors equally, $\varepsilon_t^T = \varepsilon_t^N$, with a standard deviation of 10 percent and a first order autocorrelation coefficient of 0.4. This setup implies that 60 percent of any deviation of productivity from its mean level dissipates in each period. For comparison, this calibration of the productivity process produces a standard deviation of GDP of about 10 percent and of tradable output of 15 percent.

Second, the properties of aid flows in some of the heavily aid-dependent countries are summarized in Table 1. Our simulations were not designed to match economic performance of specific countries, instead, our calibrations are based on the sample of aid-dependent countries listed above. Accordingly, the mean of aid inflows is set equal to 25 percent of steady state GDP; the volatility is set at 15 percent of that constant mean level. Aid is typically mildly procyclical, i.e., it tends to decline in those years when GDP is lower, and *vice versa*. Thus the correlation coefficient between the productivity and aid shocks is set to equal to 0.4.

Table 1. Large Recipients of Aid, 1980-2000

Country	Aid-to-GNI ratio (In percent)	Commitments-to-disbursements ratio	Relative volatility of aid1/	Cyclicality of aid 2/
Bhutan	18.5	1.65	32.6	0.78
Comoros	25.1	1.27	8.4	0.41
Gambia, The	26.3	1.08	13.4	0.36
Guinea-Bissau	50.6	1.07	4.4	0.19
Guyana	20.4	1.03	8.4	0.20
Malawi	22.5	1.02	6.8	0.03
Mozambique	30.8	1.01	11.7	-0.39
Nicaragua	25.3	1.01	7.1	0.41
Rwanda	20.7	1.04	1.7	0.65
Tanzania	19.6	1.01	4.6	0.48
Zambia	20.7	1.14	35.5	0.63
Average	25.5	1.12	12.2	0.34
Median	22.5	1.04	8.4	0.41

Source: *World Development Indicators*; *World Economic Outlook*; Bulíř and Hamann (2005).
1/ Ratio of variances of detrended aid and fiscal revenue, Bulíř and Hamann (2005).
2/ Correlation coefficient of aid and fiscal revenue, Bulíř and Hamann (2005).

B. Steady State Analysis

In this part of the analysis we focus on the steady state, in which the capital stock has converged to a constant long-run level while the country receives a constant level of aid in the absence of productivity shocks. This steady state generalizes to an intertemporal setting the implications of aid that arise in a simple static model. It also provides a reference point for the analysis of the implications of shocks to productivity and aid, which will be developed in the next section.

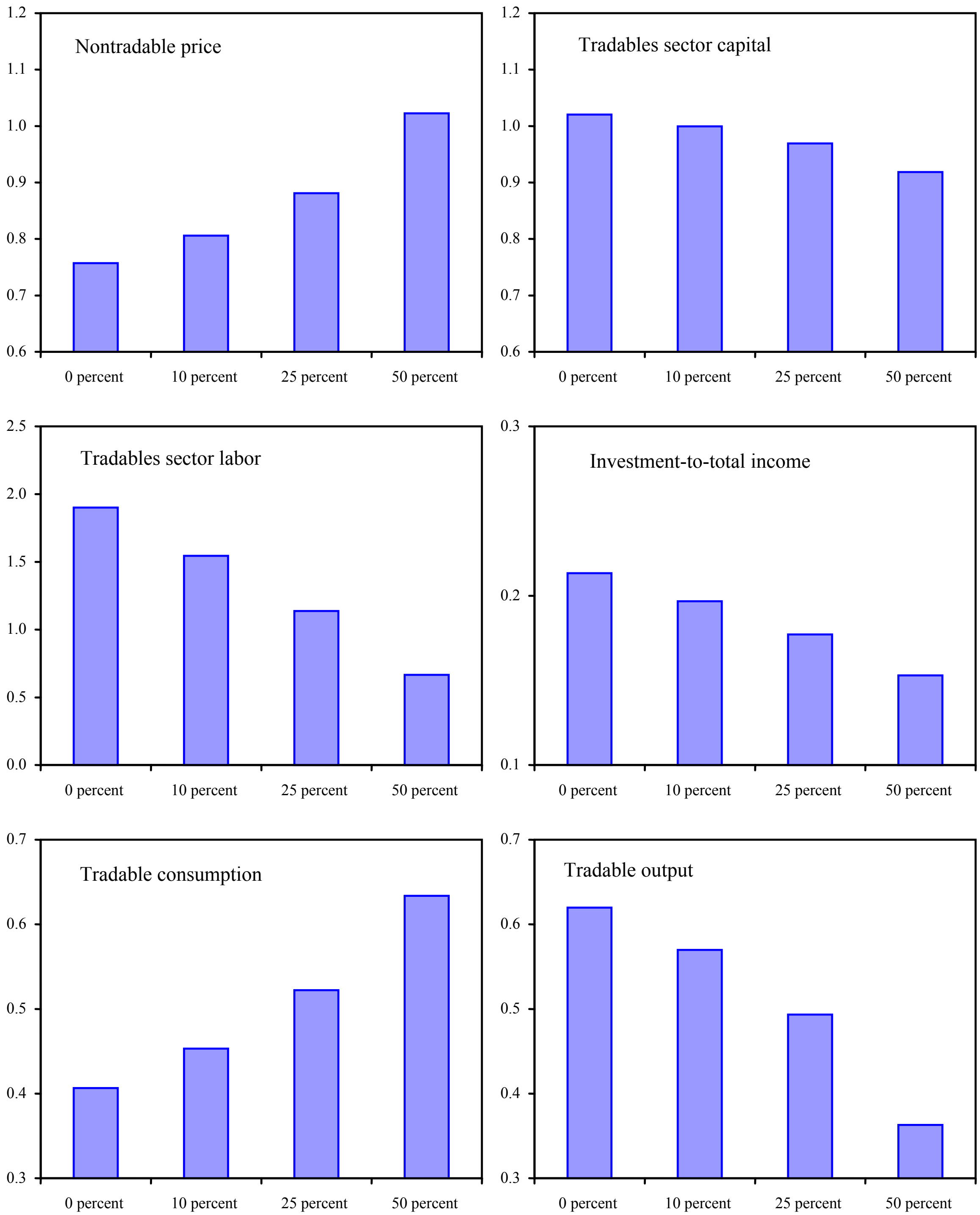
We find that with more aid the marginal rate of saving remains very low, investment declines in relation to total income, the real exchange rate rises, and tradable output shrinks. The steady state allocations shown in Table 2 are calculated for four alternative levels of aid: 0 percent, 10 percent, 25 percent and 50 percent of GDP, where GDP is defined as a sum of tradable and nontradable goods, expressed in traded good terms, $GDP = Y^T + p^N Y^N$. The impact of aid changes the composition of output, labor shares, investment rates, and consumption, as well as the relative price of nontradable goods.

