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The dynamic implications of foreign aid and its variability ☆

Cristina Arellano [a], Aleš Bulíř [b,*], Timothy Lane [b], Leslie Lipschitz [b]

[a] *University of Minnesota and Federal Reserve Bank of Minneapolis, United States*
[b] *International Monetary Fund, United States*

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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, calibrated using data for aid-dependent countries in Africa. A permanent flow of aid mainly finances consumption rather than investment—consistent with the historical failure of aid inflows to translate into sustained growth. Large aid flows are associated with higher real exchange rates and smaller tradable sectors because aid is a substitute for tradable consumption. Aid volatility results in substantial welfare losses, providing a motivation for recent discussions of aid architecture stressing the need for greater predictability of aid. These results are also consistent with evidence from cross-country regressions of manufactured exports, presented later in the paper.

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1. Introduction

As foreign aid remains a major source of income for many low-income countries, it is important to consider its implications for these countries' efforts to foster economic growth. Here, one issue is the possibility of "Dutch disease"—the adverse effect of natural resource revenues on the manufacturing sector, via a real exchange rate appreciation.[1] A second is the variability of foreign aid, which may diminish countries' ability to use aid effectively, in part by adding to the volatility of domestic investment and consumption. These issues may become all the more important as donors "scale up" aid flows to support these countries' progress toward the Millennium Development Goals.

A number of studies have examined the issue of Dutch disease related to large aid inflows in low-income countries (see a review in Bulíř and Lane, 2004). Foreign aid increases the supply of tradable goods and, ceteris paribus, lowers their price, while—through the income effect of the transfer—it also increases the demand for and price of non-tradable goods. As a result, factors of production are redirected toward the sectors producing non-tradable goods.[2] In a static model, the resulting decline in production of tradables is merely an optimal adjustment to the transfer—not really a "disease" at all. 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

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* Corresponding author. 700 19th Street NW, Washington DC, 20431, United States. Tel.: +1 202 623 7145.
E-mail address: abulir@imf.org (A. Bulíř).

[1] Dutch disease was originally analyzed in the context of the discovery of natural gas in the Netherlands (Corden, 1984; Gelb, 1988). This is a special case of the "transfer problem" first analyzed in the context 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). For a simple exposition see Isard et al. (2006).

[2] See, for example, Michaely (1981) and Laplagne et al. (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).

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diffusion and learning by doing (Grossman and Helpman, 1991; Barro and Sala-i-Martin, 1997; Connolly, 1999; Bigsten et al., 2002). Empirical papers have also found a positive relation between trade and growth (Levine and Renelt, 1992; Sala-i-Martin, 1997). But such analyses—with the exception of Adam and Bevan (2003) and Rajan and Subramanian (2005)—have not generally been integrated into the analysis of the decline in the tradables sector in response to sustained aid inflows. At a minimum, it is desirable to examine the implications of aid in a dynamic framework.

A related issue is the effect of aid on investment. It has traditionally been argued that aid may boost growth 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; Clemens et al., 2004), this evidence is far from conclusive (Easterly, 1999).

The variability of aid has also been receiving increasing attention. Indeed, recent discussions in the donor community of “aid architecture” have sought *inter alia* to develop proposals for making aid more predictable and stable. 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, 2008; 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; 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 focus on the effects just discussed while abstracting from 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 using macroeconomic data for Côte d'Ivoire—one country in Sub-Saharan Africa with significant aid and reliable national accounts—and on plausible parameter values, comparable to those used in previous literature. The model successfully replicates the key relationships observed in the Ivorian series.

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 implications of aid for 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, as aid increases relative to domestic income, it becomes an increasingly dominant influence on economic developments. Fourth, 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.

Finally, the paper tests the key prediction of the model—that aid is associated with a decline in tradable output, i.e., Dutch disease—in cross-country regressions for 73 aid-dependent countries. Manufactured 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 numerous other variables used in the trade literature.

The paper is organized as follows: Section 2 develops the model. Section 3 presents simulation results calibrated on data for Côte d'Ivoire, and discusses the welfare implications. Section 4 presents regression results on the aid-to-exports nexus. Section 4 concludes.

2. The theoretical model

The model is a neoclassical dynamic general equilibrium model of a small economy that has two productive sectors: tradable and non-tradable goods. The economy receives aid every period—assumed to be an unconditional transfer of tradable goods from the rest of the world, implying that the economy cannot affect the level or volatility of aid flows.[3] The recipient country is assumed to have no access to international capital markets.

Households in the economy maximize their expected lifetime utility and have preferences over a composite bundle of tradable and non-tradable goods:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma}}{1-\sigma}, \tag{1}$$

The utility function is characterized by constant elasticity of substitution, where σ is the coefficient of risk aversion. The consumption aggregator is of constant elasticity of substitution (CES) form

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

where ω is the weight households place on tradable consumption (C^T) and $(1-\omega)$ is the weight on non-tradable consumption (C^N). The elasticity of substitution of consumption between tradables and non-tradables is $1/(1+\mu)$.

Households receive labor income, rent capital to firms, and make investment decisions. In addition, the economy receives aid, a stochastic transfer of tradable goods, X_t. The budget constraint—in terms of tradable goods—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 non-tradables in terms of tradables (i.e., the real exchange rate), K_t is the economy's capital stock, i_t is investment, 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 $X_t = X \exp(\varepsilon_t^x)$ is a stochastic aid inflow given to the economy

[3] We are abstracting from the large literature on the implications of aid conditionality (Killick, 1997; Svensson, 2000; Mayer and Mourmouras, 2002). But such simplification is not entirely unrealistic: aid is provided by a number of uncoordinated donors with heterogeneous objectives, rendering the aggregate flow stochastic (Bulíř and Hamann, 2008).

each period. We assume investment is in the form of tradable goods, so that aid can be used directly for investment. Moreover we limit the set of financial assets of the country and assume is that it 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:

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

assuming a depreciation 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:

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

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

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 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 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):

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

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 $\nu = -1$.[4] 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 non-tradables, which in turn is equal to the marginal rate of substitution between tradables and non-tradables.

