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How Macroeconomic Instability Lowers Child Survival

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Abstract

The reduction of child mortality is one of the most universally accepted Millennium Goals. However, there is a significant debate on the means of reaching it and its realism with regard to the situation in most of the least developed countries. The recommendations made for the achievement of this goal are mainly medical ones. However, without underestimating the importance of these measures, in particular vaccinations, it seems increasingly obvious that the rate of reduction of child mortality is mainly determined by the evolution of macroeconomic environment. The influence of per capita income level on mortality is frequently underlined.

But a given income growth does not have the same effect on child survival if it is stable or unstable. Indeed, rises and falls of income probably have asymmetrical effects on mortality. The purpose of this analysis is precisely to show how macroeconomic instability influences the evolution of child mortality. The analysis is based on a panel

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sample of 97 developing countries over the period 1980-1999. The effect of exogenous shocks is first examined through a variable of income instability. The study of the relation is then deepened with 'primary instabilities': instability of world agricultural commodity prices, instability of exports of goods and services and instability of agricultural production.

1   Introduction

The reduction of under-five mortality is one of the most universally accepted Millennium Goals. Yet a significant debate appeared regarding the means of reaching it and its realism with respect to most of African countries (Sahn and Stifel 2003). The measures recommended for the achievement of this objective are mainly medical ones (Sachs 2002). However, without underestimating the importance of these measures, vaccinations in particular, it seems obvious that the reduction rate of child mortality is mainly determined by the evolution of macroeconomic environment (see Grigoriou 2005 for an overview of recent quantitative work on the determinants of under-five mortality).

The influence of per capita income level on mortality is frequently underlined. However, the same income growth does not have the same effect on child survival if it is stable or unstable. Here we assume that income rises and falls have asymmetrical effects on mortality. The goal of this analysis is thus to show how macroeconomic instability influences the evolution of under-five mortality. As income instability is itself mainly determined by exogenous factors of instability, such as world price or climatic instabilities, also defined as 'primary instabilities' (Guillaumont, Guillaumont Jeanneney and Brun 1999), we are also particularly interested in their impact on child survival.

Naturally, the analysis of the impact of instabilities on under-five mortality implies an accurate identification of the channels through which instabilities act. One of them is the effect on economic growth, which is itself a significant factor of lower mortality. But beyond this channel, which is based on a well-established literature, there are two other channels. We assume that they result either from the impact of instabilities on the evolution of income distribution for a given growth, or, more directly, from irreversible effects of negative shocks on mortality. Thus, since under-five mortality represents the most reliable and universal indicator of poverty, it enables to capture a general impact of instabilities on poverty.

Using the GMM system estimator on a panel sample of 97 developing countries covering four five-year periods from 1980 to 1999, we first examine the effect of exogenous shocks through income instability. We then explore more deeply the relation through primary instabilities: world agricultural commodity price instability, instability of exports of goods and services, and instability of agricultural production. Section 2 examines how instabilities affect child survival. Methodology and data are presented in section 3. Section 4 displays the results. Finally, section 5 concludes.

2   Three ways that instabilities affect child survival

Negative shocks on income, or political shocks, are likely to involve mortality rises, as is explained in various studies (Gakusi, Garenne and Gaullier 2005; Cornia and Paniccià 2000; Shkolnikov et al. 1998). Here, we are interested in the rarely studied effect of instability, i.e., the effect of the succession of positive and negative shocks. Instability thus defined (instability of income, exports, terms of trade, climate, etc.) generally has two types of effects: ex ante risk effects, and ex post asymmetry effects due to different responses to falls and rises of income, exports, etc. (Guillaumont 2006). Asymmetry effects are easier to highlight and, as their impact on mortality, are probably prevailing.

This is what we hypothesize in examining the three main channels through which instabilities affect child survival.