Table 2. Steady State Simulations 1/
(Steady states results for various aid levels)

	Aid Inflows (in percent of GDP)			
	0 percent	10 percent	25 percent	50 percent
Tradable output-to-GDP 2/	0.620	0.570	0.493	0.363
Nontradable output-to-GDP 2/	0.380	0.430	0.507	0.637
Relative price of nontradable goods	0.757	0.806	0.881	1.022
Tradable consumption-to-GDP	0.407	0.453	0.522	0.634
Total consumption-to-total income 3/	0.820	0.835	0.853	0.875
Investment-to-GDP 2/	0.213	0.217	0.221	0.230
Investment-to-total income 3/	0.213	0.197	0.177	0.153
Capital-to-GDP 2/	2.370	2.405	2.459	2.550
Ratio of capital stock in the tradable to nontradable sector	1.020	0.999	0.969	0.919
Ratio of labor stock in the tradable to nontradable sector	1.902	1.544	1.137	0.665

Source: Authors' calculations.
1/ For these simulations, productivity and aid shocks are set to nil.
2/ Aggregate output is defined as $GDP = Y^T + p^N Y^N$, using tradables as numéraire. Thus the ratio of nontradables output to GDP, $p^N Y^N / GDP$, depends both on physical production of nontradables and on nontradable price, p^N.
3/ Total income equals to GDP and aid.

Figure 2. Steady State Variables As a Function of Aid 1/



Source: Authors' calculations.

1/ The vertical axis indicates the steady states values of the variables. The horizontal axis shows the different steady state aid values (as percentage of GDP).

One striking result of the model is that a permanently higher level of aid is associated with a permanently higher level of consumption, with little incremental effect on saving and investment. While the investment-to-GDP ratio increases from 21 percent to 23 percent with aid rising from 0 percent of GDP to 50 percent of GDP, investment declines sharply as a ratio to total income, that is, GDP plus aid (Figure 2). Indeed, the marginal rate of saving is close to zero. Moreover, as we show in the sensitivity analysis section, this result is robust to changes in the key parameters of the model.

This finding reflects the logic of optimal consumption and investment behavior where capital goods are the only store of value and the target level of capital is independent of the level of aid. In the steady state, consumption increases slightly in relation to total income—from 82 percent to 88 percent—with aid rising from 0 percent of GDP to 50 percent of GDP. Additional aid does not affect the consumption profile, but simply shifts up the consumption level, while keeping that higher level of consumption constant over time. The target capital stock is determined by the time preference parameter and the depreciation rate and thus it remains unchanged and all the aid is consumed. Saving and investment decisions are affected by aid only to the extent that aid leads to intertemporal variations in consumption. A higher constant level of aid does not give rise to any such variation, so there is little difference in investment as a percentage of GDP for different aid levels. The reason why investment as a percentage of GDP is higher is that production of nontradables is relatively capital-intensive; the rate of return to capital is higher than in the absence of aid, providing a greater incentive for investment.[7]

A second result, in line with the classical transfer paradox, is that the relative price of nontradables is higher in the case where aid inflows are higher. In the simulation results, aid equal to 50 percent of GDP is associated with a relative price of nontradables higher (i.e., real appreciation) by one third than in the absence of aid. This change can be viewed on both the demand and the cost side: aid increases the availability of tradables relative to nontradables, raising the equilibrium price of the latter; at the same time, it pushes up the returns to capital, the factor assumed to be used intensively in nontradable production, thus increasing the relative cost of producing nontradables.

A third result, stemming from the first two, is that the relative size of the tradable sector is substantially smaller with higher levels of aid. Without aid the tradable sector comprises more than 60 percent of GDP in the steady state; its share shrinks to about 36 percent of GDP when aid is equivalent to 50 percent of GDP. The relative decline of the tradable sector is almost linear: a 1 percentage point increase in aid is associated with about a ½ percentage point decline in the share of the tradable sector in GDP. Although overall GDP (measured in terms of tradables) is larger with aid, a part of the increase in GDP is due to higher nontradable prices, p^N, rather than additional physical production of nontradables. The

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[7] This result is an inversion of the Rybczynski theorem: an increase in a country’s endowment of a factor will cause an increase in output of the good which uses that factor intensively.

relatively higher output of the nontradable sector is also associated with a higher share of labor: the ratio of labor in the tradables to the nontradables sector decreases from 1.90 without aid to 0.66 when aid is equivalent to 50 percent of GDP.

The allocation of capital in the two sectors changes much less owing to the assumption that capital is sector-specific: the ratio of capital in the tradables to the nontradables sector declines from 1.02 to 0.92 between the two poles of the aid continuum.[8] With aid, households also change the consumption bundle toward tradable goods consumption, reflecting the increase in the relative price of nontradables: tradables consumption increases from 40 percent of GDP to more than 60 percent of GDP.

While these results are in line with the static model findings, we observe some new features. First, aid is associated with a decline in the investment rate as households rely on aid inflows as opposed to investment for consumption smoothing and we do not observe any significant increase in aid-induced investment. Second, the results are sensitive to the substitutability of sectoral capital. We will explore these findings further in the subsequent sections.

C. Sensitivity Analysis

In this section we perform a series of sensitivity tests on the deterministic model to understand the mechanisms by which aid changes the composition of output. In these experiments we vary the level of aid, the elasticity of substitution of sectoral capital, and the capital intensity of the two sectors. All other parameters are held constant. In Table 3 we show four sets of results: the baseline model of the previous section; a model with identical capital shares in both sectors and perfectly substitutable capital (Model A); a model with identical capital shares in both sectors but imperfectly substitutable capital (Model B); and a model with different capital shares in both sectors but perfectly substitutable capital (Model C). The full set of numerical results is shown in Appendix, Table A2.

We find that one of the key results—a decline in tradables output—remains intact in all experiments, while the other—real appreciation—remain intact as long as capital is sector specific. First, tradables output diminishes even in the absence of real appreciation as aid substitutes for domestic tradables (all models). This follows directly from the fact that aid is a gift of tradable goods: even if higher supply of tradables does not affect the price of nontradables, because capital is seamlessly reallocated toward the production of nontradables, it still implies that demand for tradables was satisfied from aid proceeds.

[8] Given the assumption that nontradables are relatively capital intensive, an increase in the relative size of that sector requires a lower capital intensity in both sectors, associated with a rise in the returns to capital.

Table 3. Sensitivity Analysis of the Steady State Results 1/

	Baseline Model 2/	Model A 3/	Model B 4/	Model C 5/
Nontradable prices	↑	unchanged	↑	unchanged
Tradable output-to-GDP	↓	↓	↓	↓
Ratio of capital stock in the tradable to nontradable sector	↓	↓↓	↓	↓↓
Total capital	↑↑↑	unchanged	↑↑	↑
Investment-to-GDP	↑	unchanged	unchanged	↑
Investment-to-total income	↓	↓	↓	↓
GDP	↑↑	unchanged	↑↑	↑

1/ "↑" indicates that the variable increases as the economy receives more aid.
2/ A model economy with all parameters as in Table A1, that is $\alpha = 0.3$, $\eta = 0.4$, and $\nu = -10$.
3/ A model economy with identical capital shares and perfectly substitutable capital ($\alpha = \eta = 0.3$ and $\nu = -1$).
4/ A model economy with identical capital shares and imperfectly substitutable capital ($\alpha = \eta = 0.3$ and $\nu = -10$).
5/ A model economy with differentiated capital shares and perfectly substitutable capital ($\alpha = 0.3$, $\eta = 0.4$, and $\nu = -1$).