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

$$p_t^N = \left(\frac{1-\omega}{\omega}\right)\left(\frac{C_t^N}{C_t^T}\right)^{-(1+\eta)} \tag{9}$$

and

$$\frac{C_t^{-\sigma}}{p_t^C} = \beta E_t \frac{C_{t+1}^{-\sigma}}{p_{t+1}^C}\left(\frac{A^T \exp\left(\varepsilon_{t+1}^T\right)\alpha\left(K_{t+1}^T/L_{t+1}^T\right)^{\alpha-1}}{\kappa_1\left(K_{t+1}^T, K_{t+1}^N\right)} + 1 - \delta\right), \tag{10}$$

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

$$p^C = \left(\omega^{\frac{1}{1+\eta}} + (1-\omega)^{\frac{1}{1+\eta}}\left(p^N\right)^{\frac{\eta}{1+\eta}}\right)^{\frac{1+\eta}{\eta}}. \tag{11}$$

Eq. (9) equates the marginal rate of substitution between the consumption of tradable and non-tradable goods to the relative price, p^N, and Eq. (10) 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 market clearing conditions for the two sectors are:

$$C_t^N = Y_t^N \tag{12}$$

and

$$C_t^T + i_t = Y_t^T + X_t. \tag{13}$$

The relative price of non-tradables 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:

$$\begin{aligned} w_t &= A^T \exp\left(\varepsilon_t^T\right)(1-\alpha)\left(K_t^T/L_t^T\right)^{\alpha} \\ &= p_t^N A^N \exp\left(\varepsilon_t^N\right)(1-\eta)\left(K_t^N/L_t^N\right)^{\eta}, \end{aligned} \tag{14}$$

$$\begin{aligned} r_t &= \frac{A^T \exp\left(\varepsilon_t^T\right)\alpha\left(K_t^T/L_t^T\right)^{\alpha-1}}{\kappa_1\left(K_t^T, K_t^N\right)} \\ &= p_t^N \frac{A^N \exp\left(\varepsilon_t^N\right)\eta\left(K_t^N/L_t^N\right)^{\eta-1}}{\kappa_2\left(K_t^T, K_t^N\right)}. \end{aligned} \tag{15}$$

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 non-tradables, raising the economy-wide return to capital, that is, the equilibrium real rate of interest, r.

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.

[4] Introducing intertemporal equations with sector specific capital adjustment costs would not change the main implication of the model that capital is costly to move from one sector to another. We have chosen a simplified capital transformation cost schedule for computational convenience.

Table 1
Selected countries: business cycle statistics from 1990 to 2004

	Cote d'Ivoire	Ethiopia	Mozambique	Tanzania	Uganda	Madagascar	Sample average
Standard deviations							
GDP	11.53	8.94	5.52	1.66	3.63	7.62	6.48
Aid (in percent of GDP)	72.80	26.99	69.42	22.31	30.34	36.68	43.09
Non-tradable price	12.44	6.33	4.45	7.57	7.15	6.50	7.41
Consumption	11.66	6.38	2.13	3.77	3.99	2.17	5.02
Investment	32.54	18.13	23.49	4.87	10.55	16.97	17.76
Correlations with aid [a]							
Non-tradable price	0.23	−0.04	−0.07	−0.28	0.12	−0.18	−0.02
Consumption	0.45	−0.41	0.47	−0.33	−0.70	0.48	−0.01
Investment	−0.09	−0.23	−0.26	0.35	−0.46	0.39	−0.05
Memorandum items							
Aid (in percent of GDP, period average)	6.4	11.9	37.5	16.3	16.7	12.7	16.9
Population (in millions, end of period)	18.2	71.3	19.8	38.3	28.8	18.6	32.5

[a] All series are filtered with a linear trend.

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.

Having set up the problems for households and firm in our economy, we now define the competitive equilibrium of the economy:

Definition. *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 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, obtained by combining Eqs. (9) and (10) and taking logs. 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:

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

In addition to Eq. (16)—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, Eq. (9), 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. An increase in aid increases tradable 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 non-tradable sector. The solution of the model determines the portions of aid that 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.

The above problem can be represented by recursive planner problem where the allocations of consumption, capital, and labor are chosen to maximize the representative household utility subject to the feasibility constraints regarding market clearing and technology restrictions. For a given initial level of capital K and after observing the vector of shocks $\varepsilon=\{\varepsilon^X, \varepsilon^T, \varepsilon^N\}$, the planner maximizes the following value function:

$$V(K,\varepsilon) = \max_{\{C^T, C^N, C, K^T, K^N, L^T, L^N K'\}} \left\{\frac{C^{1-\sigma}}{(1-\sigma)} + \beta E V(K',\varepsilon)\right\}$$

subject to

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

$$C^T + K' - (1-\delta)K = A^T\exp\left(\varepsilon^T\right)K^{T\alpha}L^{T1-\alpha} + X\exp\left(\varepsilon^X\right)$$

$$C^N = A^N\exp\left(\varepsilon^N\right)K^{N\eta}L^{N1-\eta}$$

$$K = \left[K^{T^{-\nu}} + K^{N^{-\nu}}\right]^{-\frac{1}{\nu}}$$

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

The Appendix A describes in detail the computational algorithm used in solving the model.

3. Simulations and results

The numerical analysis starts from a baseline scenario in which the model is calibrated to replicate the key characteristics of Côte d'Ivoire. We have selected Côte d'Ivoire because it meets three criteria. First, it is a good example of a medium-sized, aid-dependent country (Table 1).[5] Second, its aid receipts as a share of GDP have been about one-third those of other sub-Saharan countries, so that doubling or tripling aid is a more relevant exercise in Côte d'Ivoire than elsewhere. Finally, owing to its administrative capacity, Côte d'Ivoire has historically produced higher-quality macroeconomic data than many other aid-receiving countries, with business-cycle properties corresponding to those in more developed countries.[6]

3.1. Côte d'Ivoire at a glance

Côte d'Ivoire, a former French colony located on the Gulf of Guinea, is a mid-sized country with population of 18 million in 2005 and average 1991–2005 *per capita* GDP of about US $1500 in PPP terms (Fig. 1 summarizes key economic indicators). Its long-term development has been derailed by two coups, in 1999 and 2001, and an ensuing civil war. Aggregate aid flows have been volatile, increasing from 2.5% of GDP during the 1980s to about 8% during the 1990s and falling sharply thereafter; the standard deviation during 1990–2002 is about 60% of the mean. Consistent with the Dutch disease hypothesis, non-tradable prices have increased rapidly relative to tradable prices and non-tradable output increased relative to tradable output. In the absence of other data, we approximate tradable output by output of the following sectors: agriculture (including fishing), mining, and manufacturing. The remainder of GDP is assumed to be non-tradable output. Tradable and non-tradable price indexes are derived from national account series in constant and current prices.