2.1 Effect resulting from a lower growth

Developing countries are often characterized by strong macroeconomic instability. This observation has led to a significant literature on the relation between instabilities and growth (for an overview, see Guillaumont 2006). Many works have tested either the negative effect of income growth instability (Ramey and Ramey 1995; Hnatkovska and Loayza 2005; Norrbin and Yigit 2005), or the effect of 'primary instabilities' (export, climatic, terms of trade instabilities) on income growth (for a simultaneous treatment of several instabilities, see for example Guillaumont, Guillaumont Jeanneney and Brun 1999). The most abundant and oldest stream of literature refers to the effects of export instability. In these various works, the authors either assume an effect of instability through uncertainty and innovation, or asymmetric responses to positive and negative shocks.[1] Moreover, several of these works examine the factors conditioning the impact of instabilities on growth through interactive variables (see Hnatkovska and Loayza 2005 for institutions quality, financial depth and trade openness; Guillaumont 1994; Combes and Guillaumont 2002 for openness policy).

Since instabilities have an effect on the average income level, they must influence mortality through this channel. The relation between average income level and mortality indicators has been studied for a long time (Preston 1975), and in many works. The existence of the relation between average income level and child survival rate is not questioned, but its functional form has been recently discussed (Grigoriou 2005): taking into account the bounded character of child survival, the logistic form is preferred to the logarithmic one that is traditionally used.

In this study, we focus on the effects of instability that do not result from a lower average income. We do not revisit the relation between instability and income growth and thus we do not need to consider the relation between average income and mortality. Nevertheless, we will see that the functional form of the relation between average income and mortality has implications concerning the effects of instability on mortality.

2.2 Effect resulting from a lower contribution of growth to poverty reduction

While there are many works relating to the effects of income growth on poverty (Ravallion and Chen 1997; Dollar and Kraay 2002; Bourguignon 2003; Adams 2004), only a few deal with the effects of income instability on poverty (and consequently on mortality). Even though the effect of shocks on poverty is considered often in the literature, particularly in microeconomic literature, the relation between income instability and poverty reduction for a given growth has rarely been tested directly (see, however, Guillaumont 2006; Guillaumont and Korachais 2006). It is indeed reasonable to assume that for a given income growth, instability affects the poverty level, measured either by its incidence, or by its depth: instability has permanent asymmetrical effects on the living conditions of the poor (people below the poverty line) and the 'almost poor' (people close to the poverty line). The poor and 'almost poor' are particularly exposed
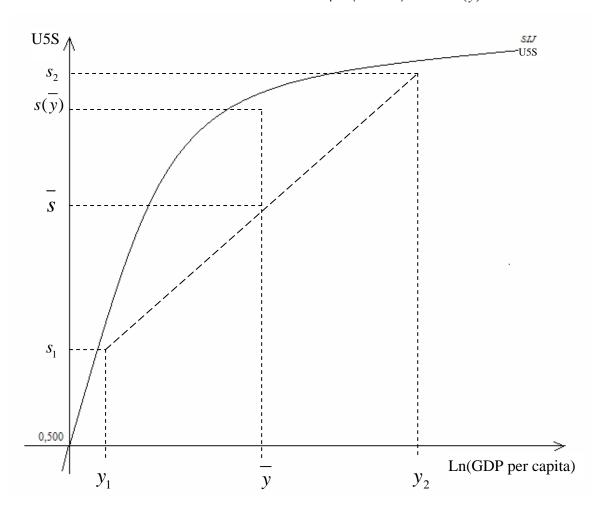
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[1] Note that the assumption of asymmetry is more particularly used in the analysis of the effects of primary instabilities.

to negative shocks, the effects of which are not compensated by positive ones. Macroeconomic instability can thus affect the standard of living of the poorest without modifying the average income level. For instance, parents' decisions regarding their children's school attendance, loss of human capital associated to layoff or to productive assets liquidation are asymmetrical in that sense they are not easily reversible. This idea is directly inherited from the microeconomic literature on the poverty trap, which is difficult to escape because of microeconomic and macroeconomic conditions.