Second, the increase in the relative price of nontradables depends on imperfect substitutability of capital: if the capital stock were freely interchangeable between sectors, no real appreciation would occur (Model A and C). This is intuitive: labor would be reallocated toward nontradable goods and the greater capital intensity of non-tradables would be reflected in a higher steady-state capital stock. Furthermore, the lower the elasticity of substitution between capital employed in the tradables and nontradables sectors, the larger the relative decline in tradables output. The argument is as follows: when capital is highly sector-specific, the aid-induced shift in the composition of output toward nontradables takes place in a less efficient way. It is more costly to reallocate capital, and more of the burden thus falls on a reallocation of labor. Although the output of tradables declines less when capital is sector-specific, the price of nontradables increases substantially, boosting GDP (Baseline model and Model B).

Third, the structure of the economy also affects the steady state stock of capital and GDP. Total capital is unchanged if sectoral capital is freely interchangeable and capital intensities are identical (Model A), but it increases in the other versions of the model. In economies where the share of capital in output is identical (Model A and B) the investment-to-GDP ratio does not change. Moreover, we find that output increases less when the elasticity of substitution between tradable and nontradable capital is high and indeed output is unchanged in Model A.

D. Stochastic Model

In this section we develop the case in which the economy may be subject to productivity shocks and aid receipts may also be uncertain and compare it with the steady state in the absence of any shocks (Table 4, first column).[9] Developing countries are subject to strong productivity fluctuations and in many of them aid constitutes a significant share of income and is potentially an important additional source of volatility. Developing countries' limited financial integration restricts their ability to insure against these shocks internationally, so the shocks may have particularly important economic implications (Mendoza, 1997, Pallage and Robe, 2003, or Turnovsky and Chattopadhyay, 2003).

Stochastic productivity and fixed aid

It is useful to consider first a case in which there are productivity shocks and a fixed level of aid, assumed equal to 25 percent of steady state GDP (second column of Table 4). The productivity shocks are assumed to be somewhat persistent, i.e., a positive shock to total factor productivity this period implies higher total factor productivity next period and, to a lesser degree, in subsequent periods. In this setting, investment varies substantially in response to productivity shocks due to the absence of capital adjustment costs: for instance, a negative shock lowers investment both for consumption smoothing reasons and because of the negative effect of the shock on the future marginal productivity of capital. But consumption also varies significantly in response to the shock: given that capital is the only store of value and is subject to diminishing marginal productivity, consumption smoothing is not complete.[10] Productivity shocks also give rise to variations in production, owing both to their direct effect and to the resulting fluctuations in investment. The steady-state capital stock and investment are marginally higher than in the absence of shocks, reflecting the role of capital as a buffer stock. Moreover, volatility in productivity results in an increase in the average production of tradables relative to nontradables: this reflects the model assumption that the capital stock can be increased by tradable goods only.

[9] The model is solved by value function iteration over a discretized state space. In the case with shocks to both productivity and aid, the state space corresponds to $\varepsilon^x = \{-0.15, 0.15\}$ and $\varepsilon^T = \varepsilon^N = \{-0.1, 0.1\}$. The probability distribution matrix is calculated such that it replicates the persistence and correlation among shocks in the data. The endogenous state variable is the aggregate capital stock with a grid corresponding to 50 equally spaced points. The points are chosen so that they cover all the positive probability points in the limiting distribution.
[10] The limited degree of consumption smoothing is in part a reflection of the model's specification, i.e., a combination of the CES utility and Cobb-Douglas production functions.

Table 4. Properties of Model Economies
(Means and Standard Deviations of Limiting Distribution)

	Steady state 1/	Fixed Aid, Stochastic Productivity 2/	Stochastic Aid, No Productivity Shocks 3/	Stochastic Aid and Productivity 4/
	Mean			
Tradable output-to-GDP 5/	0.493	0.495	0.493	0.498
Relative price of nontradables	0.881	0.884	0.882	0.878
Tradable consumption-to-GDP	0.522	0.520	0.523	0.518
Investment-to-GDP	0.221	0.223	0.222	0.229
Investment-to-total income	0.177	0.179	0.177	0.183
Capital-to-GDP	2.459	2.478	2.464	2.541
Ratio of capital stock in the tradable to nontradable sector	0.969	0.969	0.969	0.970
Ratio of labor stock in the tradable to nontradable sector	1.137	1.127	1.134	1.141
	Standard Deviation (In percent)			
Aid	...	0.0	15.0	14.9
Gross domestic product	...	8.5	1.5	8.9
Relative price of nontradables	...	5.6	0.8	6.2
Tradable output	...	16.8	1.8	17.3
Nontradable output	...	6.6	2.0	7.4
Tradable consumption	...	3.6	1.6	4.1
CES consumption	...	4.8	1.8	5.5
Investment	...	35.3	14.7	43.5
Labor in tradable sector	...	8.2	0.7	8.3
Memorandum Item:				
Aid to GDP ratio (in percent)	25.0	25.0	25.0	25.0

Source: Authors' calculations.

1/ Identical as in the third column of Table 1.
2/ Productivity shocks are identical for both the tradable and nontradable sectors. Their standard deviation is set equal to 10 percent and the first order autocorrelation coefficient is set equal to 0.4.
3/ No productivity shocks. The standard deviation of aid inflows is set equal to of 15 percent and the aid-to-GDP correlation coefficient is set equal to 0.4.
4/ Productivity shocks are identical for both the tradable and nontradable sectors. Their standard deviation is set equal to 10 percent and the first order autocorrelation coefficient is set equal to 0.4. The standard deviation of aid inflows is set equal to of 15 percent and the aid-to-GDP correlation coefficient is set equal to 0.4.
5/ Aggregate output is defined as $GDP = Y^T + p^N Y^N$. Hence, all the GDP ratios depend also on the change in prices of nontradables, p^N.

Stochastic aid and no shocks to productivity

Next, one may consider the case in which there are no productivity shocks but aid fluctuates around its mean of 25 percent of steady state GDP (third column of Table 4). On the one hand, as in the previous case, aid shocks are primarily reflected in variations in investment. On the other hand, variations in consumption are much smaller than in the case of productivity shocks. We see three reasons for this difference. First, aid shocks do not directly affect production, second, they are transitory and, third, comparatively small in absolute terms (25 percent of output). Give that nontradables consumption is supply-determined, there is little variability in output. We also find that the share of tradables in total output is similar to the baseline case as is the stock of capital. In summary, while the first moments (means) in these two economies are fairly similar, the second moments (standard deviations) are quite different, reflecting the separate channels through which shocks to productivity and aid propagate.

Stochastic aid and productivity

Finally, we consider the case where both aid and productivity are stochastic (fourth column of Table 4). The results are in line with our previous findings, namely that a more volatile economy encourages investment in order to smooth consumption; and variability in productivity and aid are largely reflected in variability in investment. The average share of tradables in total output is somewhat larger than in the other cases, reflecting mainly the effect of productivity shocks on output shares as discussed earlier.[11] With a larger capital stock, nontradables output is larger as well (although as a share of total output it is lower) and nontradables prices are marginally lower.