3.2. Calibration

The parameters in the benchmark model are calibrated to mimic the economy of Côte d'Ivoire as observed in 1990–2005 or taken from other studies. For the preference parameters, the elasticity of substitution between tradable and non-tradable consumption, $1/(1+\mu)$, is taken from Ostry and Reinhart (1992), who estimate a value of μ of 0.316 for a panel of 13 developing countries. The risk aversion coefficient σ is set to 5 (Reinhart and Végh, 1995), the time-preference parameter is set to 0.95, and the capital share of the tradable sector α is set to 0.3—all of which are standard values used in real-business-cycle studies for developing countries. The elasticity of substitution between capital used in the tradable and non-tradable sectors, $1/(1+\nu)$ is set -0.1 following Mendoza and Uribe (2000). The productivity of the tradable sector A^T is normalized to 1.

The stochastic structure of tradable and non-tradable productivity is assumed to evolve according to the same process, $\varepsilon_t^T=\varepsilon_t^N$. Aid and productivity shocks are assumed to be independent processes with a common autocorrelation coefficient of 0.9; this assumption of a standard value for the persistence parameter, rather than estimating it from the data, is necessitated by the short sample period. We discretize the shocks into discrete 2-point Markov chains.

The rest of the parameters are chosen to match observations for Côte d'Ivoire. The procedure is a non-linear calibration where 7 parameters are chosen to match 7 moments simultaneously in the stochastic model. The parameters are as follows: 1) weight of tradable consumption ω, 2) depreciation of capital δ, 3) productivity of the non-tradable sector A^N, 4) capital share in the non-tradable sector η, 5) the mean level of aid X, 6) standard deviation of productivity shocks, and 7) standard deviation of aid shocks. The moments that we match in the calibration are: 1) non-tradable output-to-GDP ratio of 61%, 2) investment-to-GDP ratio of 13%, 3) ratio of non-tradable output to tradable output of 155%, 4) standard deviation of investment of 0.325, 5) aid-to-GDP ratio of 6.4%, 6) standard deviation of GDP of 0.12, and 7) standard deviation of aid flows of 0.73. GDP is denominated in the data and the model as the sum of sectoral output in terms of tradable goods: $GDP=Y^T+p^N Y^N$. Table 2 summarizes all the parameters used in the calibration.

The calibration implies that the non-tradable sector is more capital intensive than the tradable sector. This can be rationalized on the basis of two observations: first, exporters in low-income countries typically specialize in labor-intensive, low-skill technologies (agriculture, footwear, apparel, and so on); and, second, most non-tradable 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.

Table 3 presents the statistics for the benchmark calibration of the model to the Ivorian data. The model is able to replicate successfully the seven target moments with the calibration process. Moreover, the model has an overall good fit with regard to other moments. The model matches the relatively higher volatility of tradable output relative to non-tradable output, although it overstates both volatilities. In the model, tradable output is more volatile because volatile investment needs are financed with tradable goods. In particular, higher tradable output volatility does not translate into higher volatility of consumption, which is as volatile as GDP, both in the model and in the data. The model produces a relatively high volatility of the relative price of non-tradables even under the assumption of perfectly correlated shocks. The relative price of non-tradables is determined by the ratio of the marginal utilities of tradable to non-tradable consumption. Given that shocks are perfectly correlated, the dynamics of the relative price are primarily determined by the

[5] Series were detrended using a linear trend; however, results obtained using first-difference and Hodrick–Prescott filters are not materially different. While volatility might be overstated with a univariate filter if the series contain structural breaks, computation of trend structural breaks as in Ben-David and Papell (1995) and Hausmann et al. (2005) is impossible to implement accurately in a short sample. On visual observation, we failed to detect breaks in real GDP series.

[6] In other sub-Saharan countries, macroeconomic time series have properties that cast doubt on their usefulness—for instance, consumption that is negatively correlated with aid (Ethiopia and Tanzania), or output growth that is implausibly stable (Tanzania).