Since instability influences income distribution, it has an effect on poverty that does not pass through to the average income level. This complex and changing effect has been the subject of some rare cross-country econometric analyses (Breen and Garcia-Peñalosa 2005; Laursen and Mahajan 2005). Referring to microeconomic results (see, for example, Dercon 2006), Agénor (2002) as well as Laursen and Mahajan (2005) examine the main reasons why the poor are more vulnerable than the non-poor: the poor have few sources to diversity income; they are poorly qualified and less mobile between sectors and areas; they have limited access to credit and insurance markets and they depend more on public transfers and social services. However, analyses of the instability effects among income groups show that the next to last quintile—instead of the last one—appears to be the most severely affected. That is why we can assume that the 'almost poor may become 'durably poor' under unstable conditions.

Figure 1
The survival level associated with an equal (stable) income is higher
than the survival level associated with an unequal (unstable) income: $s(\bar{y}) > \bar{s}$

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The effect of instabilities on income distribution and monetary poverty is likely to have consequences on mortality insofar as the survival function of each country is concave: since instability makes income distribution more unequal, it is likely to cause an increase in average mortality for a given average income level. Indeed, it has been shown that the relationship between child survival and income should be logistic (which means first convex then concave). But, as child survival is above 500 per thousand in all countries, this amounts to saying that we study only the concave part of the relationship. That involves a negative effect of inequality on survival, for a given average income level (Figure 1). It should be noted that the effect of instability on income distribution mainly occurs in the medium or long term.

2.3 A direct asymmetry effect or irreversibility effect

Macroeconomic instability can affect child survival without necessarily modifying either the average income level or its distribution. Indeed, negative economic shocks can have negative effects on child health, which cannot be compensated by a subsequent positive shock. Sharp falls in income involve rises in child mortality due to the deterioration of physical or mental health. This deterioration can come from a reduction in the access to food, drugs or medical care, or from suddenly unhealthier living conditions. This was the case under acute circumstances such as famines (Sen 1983) or the transition of some former Soviet Union countries (Cornia and Paniccià 2000), but is also likely to occur in less critical situations, in particular among poor people. Moreover, health deterioration leads to rises in child mortality that cannot be compensated by a positive shock: when economic conditions change and become more favourable, child mortality does not decrease sufficiently to ensure compensation. This effect is perceptible in the short term (covering the duration of a two-phase cycle), but the deterioration of child health can also have irreversible effects on child mortality in the longer term.

This effect, too, follows from the concavity of the survival function: for a given average income level, the average survival level is higher if income is stable than if unstable. Here, we refer again to Figure 1. However the 'distribution effect' differs from the irreversibility effect. First, as it is less direct, the 'distribution effect' resulting from instability may be lower than the irreversibility effect. Second, the direct effect of irreversibility is rather short term, whereas the effects that are likely to modify income distribution mainly work on a longer term.

We must also examine the implications of the change in concavity with the average income level: for a survival rate higher than 500 per thousand, concavity first increases then decreases, tending to disappear.[2] As a result, the irreversibility effect of instability on survival successively increases, then decreases with the average income level, and the maximum is reached when the third derivative of the survival function is null. However, this point is reached for an extremely low level of income, so that the countries of the sample are all located beyond this point. Thus, the direct effect of instability is expected to be decreasing on our sample (Figure 2), i.e., it is likely to be higher in the low-income countries than in other countries (see section 4 for details).

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[2] Null at the inflection point located at 500 per thousand, the second derivative of the survival function is then negative. Moreover, on this interval, it is first decreasing then increasing.

When we consider the relation over several periods, we must also take into account that the fact that the relation varies over time: the curve moves up because of technical progress, i.e., the improvement and dissemination of knowledge. Since the function is logistic, this curve's movement implies a stronger concavity. The result is that the more significant the technical progress, the stronger is the effect of the instability on the average survival level, and the greater the decline of this effect with the increase in the average income level.