In summary, the level and the volatility of aid have different implications for the structure of economic activity. Whereas a steady, predictable level of aid is reflected mainly in higher consumption, shocks to aid are absorbed mainly by variations in investment, with smaller effects on consumption. Moreover, the stock of capital and tradable output are higher under more volatile conditions. These effects reflect the interaction of several factors: primarily the easy access to investment for consumption smoothing purposes; but also fluctuations in the real exchange rate; and the allocation of labor and capital across sectors, reflecting both their average levels and response to shocks.

Welfare implications

We have shown that even volatile aid increases the average level of consumption, however, aid volatility increases the variability of consumption, with negative consequences for

[11] Shocks to aid have very different effects on investment than a change in the steady-state level of aid—a reminder that, even if it is established empirically that short-run changes in aid are correlated with changes in investment, it does not follow that a higher steady level of aid provision would result in a commensurately higher average level of investment.

welfare. This makes it particularly important to look at the overall welfare implications of aid and its variability. We examine three cases: one where volatile aid is compared to aid that is stable with no productivity shocks; a second where productivity is also stochastic; and a third where aid flows are delivered so as to stabilize consumption. The shock structure in the three scenarios is identical to the one discussed earlier (Table 3) and we use two metrics, welfare costs in the terms of CES consumption and CES consumption denominated in tradable goods. The latter metric removes the downward bias caused by nontradables price changes. To translate values from CES consumption into CES consumption denominated in tradable goods we use the relative price of aggregate consumption (15).

The estimated welfare costs of aid volatility are comparable to what was found in previous research on business cycle costs in developing countries.[12] In the first case—no productivity shocks—welfare costs of aid volatility in terms of CES consumption and in terms of CES consumption denominated in terms of tradables are ⅒ of 1 percent and ⅙ of 1 percent, respectively. This is a pure impact of volatile aid in an economy with no other shocks. A more realistic welfare calculation would incorporate also productivity shocks: in such a case welfare costs increase to ⅙ of 1 percent and ⅓ of 1 percent, respectively. If aid could be delivered in such a way as to insure households in the recipient country against the effects of productivity shocks, i.e., fully stabilizing aggregate consumption, the welfare gains would be equivalent to ¾ of 1 percent of CES consumption and 1½ percent of CES consumption denominated in tradable goods.

We note two caveats of these model results. First, our calculations of welfare losses are on the very low bound of the range of plausible estimates: had we introduced capital adjustment costs, we would have obtained much higher welfare costs of volatility. In such a case, investment would be a less effective instrument to insure against consumption fluctuations. Second, in a model with a government, aid shortfalls would result in disruption in public services and investment with associated welfare implications.

We can also ask what level of aid would render households indifferent, in terms of utility, between an environment of volatile and procyclical aid and one where aid is constant at the mean—the so-called compensating variation. This is equivalent to the reduction in consumption that households would be willing to give up in order to receive constant aid flows. We calculate the compensating variation as the welfare costs above, denominated in

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[12] Our welfare calculation is identical to that of Lucas (1987), who estimated welfare cost as ½ times the risk aversion coefficient (σ) times the difference in the variance of consumption. There are well-known measurement problems with this approach: aid volatility not only changes the volatility of consumption, but also changes consumption as a result of precautionary savings that enlarge the stock of capital. On the one hand, shocks increase consumption volatility and decrease welfare; on the other hand, consumption increases in the long run due to a higher capital stock, increasing welfare. Thus, we base our welfare calculations solely on consumption volatility, ignoring the changes in levels.

terms of tradable goods, as a percentage of mean aid inflows. First, if donors delivered aid in a stable manner and ignoring productivity shocks, they could maintain the same level of recipient well-being while reducing aid by ¾ of 1 percent. Second, if aid could insure against productivity shocks, donors could reduce aid inflows by 3 percent without reducing the present level of welfare.

These estimated welfare effects are comparatively large: as one reference point, they far exceed estimates in the literature for the welfare costs of business cycles in industrial countries (between 1⁄10 and 3⁄10 of 1 percent of annual U.S. consumption for the post-war period in the United States, see İmrohoroğlu, 1989). In summary, if donors were to allocate aid either in a stable fashion or, better still, to smooth out productivity shocks, the benefits to poor countries would be equivalent to those of a substantial increase in the overall level of aid.[13]

IV. Some Empirical Results

In the theoretical section we have shown that aid lowers tradable goods output substantially, while aid volatility has a comparatively small impact on tradables. In this section, we will link these results to output of tradable goods in aid-dependent countries. The cross-country regressions suggest that a high degree of aid dependence is indeed associated with lower manufacturing exports and that aid volatility appear to play a negative role in export determination. However, the latter results are not robust.

A. Explaining Exports

We explore the relative importance of various factors that may explain tradable goods performance in cross-country regressions. Unfortunately, empirical investigations of tradable goods have been plagued with measurement problems. On the one hand, the distinction between tradable and nontradable goods has become increasingly ambiguous.[14] On the other hand, even clearly tradable goods are not homogeneous: some notionally tradable commodities are not traded externally because of their quality, price, or producer location.[15] Moreover, the valuation of tradables in domestic currency terms is often complicated by the volatility of the exchange rate in developing countries. National accounts data are generally of inferior quality to international trade data.

[13] The possible use of countercyclical aid to insure low-income countries against economic fluctuations is explored by Pallage, Robe, and Bérubé (2004).
[14] Čihák and Holub (2003) demonstrated this argument for transition countries.
[15] Goldstein and Lardy (2005) use the example of car manufacturing in China that is predominantly serving the domestic market. Indeed, sectors producing tradable goods for the domestic market and for export tend to be fairly distinct in most newly industrialized and development countries. While the former are capital intensive, the latter often specialize in labor intensive, low-skill technologies that have been outsourced from industrial countries.