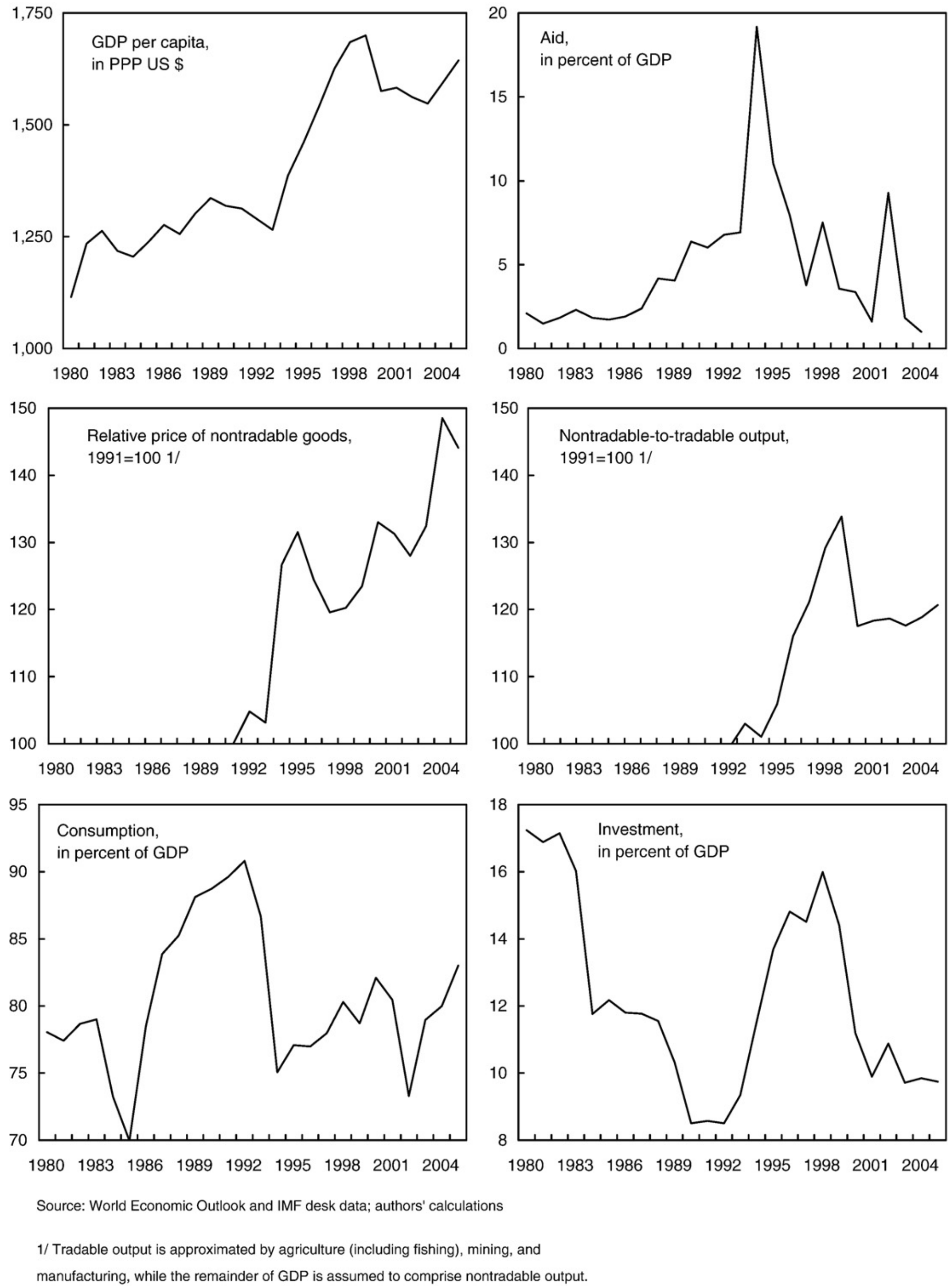


Fig. 1. Côte d'Ivoire: selected indicators, 1980–2005.

dynamics of investment and aid. For example, when a positive productivity shock hits the economy, tradable and non-tradable outputs increase. Non-tradable consumption cannot be adjusted but tradable consumption can be adjusted by altering investment. Thus tradable consumption increases by less than non-tradable consumption, which causes the relative price to increase. Aid inflows also influence the volatility of the relative price; when the economy receives a positive aid shock, tradable consumption rises and thus the relative price increases.

In terms of correlations with GDP, the model matches the positive correlations of consumption, investment, tradable and non-tradable output with GDP. The model fails to replicate the observed positive correlation between the relative price of non-tradable goods and GDP. However, as we explain below, aid shocks increase the correlation of GDP and the relative price of non-tradables, bringing the model results more closely in line with the data. The model matches well the correlation of aid with GDP, consumption, and the relative price of non-tradables.

The positive correlation between consumption and aid can be easily understood: an increase in aid directly increases tradable consumption. The increase in tradable consumption with higher aid is also the mechanism for the model to deliver a positive correlation between the relative price of non-tradables and aid inflows. Moreover, the model matches the mild procyclicality of aid in the data, even though the underlying productivity shocks and aid shocks are assumed to be uncorrelated.

3.3. Aid sensitivity analysis

In this part of the analysis, we focus on comparing the benchmark model, calibrated to Ivorian data and with an aid-to-GDP ratio of 6%, to hypothetical situations when the same economy would receive an average aid inflow equivalent to 0, 10, 15, and 20% of GDP. In particular, the only parameter we vary in these experiments relative to Table 2 is the mean level of aid X. This setting also provides a reference point for the analysis of the implications of shocks to productivity and aid, which will be developed subsequently.

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. Table 4 shows first and second moments for the series in our model computed for the four alternative levels of aid. The impact of aid changes the composition of output, labor shares, investment rates, and consumption, as well as the relative price of non-tradable goods.

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 declines from 13.4% to 11.4%, with aid rising from 0% of GDP to 20% of GDP, investment declines more sharply as a ratio to total income comprising GDP plus aid (from 13.4% to 9.4%). This result is robust to changes in the key parameters of the model; see Arellano and others (2005).

This finding reflects the logic of optimal consumption and investment behavior where the capital stock is determined by the expected marginal return on capital relative to the discounted expected consumption growth rate as in Eq. (14). Additional aid does not affect the dynamics of consumption, but simply shifts up the consumption level for all periods. Thus investment rates are not affected and most of 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. Still, production of non-tradables is relatively capital intensive and the rate of return on capital is higher than in the absence of aid, supporting investment.[7]

A second result, in line with the classical transfer problem, is that the relative price of non-tradables is higher in the case where aid inflows are higher. In the simulation results, aid equal to 20% of GDP is associated with a relative price of non-tradables almost 30% higher than in the absence of aid—i.e. a real appreciation.