Thus, macroeconomic instability can reduce under-five survival in three ways: reducing the average income growth and making it more unequal—these two indirect effects contribute to a lower reduction of child mortality—but also by directly increasing child mortality by an irreversible manner, when the living conditions of the poor temporarily worsen.
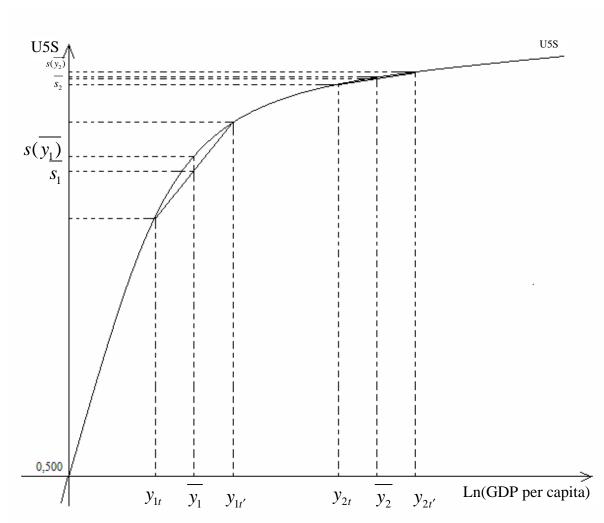
Figure 2
Instability is likely to be higher in low-income countries

The survival level associated to a stable income is higher than the survival level associated to an unstable income, and all the more so as the average income is weak (as long as we are located in the zone where concavity decreases).

3 Methodology

3.1 Definitions of the variable to be estimated and the variable of interest

Since the under-five survival indicator is limited asymptotically, and an increase in this indicator does not represent the same performance when its initial level is weak or high, the best functional form to examine is that where the variable is expressed as a logit, as Grigoriou (2005) underlined (Figure 3). We choose the under-five survival indicator (U5S) in preference to the under-five mortality indicator (U5M), so that an increase in the indicator reflects an improvement, that is to say:

$$S = \text{logit U5S} = \ln\left(\frac{\text{U5S}}{1\text{-U5S}}\right) = \ln(\text{U5S}) - \ln(\text{U5M})$$

where U5M is the under-five mortality rate ranging between 0 and 1 and U5S = 1 – U5M.

The under-five survival indicator is extracted from the under-five mortality data of the Demographic Health Surveys supplemented by the estimates of the World Health Organization (Ahmad, Lopez and Inoue 2000). This database corresponds to the most recent update, complete and homogeneous of the various works already carried out by the UNICEF, the World Bank and the United Nations, since it provides estimates of the average under-five mortality rate, over five-year periods between 1955 and 1999, for 171 of the 191 member states of the World Health Organization.
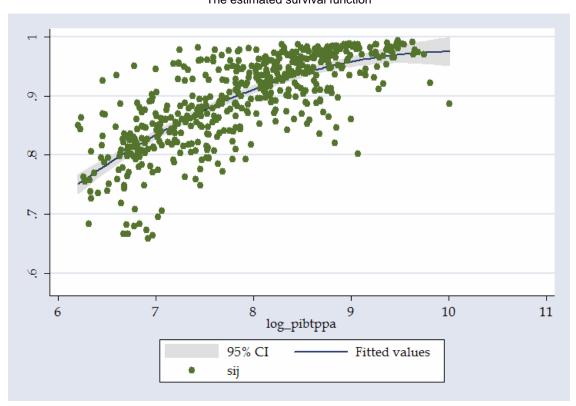
Figure 3
The estimated survival function

Source: Authors' calculations.

The instability of a variable is always measured relative to a reference value. It is often measured by the standard deviation of the growth rate, i.e., relative to the average growth rate. But measuring the deviation from the trend is preferred. The problem then lies in the choice of this trend value. Insofar as the series may be neither purely deterministic, nor purely stochastic, the reference value can be estimated from a mixed adjustment, concurrently combining a deterministic element and a stochastic element (method used in various works of the CERDI and chosen by the Committee for Development Policy (United Nations) for the measurement of the economic vulnerability index). The indicator thus selected is the average of the quadratic deviation relative to the mixed trend.[3]

$$Ins_{quadra} = 100 \sqrt{\frac{1}{n+1} \sum_{k=0}^{n} \left(\frac{Y_{t+k} - \hat{Y}_{t+k}}{\hat{Y}_{t+k}} \right)^2}$$

where $\hat{Y}_t = \exp(\ln Y_t')$ and $\ln Y_t' = \hat{a} + \hat{b}.\ln Y_{t-1} + \hat{c}.t$