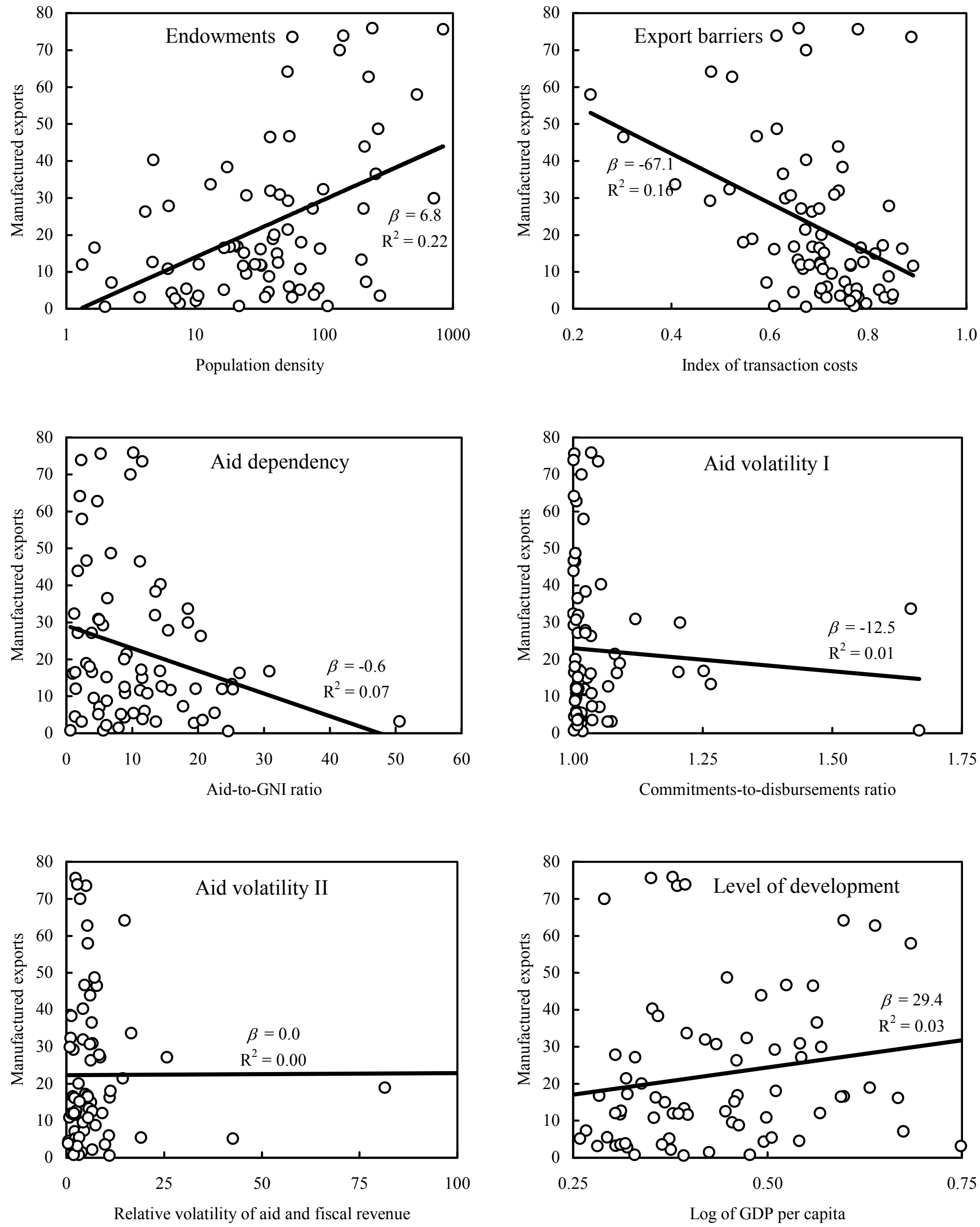
Empirical research on the structure of production in developing countries has thus focused on manufactured exports in relation to total exports as opposed to tradable goods in relation to GDP and we follow in this tradition (Sekkat and Varoudakis, 2000). First, international trade data are compiled at reasonable quality and frequency. Second, the motivation for the narrow focus on manufactured exports reflects that fact that primary-sector exports (agriculture and mining in particular) are likely to be affected to only a limited degree by the factors examined in this paper; for example, mining output depends largely on discovered reserves which tend to be price-inelastic in the short to medium term and the associated rents serve as a cushion against exchange rate fluctuations. Third, by expressing manufactured exports as a percentage of total exports we sidestep the problem of assessing overall economic activity and the measurement error caused by exchange rate volatility. Nevertheless, to control the robustness of our results, we estimated the impact of aid on two other dependent variables: the value added in the merchandise sector as a percentage of GDP and the nonmining exports as a percentage of total exports, finding that the impact of aid and aid volatility remained statistically significant. (These results are available on request.)

In assessing manufactured export performance, several considerations are likely to be important (see Elbadawi, 1998 for a review). First, *differences in countries' relative endowments*—including human capital, natural resource endowment, and location—are arguably important determinants of exports (Wood and Berge, 1997 and Rodrik, 1998). This consideration would suggest, in particular, that sub-Saharan Africa's poor human capital resources, vast supply of primary commodities, and long distance to external markets are important reasons its manufactured good exports are, on average, significantly lower than those in other regions. Second, *transaction costs*–associated, for instance, with export taxes, poor governance, and dilapidated infrastructure—may pose important barriers to export performance for a given set of endowments (Collier, 2000). It is important to control for these factors in examining the effect of aid inflows on the production of tradables and on exports, as predicted in the model developed earlier in this paper.

We are adding *aid and aid volatility* to the list of potential explanatory variables. While the measurement of the former variable is straightforward, aid volatility can be measured in a variety of ways and we show results for two of them. First, the volatility of aid can be compared vis-à-vis expectations of aid, that is, the donor commitments of aid. A higher ratio of commitments to disbursements (denoted as Aid volatility I in Table 5) implies more aid volatility. This ratio is invariably larger than 1 in our sample: donors commit more aid than they disburse. Second, the volatility of aid can be compared to other macroeconomic variables, such as domestic fiscal revenue. The ratio of variances of aid and domestic revenue (denoted as Aid volatility II in Table 5) is an obvious benchmark as aid receipts supplement domestic fiscal revenue.[16] Hence, while the first measure can be related to the notion of aid predictability, the second measure relates aid volatility to the instability of the overall

[16] We express the annual series of aid and domestic revenue in percent of GDP, take logs, and filter the series by the Hodrick-Prescott filter. Variances of aid and revenue are then computed from the detrended series. See Bulíř and Hamann (2003) for additional details.

Figure 3. Determinants of Exports of Manufactured Goods, 1981-2000 1/



Source: *World Development Indicators* ; authors' calculations.

1/ Manufacturing exports as a share of total exports, in percent.

macroeconomic framework. We also experimented—without much success—with various measures of pure aid volatility, such as: standard deviation of aid, standard deviation of Hodrick-Prescott filtered aid, normalizing the previous variables by the level of GDP, and so on. While being negatively related to manufactured exports, these variables failed the usual robustness tests.

Examining the relationship between aid and exports raises the possibility of reverse causality. First, in the short run, some donors may provide additional aid to poor countries hit by adverse shocks affecting their tradables sector. However, the available evidence does not support the view of aid as a "shock absorber" (Bulíř and Hamann, 2005). Second, some countries have experienced secular declines in exports, say, owing to declining export prices, and aid has been used to maintain consumption in those countries. Of course, if the aid inflows were used to build these countries' capital stocks and boost their export capacity, a negative correlation between aid and exports would not persist over the longer run; such reverse causality should thus be attenuated, if not eliminated completely, by working with 10- and 20-year averages.

B. Regression Results

We regressed exports of manufactured goods as a share of total exports on a vector of variables that describe the effects of the endowment, transaction costs, and aid, and a host of control variables. Table 5 lists the definitions of variables and the sample first and second moments. We use population density and secondary education achievement to capture endowment effects, various indices of trade taxes and infrastructure development for the transaction costs effect,[17] and the aid-to-GNI ratio and two measures of aid volatility for the transfer problem effect. In addition, our control variables include aggregate investment,[18] terms-of-trade, dummies for Africa and a war conflict, interactive variables to capture the impact of aid on education achievements, and the level of development (GDP per capita in constant US dollars). The bivariate correlation coefficients for these variables are summarized in Table 6. We employ data for 73 aid-receiving countries for the period 1981-2000, which we further split into 1981-1990 and 1991-2000 and a change between those two subperiods.