Table 2
Calibration for the benchmark model

Parameter		Value
Time preference	β	0.95
Weight of tradable consumption in the consumption function	ω	0.26
Elasticity of substitution between tradable and non-tradable consumption	$1/(1+\mu)$	0.76
Depreciation rate	δ	0.05
Capital share in the tradable sector	α	0.30
Capital share in the non-tradable sector	η	0.50
Risk aversion coefficient	σ	5
Elasticity of substitution between capital used in the tradable and non-tradable sectors	$1/(1+\nu)$	−0.11
Productivity of tradable sector	A^T	1
Productivity of non-tradable sector	A^N	1.52
Standard deviation of productivity shocks	$\sigma_\varepsilon^T=\sigma_\varepsilon^N$	0.11
Aid, level	X	1.32
Aid, standard deviation	σ_ε^X	0.74

Table 3
Data and the benchmark model

	Ivorian data	Benchmark model
Means		
Tradable output-to-GDP[a]	0.3959	0.3993
Non-tradable output-to-GDP	0.6041	0.6007
Non-tradable-to-tradable output	1.5480	1.5188
Total consumption-to-GDP	0.8523	0.8700
Investment-to-GDP	0.1343	0.1300
Aid-to-GDP ratio	0.0642	0.0630
Standard deviations		
GDP	0.1153	0.1118
Aid	0.7280	0.7348
Relative price of non-tradables	0.1244	0.0461
Tradable output	0.1041	0.1504
Non-tradable output	0.0634	0.1178
Consumption	0.1166	0.1141
Investment	0.3254	0.3230
Labor in tradable sector	Not available	0.0651
Correlations with GDP		
Tradable output	0.9355	0.8732
Non-tradable output	0.3221	0.9934
Relative price of non-tradable goods	0.8658	−0.4165
Consumption	0.6197	0.9771
Investment	0.5656	0.6542
Correlations with aid		
GDP	0.1642	0.1964
Tradable output	0.0868	−0.1702
Non-tradable output	−0.0436	0.2320
Relative price of non-tradable goods	0.2286	0.5824
Consumption	0.4453	0.3064
Investment	−0.0866	0.3726

Source: IMF desk data; authors' calculations.
All series are filtered with a linear trend.
[a] Aggregate output is defined as GDP $=Y^T+p^NY^N$ equally in the data and the model.

[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 that uses that factor intensively.

Table 4
Aid sensitivity simulations

	Benchmark model	Aid in percent of GDP is equal to			
		0	10	15	20
Means					
Tradable output-to-GDP [a]	0.3993	0.4452	0.3701	0.3303	0.2879
Non-tradable output-to-GDP [a]	0.6007	0.5548	0.6299	0.6697	0.7121
Non-tradable-to-tradable output	1.5188	1.2525	1.7329	2.1195	2.7261
Relative price of non-tradables	0.4311	0.4030	0.4506	0.4813	0.5199
Tradable consumption-to-GDP	0.3319	0.3115	0.3443	0.3602	0.3759
Investment-to-GDP [a]	0.1300	0.1337	0.1271	0.1212	0.1142
Investment-to-total income [b]	0.1221	0.1337	0.1149	0.1045	0.0941
Capital-to-GDP [a]	2.8756	2.9667	2.8065	2.6829	2.5395
Tradable-to-non-tradable capital	0.9121	0.9295	0.9008	0.8847	0.8660
Tradable-to-non-tradable labor	0.9373	1.1291	0.8320	0.7068	0.5891
Aid-to-GDP ratio	0.0626	0.0000	0.1000	0.1500	0.2000
Standard deviations					
GDP	0.1118	0.1128	0.1138	0.1199	0.1367
Aid	0.7348	N/A	0.7349	0.7348	0.7349
Relative price of non-tradables	0.0461	0.0376	0.0593	0.0879	0.1222
Tradable output	0.1504	0.1461	0.1581	0.1869	0.2335
Non-tradable output	0.1178	0.1182	0.1205	0.1261	0.1368
Consumption	0.1141	0.1126	0.1197	0.1308	0.1493
Investment	0.3230	0.3107	0.3719	0.4710	0.5498
Labor in tradable sector	0.0651	0.0457	0.0922	0.1531	0.2390
Correlations with aid					
GDP	0.1964	N/A	0.2893	0.4793	0.6637
Tradable output	−0.1702	N/A	−0.3292	−0.5079	−0.6542
Non-tradable output	0.2320	N/A	0.3191	0.4574	0.5697
Relative price of non-tradables	0.5824	N/A	0.7674	0.8629	0.9060
Consumption	0.3064	N/A	0.4258	0.5936	0.7131
Investment	0.3726	N/A	0.4883	0.5293	0.5600

Source: Authors' calculations.
All series are filtered with a linear trend.
[a] Aggregate output is defined as $GDP = Y^T + p^N Y^N$ equally in the data and the model.
[b] Total income equals to GDP and aid.

This change can be viewed on both the demand and the cost side: aid increases the availability of tradables relative to non-tradables, 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 non-tradable production, thus increasing the relative cost of producing non-tradables.

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 about 45% of GDP in the steady state; its share shrinks to less than 30% of GDP when aid is equivalent to 20% of GDP. The relative decline of the tradable sector is linear: a 1 percentage point increase in aid is associated with about a 0.75 percentage point decline in the share of the tradable sector in GDP.[8] The relatively larger non-tradable sector is due to a higher labor share in this sector rather than a larger capital stock. The ratio of labor in the tradables to the non-tradables sector decreases from 1.13 without aid to 0.60 when aid is equivalent to 20% 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 tradable to the non-tradable sectors declines from 0.93 to 0.87 between the two poles of the aid continuum.[9] Although the size of the tradable sector decreases relative to GDP with higher aid, the consumption bundle of households shifts toward tradable goods, reflecting the increase in the relative price of non-tradables: tradables consumption increases from 31.2% of GDP to 37.6% of GDP.

A fourth result is that as aid increases, it becomes an increasingly dominant influence on economic developments in the model economy. For example, the correlation coefficient between aid and GDP increases to 0.6 when aid is equivalent to 20% of GDP relative to the 0.2 correlation in the benchmark model. We observe similar shifts along the aid continuum in the relationship between aid and tradable output (a stronger negative relationship) and non-tradable prices (a stronger positive relationship). Higher aid levels can also rationalize a positive relationship observed in the data between non-tradable prices and GDP because higher aid levels increase both variables. The correlation between GDP and the non-tradable relative price when aid inflows are on average 20% of GDP is equal to 0.4 (as compared to –0.7 with aid equal to 0% of GDP). Higher aid inflows also increase the volatility of all variables in the economy. Consumption volatility increases from 11% to 15% relative to the benchmark model when aid flows are increased to 20% of GDP. Investment and aggregate output also become much more volatile with higher aid flows. Finally, the relative price of non-tradables is three times as volatile (12% compared with 4%) when aid flows are 20% of GDP relative to the benchmark. Our results show that aid volatility is especially costly for economies that receive large aid inflows.