3.2 The model

The relation between income instability and under-five survival

The model that allows us to test the effect of income instability on under-five survival while controlling for the average income level is as follows:

$$S_{it} = \alpha_0 + \alpha_1.Ins_{it} + \alpha_2.y_{it} + \alpha_3.X_{it} + \mu_i + \eta_{it} \tag{1}$$

where S_{it} is the logit of the under-five survival rate over a five-year period, y_{it} is the average per capita income over the period expressed in logarithms, X_{it} is a vector of control variables such as the importance of vaccinations or women's education (expressed in logarithms), μ_i represents country-specific effects and η_{it} is the error term. Here, income instability (Ins_{it}) influences the average child survival rate, independently of the average income level.

We first choose to measure the instability of per capita income over the same period *t*. This 'present instability' is measured with regard to a four-decade mixed trend (1960-2000) as explained above. Then, we also measure instability over the previous period, in order to capture the effects likely to act on a longer term (in particular, some effects likely to modify income distribution). 'Past instability' captures the effect of shocks occurring between 1975 and 1979 on child survival during the period 1980-84, between 1980 and 1984 on child survival during period 1985-89, and so on. Finally, we use a measure of instability covering twelve years, i.e., both the past and present periods. In other words, 'overall instability' takes into account shocks occurring between 1972 and 1984 for period 1980-84, between 1977 and 1989 for period 1985-89, and so on.

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[3]   This measurement seems to be best adapted to our study. However, tests of robustness have been carried out with alternative measurements such as the standard deviation of the annual growth rate and

the average of the absolute deviation relative to the mixed trend: $Ins_{absolu} = \frac{100}{n+1} \sum_{k=0}^{n} \frac{\left| Y_{t+k} - \hat{Y}_{t+k} \right|}{\hat{Y}_{t+k}}$

The relation between primary instabilities and under-five survival

We also analyse the effect of primary instabilities on child survival because we assume they are the main sources of income instability. As low-income countries are often characterized by a significant share of primary commodities in their exports and by strong exposure to natural disasters, the incidence of instability in global agricultural commodity prices and climatic shocks is hypothesized to be higher in these countries than in the developed nations (IMF 2003). In order to test the effect of primary instabilities, we introduce successively into the model the instability of exports of goods and services in constant dollars (in this sense, exports measure is a 'volume' measure), the instability of agricultural production per capita (which often refers to climatic instability), and the instability of world agricultural commodity prices.[4] The econometric models, which allow us to test the effects of primary instabilities on child survival for a given income level, are similar to the previous model.

3.3 Data, variables, and sample

The econometric analysis is based on a panel of 97 developing countries over the periods 1980-84, 1985-89, 1990-94 and 1995-99. Table 1 displays the composition of the sample. In order to control for the country-specific effects, the potential endogeneity of the regressors and the omitted variable bias, we use the *GMM system* estimator.

Table 1
Composition of the sample

*	Algeria		Eritrea	*	Mozambique
	Angola		Ethiopia		Namibia
*	Argentina	*	Fiji	*	Nepal
*	Bangladesh		Gabon	*	Nicaragua
	Belize	*	Gambia	*	Niger
*	Benin	*	Ghana		Nigeria
*	Bolivia	*	Guatemala		Oman
*	Botswana		Guinea	*	Pakistan
*	Brazil		Guinea-Bissau	*	Papua New Guinea
	Burkina Faso	*	Guyana	*	Paraguay
*	Burundi	*	Haiti	*	Peru
	Cambodia	*	Honduras	*	Philippines
*	Cameroon	*	India	*	Rwanda
	Cape Verde	*	Indonesia		Samoa
*	Central African Republic	*	Iran, Islamic Rep.		Saudi Arabia
	Chad	*	Jamaica	*	Senegal
*	Chile	*	Jordan	*	Sierra Leone
*	China	*	Kenya		Solomon Islands
*	Colombia		Lao PDR	*	South Africa
	Comoros		Lebanon	*	Sri Lanka
*	Congo, Dem. Rep.	*	Lesotho	*	Sudan
*	Congo, Rep.		Madagascar	*	Swaziland
*	Costa Rica	*	Malawi	*	Syrian Arab Republic
	Cote d'Ivoire	*	Malaysia		Tanzania

Table 1 continues

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[4] It is also possible to combine these two primary instabilities in an index of exogenous shocks, via a simple or weighted average. The results obtained did not prove to be conclusive.