[17] We account for transaction costs by a composite index of three variables normalized in the (0;1) space, each of which has a weight of one-third in the total: the ratio of trade taxes to total taxes, the ratio of paved roads to total roads, and number of faxes per 1000 people. Elbadawi (1998) constructed a similar index, using a corruption index instead of our trade tax ratio. Unfortunately, the corruption data are unavailable for many countries in our sample.

[18] Aggregate investment is included as a possible control variable in line with previous literature, even though in the theoretical model it is determined simultaneously with the composition of output and consumption. However, the results for aid remain unaffected when investment is either dropped from the equation or instrumented.

Table 5. Definition of Variables and Their Sample Moments 1/

Variable notation	Definition	Source 2/	Mean	Standard deviation 3/
Exports of manufactured goods	Manufactured exports in percent of total exports	WDI	22.4	92.4
Aid-to-GNI ratio	Gross aid disbursements in percent of GNI	WDI	10.9	80.7
Volatility of aid I	The commitment-to-disbursements ratio	WDI	1.05	11.1
Volatility of aid II	The ratio of variances of Hodrick-Prescott filtered aid and domestic fiscal revenue	WDI, WEO	33.2	282.5
Secondary education	Gross secondary school enrollment	WDI	30.5	65.9
Population density	People per square km	WDI	87.8	167.2
Transaction costs	Index designed as (0.3*Trade taxes/total taxes + 0.3*roads paved/ total roads + 0.3*faxes/1000 population)	WDI	0.692	17.6
Investment	Aggregate investment in percent of GDP	WEO	19.7	34.8
Volatility of terms of trade	Standard deviation of terms of trade	WEO	14.17	60.8
GDP per capita	Log of GDP per capita in constant 1996 US$	WEO	2.83	12.1

1/ All descriptive statistics refer to the mean for the full sample period, 1981-2000.
2/ WDI stands for *World Development Indicators* and WEO stands for the *World Economic Outlook*.
3/ In percent of the mean.

We estimated our regression equations by ordinary least squares (OLS) with heteroskedastic-consistent standard errors and those equations where variables were parameter estimates themselves, such as Aid volatility II, by two-stage least squares (IV) and generalized method of moments (GMM). The reasons for using GMM are twofold (Wooldridge, 2001). First, variables measured with error tend to have bias toward zero. Second, OLS does not account for the standard errors in the first-stage estimator. We used the following instruments for Aid volatility II: the variance of the Hodrick-Prescott filtered aid disbursements, the variance of terms of trade, and the investment-to-GDP ratio.[19] Our instruments both increased the absolute value of the estimated parameter of Aid volatility II and lowered its estimated standard error. Still, the estimated coefficients are only marginally significant and far from being robust. However, the overall regression fit is reasonable, explaining 40-55 percent of the variance of the dependent variable in levels and around 20 percent of the variance of the variable in first differences. All equations in levels are statistically significant at the 1 percent level.

The results are intuitive. The regression estimates are consistent with the idea that endowment and transaction costs are relevant variables for determining exports.[20] Densely populated countries and those with lower transaction costs tend to have a higher share of manufactured exports in total exports. Of the controlling variables, aggregate investment appears to be positively related to manufactured good exports and the volatility of terms-of-trade shocks is negatively associated with manufactured exports.

The regression estimates also indicate a strong negative relationship between the level of aid and exports, consistent with the theoretical model developed above (Table 7). Countries receiving additional aid equivalent to 1 percentage point of GDP compared to the mean have manufactured exports lower by ⅖ to 1 percentage point of total exports. When the dependent variable is expressed as a difference between 1991-2000 and 1981-1990, the results suggest that additional aid equivalent to 1 percentage point of GDP compared to the mean was associated with a decrease in manufactured exports by about ⅓ to ½ of 1 percentage point of total exports. It is worth noting that the only two statistically significant variables in the regression in first differences were the level of aid and transaction costs. All results are robust to the inclusions of controlling variables and estimation techniques.

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[19] Inclusion of the investment-to-GDP ratio suggests that aid shocks are propagated by investment instability.

[20] In contrast, education variables were all insignificant. We also did not detect any effect of aid on human capital accumulation: the interactive term for secondary education and aid was consistently insignificant in all regression. Arguably, the link between domestic spending on education and aid, which donors began to stress in the 1990s, may be too short-lived to show any impact on manufactured good exports in our sample.

Table 6. Matrix of Correlation Coefficients 1/

	Nonmining exports	Aid-to-GNI	Aid volatility I	Aid volatility II	Transaction costs	Secondary education	Population density	Investment-to-GDP	Volatility of terms of trade	GDP per capita
Manufactured exports	0.72	-0.26	-0.07	-0.04	-0.40	0.22	0.47	0.29	-0.37	0.06
Nonmining exports		-0.16	-0.08	-0.06	-0.12	0.02	0.32	0.18	-0.25	0.17
Aid-to-GNI			0.14	-0.09	0.26	-0.42	-0.07	0.11	0.12	-0.50
Aid volatility I				0.00	-0.10	-0.18	0.00	0.11	-0.17	-0.01
Aid volatility II					-0.02	0.17	-0.04	-0.01	0.24	0.05
Transaction costs						-0.47	-0.20	-0.35	0.25	-0.49
Secondary education							0.07	0.42	-0.14	0.68
Population density								0.06	-0.00	-0.02
Investment-to-GDP									-0.10	0.35
Volatility of terms of trade										-0.19

Source: Authors' calculations.

1/ All descriptive statistics refer to the full sample period, 1981-2000.

Table 7. Aid, Endowment, Transaction Cost, and Manufactured Exports
(Dependent variable = Manufacturing exports-to-total exports, in percent)

	1981-1990			1991-2000			1981-2000			Change between 1981-1990 and 1991-2000		
	OLS	OLS	GMM	OLS	OLS	GMM	OLS	OLS	GMM	OLS	OLS	GMM
Aid-to-GNI ratio	-0.455 (2.21)**	-0.748 (3.00)***	-0.401 (2.43)**	-0.701 (3.57)***	-0.714 (2.41)**	-1.146 (4.00)***	-0.542 (3.79)***	-0.634 (3.11)***	-0.481 (2.36)**	-0.539 (3.16)***	-0.354 (1.73)*	-0.377 (2.00)**
Aid volatility I	-13.34 (2.70)***			-24.88 (3.43)***			-24.23 (2.12)**			-13.58 (1.72)*		
Aid volatility II		-0.008 (0.65)	-0.085 (1.76)*		-0.014 (0.84)	-0.079 (1.33)		-0.012 (1.42)	-0.081 (1.73)*		-0.003 (0.17)	-0.012 (0.51)
Population density	0.065 (7.74)***	0.024 (0.96)	0.058 (5.87)***	0.025 (1.00)	0.031 (1.46)	0.027 (1.09)	0.054 (5.00)***	0.052 (3.75)***	0.058 (5.83)***	0.008 (1.04)	0.009 (0.62)	0.003 (0.20)
Transaction cost	-58.51 (3.67)***	-39.88 (1.99)**	-60.09 (3.61)***	-37.44 (1.99)**	-70.09 (3.12)***	-60.46 (3.03)***	-55.87 (3.18)***	-65.09 (4.04)***	-64.46 (4.06)***	-15.87 (1.36)	-26.69 (2.03)**	-28.14 (2.10)**
R^2	0.415	0.501	0.223	0.523	0.276	0.331	0.484	0.384	0.235	0.236	0.138	0.130
RSS	15,454	22,215	20,511	21,233	32,254	29,805	15,930	19,042	20,198	12,500	14,109	14,235
F-test (8,64)	5.66***	8.03***	n.a.	8.78***	4.19**	n.a.	8.73***	8.85***	n.a.	2.48**	1.76*	n.a.
DW	2.37	2.11	2.52	1.99	2.18	2.37	1.96	2.23	2.51	1.88	1.97	2.02