While these results are in line with the static model findings, we observe some new features. 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 increase in aid-induced investment. Higher and volatile aid flows introduce large volatility in the economy in terms of consumption, investment and real exchange rates. Finally, Dutch disease—real depreciation and the decline in tradable output—grows stronger with higher aid.

3.4. Welfare implications

In this section, we use the calibrated model to examine the welfare implications of aid volatility. As a starting point, we

[8] The shrinkage of the tradable sector with larger aid could have larger effects on the economy in a more sophisticated framework in which tradables production generates learning-by-doing externalities.

[9] Given the assumption that non-tradables 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.

consider the implications of a counterfactual case in which the variance of the aid shock is zero, and compare these results to those for the benchmark economy, keeping all parameters as in Table 2.

The results for this experiment are presented in the second column of Table 5. As is typically found in standard real business cycle models, even in the absence of aid shocks there is substantial variability in investment and in aggregate output, associated with productivity shocks. Consumption also displays large fluctuations due to the inability of households to insure against fluctuations, due to limited financial integration with the global market (see Mendoza, 1997; Pallage and Robe, 2003; Turnovsky and Chattopadhyay, 2003). The capital stock is not a very good insurance instrument because its return co-varies strongly with the aggregate consumption of the representative household. In summary, we find that the large productivity fluctuations typical of aid-dependent countries such as Côte d'Ivoire introduce high volatility in all macroeconomic aggregates, even in the absence of aid volatility. However, in this framework, aid volatility further exacerbates macroeconomic fluctuations. Another counterfactual case in which productivity shocks are zero but aid volatility is at the baseline level is shown in the third column of Table 5; this case is discussed in greater detail in an earlier version of this paper, Arellano et al. (2005).

Table 5
The benchmark model and shocks to aid and GDP

	Benchmark model	TFP shocks only	Aid shocks only
Standard deviations			
GDP	0.1118	0.1092	0.0249
Aid	0.7348	0.0000	0.7349
Relative price of non-tradables	0.0461	0.0362	0.0401
Tradable output	0.1504	0.1485	0.0419
Non-tradable output	0.1178	0.1140	0.0303
Tradable consumption	0.1107	0.0985	0.0607
CES consumption	0.1141	0.1080	0.0411
Investment	0.3230	0.2631	0.0518
Labor in tradable sector	0.0651	0.0491	0.0575
Correlations with GDP			
Tradable output	0.8732	0.9469	−0.9994
Non-tradable output	0.9934	0.9954	0.9999
Relative price of non-tradable goods	−0.4165	−0.7086	0.9995
Consumption	0.9771	0.9859	1.0000
Investment	0.6542	0.6987	0.2506
Correlations with aid			
GDP	0.1964	…	0.9812
Tradable output	−0.1702	…	−0.9873
Non-tradable output	0.2320	…	0.9795
Relative price of non-tradable goods	0.5824	…	0.9867
Consumption	0.3064	…	0.9816
Investment	0.3726	…	0.4321

Source: IMF desk data; authors' calculations.
All series are filtered with a linear trend.
Aggregate output is defined as $\text{GDP}=Y^T+p^N Y^N$.

The next step is to examine the welfare implications of aid volatility, and explore how an alternative time path of aid disbursements could help ameliorate these costs. Our welfare calculation is identical to that of Lucas (1987), who estimated welfare cost as 1/2 times the risk aversion coefficient (σ) times the difference in the variance of CES consumption. Consumption volatility also affects the optimal capital stock. It is well known that, in the long run, the capital stock is larger with higher volatility; a higher capital stock is beneficial, but the transition is costly because households need to save to accumulate capital. Thus, we base our welfare calculations solely on consumption volatility, ignoring changes in the capital stock.

The estimated welfare costs of volatility for these economies are higher than has been estimated in previous studies of business cycles in developing countries, because of the higher volatility characteristic of aid-dependent countries. The welfare benefit of reducing aid volatility to zero would be 0.4% of consumption. Delivering aid in such a way as to insure households against the effects of productivity shocks on consumption would provide welfare benefits equivalent to 3.3% of CES consumption.[10] The welfare benefits for the average country of delivering aid in such a way as to insure against consumption volatility in Table 1 remain high and equal to 0.6% of consumption.

These estimated welfare effects are very large: as one reference point, they far exceed estimates in the literature for the welfare costs of business cycles in industrial countries (0.1 and 0.3% of annual U.S. consumption for the post-war period in the United States, as reported in İmrohoroğlu, 1989). The magnitude of these estimates reflects the fact that they are calibrated to actual data on output and investment volatility which is very large, as well as the limited ability of households in low-income countries to insure internationally.

As a related question, we can also ask what level of aid would render households indifferent, in terms of utility, between an environment of volatile aid and one where aid is stable or is aimed at smoothing productivity shocks. First, if donors delivered aid in a stable manner, they could reduce aid by 8% while maintaining the same level of well-being for citizens of aid-receiving countries; or, to put it another way, reducing aid volatility could be equivalent to a commensurate increase in aid provided. Second, if aid could be delivered in such a way as to insure fully against productivity shocks, donors could reduce aid inflows by 64% without reducing the present level of welfare.[11] These results suggest that the benefits of providing aid in such a way as to insure the recipients against other shocks could be equivalent to a very dramatic increase in aid.[12]

[10] These welfare costs would be amplified with a utility specification that incorporates a minimum consumption level which is relevant for low-income countries where households maintain levels of consumption close to survival (Burnside and Dollar, 2000).

[11] These figures are considerably larger than those reported in an earlier version of the paper (Arellano et al., 2005), reflecting the fact that, in the present version, consumption and investment volatility are being calibrated to a lower figure consistent with actual Ivorian data.