Table 1 (con't)
Composition of the sample

	Djibouti	*	Mali	*	Thailand
*	Dominican Republic	*	Mauritania	*	Togo
*	Ecuador	*	Mauritius	*	Trinidad and Tobago
*	Egypt, Arab Rep.	*	Mexico	*	Tunisia
	El Salvador		Mongolia	*	Turkey
	Equatorial Guinea		Morocco	*	Uganda
				*	Uruguay
					Vanuatu
				*	Venezuela
					Vietnam
					Yemen, Rep.
				*	Zambia
				*	Zimbabwe

Note: * Refers to the small sample (Table 3: Column 2)

We introduce into each model two important control variables, but for which the availability is relatively limited (which implies a reduction in the sample): the rate of diphtheria-pertussis-tetanus (DPT) vaccination of children less than one year of age (WDI 2005) as well as the average years of schooling for women over 25 years (Barro and Lee 2000).

For the instability variables, average income is measured by the GDP per capita expressed in constant dollars for the base year 2000 (WDI 2005). The variable of export instability is measured from total exports of goods and services in constant dollars base year 2000 (WDI 2005). The variable of climatic instability is measured from the agricultural production index per capita (FAOSTAT 2006). The world agricultural commodity price index is of Deaton-Miller type,[5] constructed from price series in dollars (IFS 2005), converted into local currency, deflated by the export unit value of the developed countries.

4   Results

4.1 Descriptive statistics

As mentioned above, the econometric analysis is based on a panel of 97 developing countries for which four observations are available: 1980-84, 1985-89, 1990-94 and 1995-99. The panel is not balanced. Moreover, the sample can vary noticeably with the introduction of some variables.[6]

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[5]   The Deaton-Miller index is a geometrically weighted index. Here, the price of each commodity is weighted by its share in the total value of the agricultural production in 1990: $P_{it} = \prod_j P_{jt}^{Wi0}$.

[6]   In particular, the estimate of the effect of the instability of world agricultural prices on child survival is carried out on a sample reduced to the agricultural commodity-exporting countries, i.e., the countries whose exports of agricultural commodities constitute 50 per cent or more of total commodity exports.

Table 2 gives the statistical description of the variables. It reveals some heterogeneity within the sample: the under-five mortality rate is multiplied by 3.2 between the first and the third quartile, the rate of vaccination by almost 2 and the level of education by 3.4. We also observe some heterogeneity in the levels of income instability, export instability, agricultural production instability and world agricultural commodity price instability are not particularly striking between the quartiles (instability is multiplied by approximately 2 between the first quartile and the third quartile). Furthermore, if income instability and climatic instability remain moderate on average (respectively 4.14 per cent and 6.22 per cent), the average instability of exports and that of world prices (which are dependent) prove rather important since they respectively reach 10.83 per cent and 16.63 per cent.

Table 2
Descriptive statistics

	U5S	U5M	GDP	VACCIN	EDUC
Min	0.67	0.01	494.11	1.00	0.10
Max	0.99	0.33	18323.86	99.00	8.18
Mean	0.89	0.11	3358.55	61.23	3.12
1st quartile	0.84	0.05	1283.18	42.25	1.37
2d quartile	0.90	0.10	2563.61	65.60	2.86
3rd quartile	0.95	0.16	4636.39	82.20	4.68
No. of countries	97	97	97	97	67

	INS(GDP)	INS(X)	INS(AGRI)	INS(Pw)
Min	0.36	0.97	0.96	2.30
Max	18.54	62.65	22.57	124.72
Mean	4.14	10.83	6.22	16.63
1st quartile	2.34	5.87	3.22	8.94
2d quartile	3.58	8.81	4.71	12.75
3rd quartile	5.38	13.12	8.54	17.96
No. of countries	97	82	92	43