Notes: Additional conditioning variables include the ratio of investment to GDP, the standard deviation of terms of trade, log of GDP per capita and per capita squared, a dummy for a war conflict, and a constant. The estimation is by OLS with heteroskedasticity-consistent standard errors (HACSE), t-test in parentheses and by the GMM, where Aid volatility II is instrumented by the variance of the Hodrick Prescott filtered aid disbursements, the variance of terms of trade, and the investment to GDP ratio. Number of observations is 73. The estimated parameters denoted with *, **, and *** are statistically significant at 10 percent, 5 percent, and 1 percent, respectively.

The relationship between aid volatility and manufactured exports is also negative, albeit not very robust and it is statistically significant only for the Aid volatility I variable.[21] However, the failure to find a link between a simple and direct measure of aid volatility and manufactured exports is in line with the theoretical model. Quantitatively, these point estimates are smaller than the impact of the level of aid. First, countries where the ratio of expected aid to disbursed aid was higher by 1 percentage point compared to the mean have manufactured exports lower by about 1/6 to ¼ of 1 percentage point of total exports (Aid volatility I). Second, countries where the ratio of aid volatility to revenue volatility was higher by 1 percentage point compared to the mean have manufactured exports lower by about 1/30 of 1 percentage point of total exports (Aid volatility II).

What is the quantitative contribution of the various effects to manufactured good exports in our regressions? These contributions are typically estimated as a product of the regression coefficient of the explanatory variable and its standard deviation (Table 8). The interpretation is as follows: if, for example, the 1981-2000 aid-to-GNI ratio is one standard deviation higher than its mean, then the share of manufactured good exports in total exports is predicted to be lower by between 2 ½ percentage points and 6 ½ percentage points. Similarly, a one-standard-deviation increase in the measures of aid volatility is associated with a decrease in manufacturing exports by between 0 percentage points and 4 percentage

Table 8. Sensitivity Analysis: How Important Are the Individual Contributing Factors? 1/

Variable	Impact on manufactured good exports (In percentage points of total exports)	
	Lower bound	Upper bound
Aid-to-GNI ratio	-2.4	-6.5
Aid volatility I	Not different from zero	-4.2
Aid volatility II	Not different from zero	-4.0
Population density	6.3	10.0
Transaction costs	-4.7	-9.8

1/ The calculations are based on the coefficients from the relevant equations of the 1981-2000 sample period in Table 6. We multiply the estimated coefficient with the sample standard deviation; the lower and upper bounds are defined as one standard error of the parameter estimate.

[21] Even this result disappears when two outliers with very high ratios of commitments to disbursements—Bhutan and Liberia—are excluded from the regression (see Figure 3). While the point estimate remains negative, it becomes statistically insignificant.

points; and so on. In summary, the empirical results for the level of aid in our sample are broadly consistent with the earlier literature and theoretical model: large aid is associated with substantially lower manufacturing exports and the impact of aid volatility is small or insignificant, or both.

V. Issues for Further Research

As in any modeling and calibration exercise, we had to make choices that affect the final outcome. In general, we strove to construct the model using standard building blocks, with a view to establishing a relatively uncontroversial benchmark specification, to which additional building blocks could be added with relative ease. Below are summarized some potential extensions of our model, both with respect to the theoretical and empirical models. It should be noted that these extensions work in both directions—some are likely to make the resulting decline of the tradable sector or welfare losses bigger and others are likely to decrease them. In our view, none of the extensions below is likely to overturn our findings.

Most extensions to the theoretical model are likely to increase the estimate of the tradable good sector decline and welfare losses. First, the choice of the utility function matters for the impact of aid volatility. The assumption of constant relative risk aversion is a conservative one, particularly in relation to low-income countries close to the margin of survival (Burnside and Dollar, 2000). It could be useful to test the robustness of our findings in models that would either use a different risk aversion coefficient or replace constant relative risk aversion preferences with a more extreme risk aversion specification. Second, the impact of aid on the composition of tradable and nontradable output could be modeled in a more sophisticated framework in which tradables production generates learning-by-doing externalities but requires sector-specific investments. Third, the impact of aid volatility depends on the efficiency of available instruments to mitigate such impact. Agents in our model are not constrained by capital adjustment costs and can reallocate capital with relative ease, making investment perhaps too efficient an instrument to insure against consumption fluctuations. Fourth, in our economy households can continue their economic activity in the case of an aid shortfall. It could be argued that in aid-dependent countries aid shortfalls may suppress economic activity either because aid finances basic public good and services (a demand-side effect) or because aid finances infrastructure spending (a supply-side effect). Thus incorporation of a public sector in the model could be another useful extension. Finally, the capital transformation cost schedule could be replaced with an intertemporal equation where capital is costly over time. Although this would make the model more complex, it would allow us to test richer alternative scenarios.

The impact of potential extensions to the empirical model is more difficult to gauge. First, the definition of aid used in the paper—gross aid flows—could be broadened to include debt relief net of arrears clearance. The underlying definition has consequences for the measurement error of aid volatility and the eventual empirical estimates. Second, to the extent aid is not completely fungible, various kinds of aid—budgetary support, project aid, disaster relief, technical assistance and so on—are bound to have differential impact on the tradable sector. The methodology used by Clemens et al. (2004) could be readily applied to the empirical model.

VI. Conclusions

This paper has examined the effects of aid on consumption and investment and on the structure of production in the context of an intertemporal two-sector general equilibrium model. Regression results using a sample of 73 aid-receiving countries were shown to be consistent with the key conclusions of the theoretical model. The level of manufactured good exports was shown to be negatively related to the scale of aid, while the impact of aid volatility on manufactured exports was not robust.

The analysis yields several results that are relevant to assessing the role of aid and aid volatility. First, the usual static effects of aid on the real exchange rate and the composition of output—a real appreciation and a shift in output toward the nontradables sector—are borne out in an intertemporal model. A flow of aid has a large negative impact on the output of the tradable goods sector. To satisfy aid-driven demand for nontradables, which are supply-constrained, capital and labor have to shift out of tradables production, with imports satisfying the increased demand for tradables.

Second, in this simple model a continuing flow of aid receipts is used mainly to finance consumption. This use of aid is consistent with optimal intertemporal choice, suggesting that cases in which aid is consumed should not be considered anomalous. Moreover, the use of aid for consumption may be consistent with the wishes of donors, as they care about the well-being of the poor. But this result is also consistent with the evident historical failure of aid inflows to translate into productive investment and growth (as discussed for instance in Easterly, 1999). If aid is expected to have a more striking effect on investment and growth in the future, this effect would need to depend on factors not captured in the simple model of intertemporal optimization presented here.