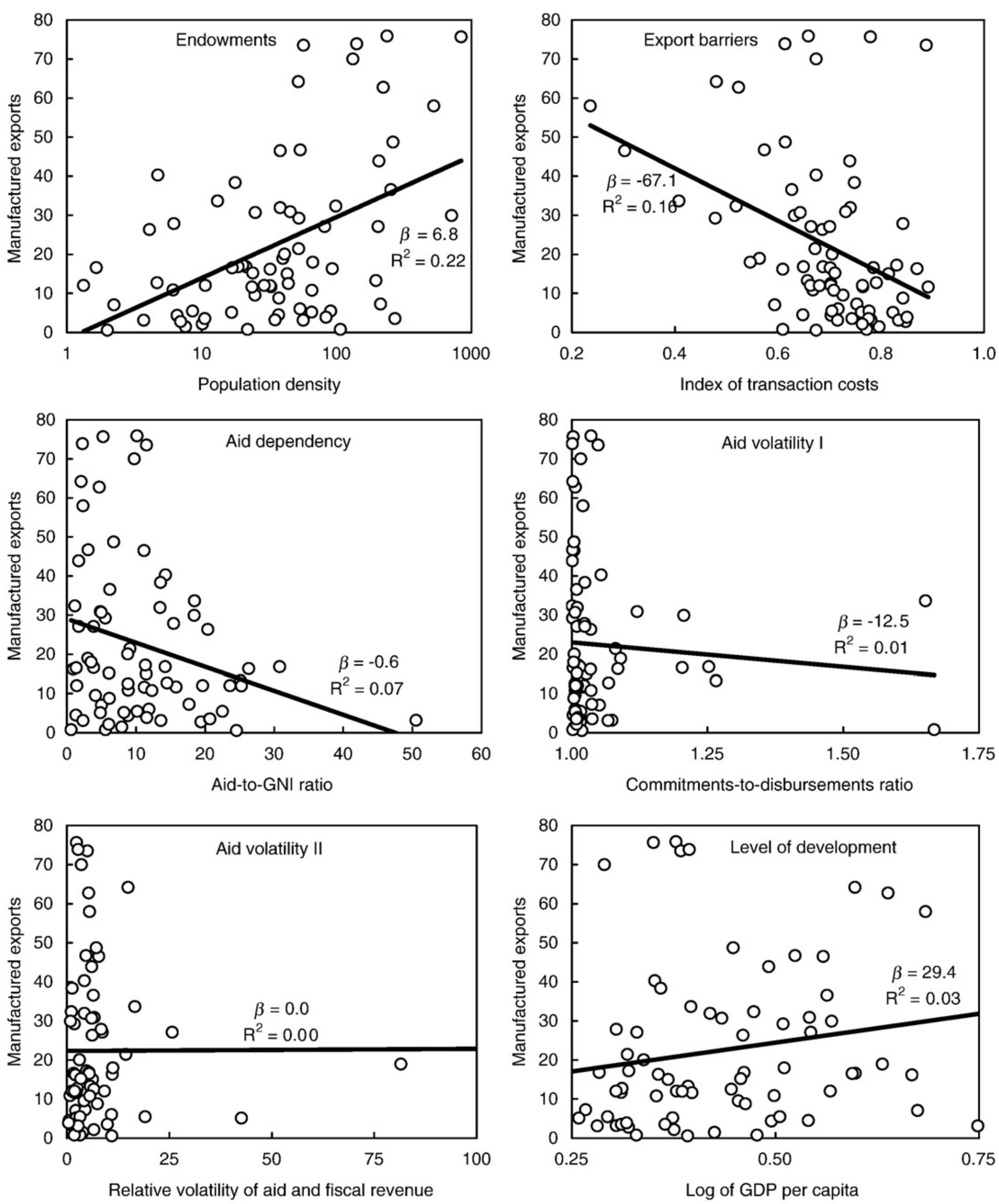
[12] The possible use of countercyclical aid to insure low-income countries against economic fluctuations is explored by Pallage et al. (2007).

4. Empirical results: does aid lower tradable output?

In the theoretical section, we have shown that aid lowers tradable goods output substantially. 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 manufactured exports and that aid volatility also plays a negative role, although the latter results are not robust.

4.1. 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 non-tradable goods has become increasingly ambiguous. On the other hand, even clearly tradable goods are not homogeneous: some notionally tradable commodities



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

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

Fig. 2. Determinants of exports of manufactured goods, 1981–2000 1/ (period averages; 73 low-income countries).

Table 6
Definition of variables and their sample moments

Variable notation	Definition	Source [a]	Mean	Standard deviation [b]
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

All descriptive statistics refer to the mean for the full sample period, 1981–2000.
[a] WDI stands for *World Development Indicators* and WEO stands for the *World Economic Outlook*.
[b] In percent of the mean.

are not traded externally because of their quality, price, or producer location.[13] Moreover, the valuation of tradables in domestic currency terms is often complicated by the volatility of the exchange rate in developing countries and national accounts data are generally of inferior quality to international trade data. Thus, rather than approximating tradables by agriculture, mining, and manufacturing, as with the Ivorian data used in the calibrations of the previous section—we could not collect this information for many low-income countries—we measure tradable goods by manufactured exports.

Empirical research on the structure of production in developing countries has 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 check the robustness of our results, we estimated the impact of aid on two other dependent variables: value added in the merchandise sector as a percentage of GDP and non-mining exports as a percentage of total exports, finding that the impact of aid remained statistically significant.[14]

In assessing manufactured export performance (Fig. 2), 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 important determinants of exports (Wood and Berge, 1997; 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; we present results for two of them. First, the volatility of aid can be compared with donor commitments of aid. A higher ratio of commitments to disbursements (denoted as aid volatility I in Table 6) 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 detrended aid to domestic revenue (denoted as aid volatility II in Table 6) is an obvious benchmark as aid receipts supplement domestic fiscal revenue (Bulíř and Hamann, 2003). Hence, while the first measure can be related to the notion of aid predictability, the second measure relates aid volatility to the macroeconomic volatility more generally. 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, the previous variables normalized by the level of GDP, and

[13] 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.
[14] Results available from authors on request.

Table 7
Matrix of correlation coefficients

	Non-mining 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
Non-mining 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.
All descriptive statistics refer to the full sample period, 1981–2000.

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, 2008). 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 completely eliminated, by using 10- and 20-year averages.

4.2. Regression results

We regressed exports of manufactured goods as a share of total exports on a vector of variables that characterize the effects of the endowment, transaction costs, and aid, and a host of control variables. Table 6 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,[15] 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,[16] 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 7. 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.

We estimated our regression equations by ordinary least squares (OLS) with heteroskedasticity-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) (Table 8). The reasons for using GMM are twofold (Wooldridge, 2001): first, variables measured with error tend to have a 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. The last instrument suggests that aid shocks are propagated by investment instability. 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% of the variance of the dependent variable in levels and around 20% of the variance of the variable in first differences. All equations in levels are statistically significant at the 1% level.

The results are intuitively plausible. The regression estimates are consistent with the idea that endowment and transaction costs are relevant variables influencing exports. Densely-populated countries and those with lower transaction costs tend to have a higher share of manufactured exports in total exports. Of the control 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. 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 regressions. Arguably, the link between domestic spending on education and aid, which donors began to stress in the 1990s, may

[15] 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.

[16] 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 with aid.

Table 8
Aid, endowment, transaction cost, and manufactured exports

	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	−0.455	−0.748	−0.401	−0.701	−0.714	−1.146	−0.542	−0.634	−0.481	−0.539	−0.354	−0.377
Ratio	(2.21)**	(3.00)***	(2.43)**	(3.57)***	(2.41)**	(4.00)***	(3.79)***	(3.11)***	(2.36)**	(3.16)***	(1.73)*	(2.00)**
Aid	−13.34			−24.88			−24.23			−13.58		
Volatility I	(2.70)***			(3.43)***			(2.12)**			(1.72)*		
Aid		−0.008	−0.085		−0.014	−0.079		−0.012	−0.081		−0.003	−0.012
Volatility II		(0.65)	(1.76)*		(0.84)	(1.33)		(1.42)	(1.73)*		(0.17)	(0.51)
Population	0.065	0.024	0.058	0.025	0.031	0.027	0.054	0.052	0.058	0.008	0.009	0.003
Density	(7.74)***	(0.96)	(5.87)***	(1.00)	(1.46)	(1.09)	(5.00)***	(3.75)***	(5.83)***	(1.04)	(0.62)	(0.20)
Transaction	−58.51	−39.88	−60.09	−37.44	−70.09	−60.46	−55.87	−65.09	−64.46	−15.87	−26.69	−28.14
Cost	(3.67)***	(1.99)**	(3.61)***	(1.99)**	(3.12)***	(3.03)***	(3.18)***	(4.04)***	(4.06)***	(1.36)	(2.03)**	(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

Dependent variable=Manufacturing exports-to-total exports, in percent.
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%, 5%, and 1%, respectively.

be too short-lived to show any impact on manufactured good exports in our sample.

The regression estimates also indicate a strong negative relationship between the level of aid and exports, consistent with the theoretical model developed above. Countries receiving aid of 1 percentage point of GDP above the mean have manufactured exports 0.4–1 percentage points of total exports below the mean. 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 0.3–0.5 percentage points 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 inclusion of controlling variables and estimation techniques.

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. Even this result disappears when two outliers with very high ratios of commitments to disbursements—Bhutan and Liberia—are excluded from the regression (see Fig. 2). While the point estimate remains negative, it becomes statistically insignificant. 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. 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 0.13–0.25 percentage points of total exports (Aid volatility I) and the estimated impact was insignificant for Aid volatility II.

What is the quantitative contribution of the various effects to manufactured good exports in our regressions? These contributions are estimated as a product of the regression coefficient of the explanatory variable and its standard deviation (Table 9). 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 2.5 percentage points and 6.5 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 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 our theoretical model: large aid is associated with substantially lower manufacturing exports while the impact of aid volatility on tradable output is small or insignificant, or both.

5. Conclusions

This paper has examined the effects of aid on consumption and investment and on the structure of production in the context

Table 9
Sensitivity analysis: how important are the individual contributing factors?

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

The calculations are based on the coefficients from the relevant equations of the 1981–2000 sample period. We multiply the estimated coefficients from Table 8 with the relevant sample standard deviations from Table 6; the lower and upper bounds are defined as one standard error of the parameter estimate.

of an intertemporal two-sector general equilibrium model, calibrated using data for Côte d'Ivoire. 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 non-tradable goods 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 non-tradables, 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 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 in volatile consumption. Thus, even when aid shocks are transitory, these shocks 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 and costly insurance instrument.

Finally, the results in the paper suggest that the welfare implications of aid variability are potentially very large. These effects of aid variability attenuate the welfare benefits of receiving aid. In the model calibrated to Ivorian data, eliminating aid volatility would have benefits equivalent to 8% of total aid. Delivering aid in a manner that insures consumption against volatility shocks would have much larger benefits, equivalent to 64% of total aid. The results in this paper thus provide a strong motivation for efforts to make aid more stable and predictable—or better yet, tailor the provision of aid to insure recipients against other sources of macroeconomic volatility.

Appendix A. Numerical algorithm

We use the following algorithm to compute the model:

1. We choose parameters and discretize the capital space into 200 grid points and shocks into 2 values each.
2. For every possible value of the shock ε and capital today, K, we solve the equilibrium choices of $\{C^T, C^N, K^T, K^N, L^T, L^N, p^N\}$ for every candidate level of the capital state tomorrow, K', such that the following seven conditions are satisfied:

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

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

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

$$C^T + K' - (1-\delta)K = A^T \exp(\varepsilon^T) K^{T\alpha} L^{T1-\alpha} + X \exp(\varepsilon^X)$$

$$C^N = A^N \exp(\varepsilon^N) K^{N\eta} L^{N1-\eta}$$

$$K = \left[K^{T^{-v}} + K^{N^{-v}}\right]^{-\frac{1}{v}}$$

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

3. Then, given the allocations, we calculate optimal aggregate consumption for the candidate solution $C(K,\varepsilon,K')$ and find optimal consumption through value function iteration.

$$V(K,\varepsilon) = \max_{\{C\}} \left\{ \frac{C(K,\varepsilon,K')^{1-\sigma}}{(1-\sigma)} + \beta E V(K',\varepsilon) \right\}.$$

4. We compute business cycles statistics and compare them with the model. If statistics are close enough we stop, otherwise we return to step 1 and repeat the procedure.

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

Table A1 (*continued*)

Country	Country
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	

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