Third, for a country with limited access to international capital markets, shocks to aid are reflected mainly by fluctuations in investment, as a result of consumption smoothing, but consumption is not smoothed completely. Thus, even when aid shocks are transitory, these shocks do result in variations in consumption that detract from welfare. The reason is that, in the absence of the ability to borrow and lend internationally, consumption smoothing takes place through the capital stock—but capital is an imperfect store of value, due to its diminishing marginal productivity.

Finally, the results in the paper suggest that aid variability has potentially large welfare effects, which should be taken into account in designing aid architecture. These effects of aid variability attenuate, but do not eliminate, the welfare benefits of receiving aid. The results in this paper suggest that the benefits of reducing aid variability—or better yet, tailoring the provision of aid to insure recipients against productivity shocks—could be very substantial.

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Table A1. The Parameters Used in the Baseline Model

Parameter	Symbol	Value
Time preference	β	0.95
Weight of tradable consumption in the consumption function	ω	0.50
Elasticity of substitution between tradable and nontradable consumption	$1/(1+\mu)$	0.316
Depreciation rate	δ	0.09
Capital share in the tradable sector	α	0.30
Capital share in the nontradable sector	η	0.40
Risk aversion coefficient	σ	5.00
Elasticity of substitution between capital used in the tradable and nontradable sectors	$1/(1+\nu)$	-10
Productivity	$A^T = A^N$	1

Table A2. Steady State Simulations

	Aid in percent of GDP			
Baseline model 1/	0	10	25	50
Tradable output-to-GDP ratio	0.620	0.570	0.493	0.363
Nontradable output-to-GDP ratio	0.380	0.430	0.507	0.637
Tradable consumption-to-GDP ratio	0.407	0.453	0.522	0.634
Investment-to-GDP ratio	0.213	0.217	0.221	0.230
Investment-to-GDP and aid ratio	0.213	0.197	0.177	0.153
Ratio of capital stock in the tradable to nontradable sector	1.020	0.999	0.969	0.919
Ratio of labor stock in the tradable to nontradable sector	1.902	1.544	1.137	0.665
Relative price of nontradable goods	0.757	0.806	0.881	1.022
Capital to GDP Ratio	2.370	2.405	2.459	2.550
Model A 2/				
Tradable output-to-GDP ratio	0.595	0.545	0.470	0.345
Nontradable output-to-GDP ratio	0.405	0.455	0.530	0.655
Tradable consumption-to-GDP ratio	0.405	0.455	0.530	0.655
Investment-to-GDP ratio	0.189	0.189	0.189	0.189
Investment-to-GDP and aid ratio	0.189	0.172	0.151	0.126
Ratio of capital stock in the tradable to nontradable sector	1.467	1.196	0.886	0.526
Ratio of labor stock in the tradable to nontradable sector	1.467	1.196	0.886	0.526
Relative price of nontradable goods	1.000	1.000	1.000	1.000
Capital to GDP Ratio	2.103	2.103	2.103	2.103

Table A2. Steady State Simulations (concluded)

	Aid in percent of GDP			
Model B 3/	0	10	25	50
Tradable output-to-GDP ratio	0.600	0.548	0.467	0.330
Nontradable output-to-GDP ratio	0.400	0.453	0.533	0.670
Tradable consumption-to-GDP ratio	0.411	0.458	0.528	0.640
Investment-to-GDP ratio	0.189	0.189	0.189	0.189
Investment-to-GDP and aid ratio	0.189	0.172	0.151	0.126
Ratio of capital stock in the tradable to nontradable sector	1.041	1.019	0.987	0.932
Ratio of labor stock in the tradable to nontradable sector	1.500	1.210	0.8788	0.492
Relative price of nontradable goods	0.896	0.950	1.036	1.211
Capital to GDP Ratio	2.103	2.103	2.103	2.103
Model C 4/				
Tradable output-to-GDP ratio	0.613	0.565	0.494	0.374
Nontradable output-to-GDP ratio	0.387	0.435	0.506	0.626
Tradable consumption-to-GDP ratio	0.399	0.449	0.522	0.645
Investment-to-GDP ratio	0.214	0.217	0.221	0.229
Investment-to-GDP and aid ratio	0.2137	0.197	0.177	0.153
Ratio of capital stock in the tradable to nontradable sector	1.188	0.975	0.731	0.449
Ratio of labor stock in the tradable to nontradable sector	1.848	1.5175	1.137	0.698
Relative price of nontradable goods	0.879	0.879	0.879	0.879
Capital to GDP Ratio	2.375	2.408	2.458	2.542

1/ A model economy with all parameters as in Table A1, that is $\alpha = 0.3$, $\eta = 0.4$, and $\nu = -10$.
2/ A model economy with $\alpha = \eta = 0.3$ and $\nu = -1$.
3/ A model economy with $\alpha = \eta = 0.3$ and $\nu = -10$.
4/ A model economy with $\alpha = 0.3$, $\eta = 0.4$, and $\nu = -1$.

Table A3. List of Countries Used in Regressions

Country	Country
Angola	Liberia
Bangladesh	Madagascar
Benin	Malawi
Bhutan	Maldives
Bolivia	Mali
Botswana	Mauritania
Burkina Faso	Mauritius
Burundi	Mongolia
Cambodia	Morocco
Cameroon	Mozambique
Central African Republic	Namibia
Chad	Nepal
Comoros	Nicaragua
Congo, Democratic Republic of	Niger
Congo, Republic of	Nigeria
Côte d'Ivoire	Pakistan
Djibouti	Panama
Ecuador	Papua New Guinea
Egypt	Paraguay
El Salvador	Peru
Ethiopia	Philippines
Fiji	Rwanda
Gabon	Senegal
Gambia, The	Sierra Leone
Ghana	Sri Lanka
Guatemala	Sudan
Guinea	Swaziland
Guinea-Bissau	Syrian Arab Republic
Guyana	Tanzania
Haiti	Togo
Honduras	Tunisia
Indonesia	Uganda
Jamaica	Vietnam
Jordan	Yemen, Republic of
Kenya	Zambia
Lao Peoples’ Democratic Republic	Zimbabwe
Lesotho	

Long-Run Equilibrium Solution

The following equations characterize the long-run equilibrium of this economy:

$$\frac{1}{\beta} = \left(\frac{A^T \alpha (K^T / L^T)^{\alpha-1}}{\kappa_1(K^T, K^N)} + 1 - \delta \right)$$

$$\frac{A^T \alpha (K^T / L^T)^{\alpha-1}}{\kappa_1(K^T, K^N)} = p^N \frac{A^N \eta (K^N / L^N)^{\eta-1}}{\kappa_2(K^T, K^N)}$$

$$A^T (1-\alpha)(K^T / L^T)^{\alpha} = p^N A^N (1-\eta)(K^N / L^N)^{\eta}$$

$$p^N = \left(\frac{1-\omega}{\omega} \right) \left(\frac{C^N}{C^T} \right)^{-(1+\eta)}$$

$$C^N = A^N K^{N\eta} L^{N1-\eta}$$

$$C^T + i = A^T K^{T\alpha} L^{T1-\alpha} + X$$

$$i = \delta K$$

$$K = \kappa(K^T, K^N)$$

$$L^N + L^T = 1$$