Note: U5M   Under-five mortality rate, bounded by 0 and 1;
U5S   Under-five survival rate, bounded by 0 and 1 (U5S = 1 – U5M);
GDP   Gross domestic product per capita, based in purchasing power parity, constant international dollars base year 2000;
VACCIN   Rate of DPT vaccination of children under the age of one year;
EDUC   Average number of schooling years of women over 25 years of age;
INS(GDP)   Instability of per capita income, constant dollars, base year 2000;
INS(X)   Instability of exports of goods and services, constant dollars, base year 2000;
INS(AGRI) Instability of agricultural production per capita;
INS(Pw)   Instability of international agricultural prices.

4.1 The effects of instability on child survival

The effects of instability on child survival have been tested with a semi-logarithmic model. Indeed, the effect depends on whether the initial level of instability is weak or high. The variable of interest is thus not expressed in logarithms, unlike the control variables.

Table 3 displays the results of the estimate of the effect of 'present instability' (measured by the average of the quadratic deviation relative to a mixed trend) on the logit of child survival, using the GMM system estimator. In order to enlarge the sample,

Table 3
Effect of 'present instability' on child survival

	INS(GDP)		INS(X)		INS(AGRI)		INS(Pw)	
	1	2	3	4	5	6	7	8
Instability	-0.061***	-0.039***	-0.005	-0.010**	-0.042***	-0.020*	-0.008***	-0.010***
	0.012	0.014	0.004	0.005	0.012	0.012	0.003	0.004
GDP per capita	0.881***	0.749***	0.825***	1.007***	0.920***	1.094***	0.846***	0.806***
	0.106	0.124	0.108	0.273	0.127	0.247	0.087	0.205
Vaccination	0.160***	0.122*	0.208***	0.357***	0.175***	0.370***	0.283***	0.246**
	0.055	0.066	0.062	0.13	0.049	0.117	0.075	0.113
Education		0.215**		-0.107		-0.133		0.078
		0.103		0.245		0.203		0.163
Constant	-4.935***	-3.995***	-4.883***	-6.780***	-5.278***	-7.436***	-5.217***	-4.821***
	0.769	0.964	0.787	2.27	0.958	2.06	0.692	1.766
No. of observations	353	254	293	225	345	247	168	134
No. of countries	97	67	82	61	92	65	43	35
Hansen	0.071	0.141	0.034	0.119	0.088	0.069	0.109	0.226
AR1	0.004	0.002	0.000	0.001	0.082	0.000	0.073	0.045
AR2	0.803	0.119	0.826	0.869	0.116	0.190	0.069	0.069

Notes: Estimator: GMM system;
Dependent variable: logit of under-five survival rate (S);
INS(GDP): Instability of per capita income, constant dollars, base year 2000;
INS(X): Instability of exports of goods and services, constant dollars, base year 2000;
INS(AGRI): Instability of agricultural production per capita;
INS(Pw): Instability of international agricultural prices;
Instability is measured on each period t;
All variables are expressed in logarithms except instability;
Periods: 1980-84, 1985-89, 1990-94, 1995-99;
Standard errors, corrected for heteroscedasticity, appear below the coefficients;
* significant at 10%, ** significant at 5%, *** significant at 1%.

we also choose to run regressions without including the education variable, which drops many observations. The effect of average income instability on child survival proves to be significant at a threshold of 1 per cent for the two samples. In addition, primary instabilities appear to be significant (only on the small sample for export instability). Moreover, the effect of income instability on child survival has been tested with two other instability measurements (the standard deviation of annual growth rate and the average of the absolute deviation relative to the mixed trend). The results also prove to be significant (not presented here).

We also run regressions including an interactive term ($Ins_{it}*y_{it}$) in order to capture the likely decreasing effect of instability with income level. The results are not significant (not presented here). In fact, although the effect of instability seems to decrease with income level, this phenomenon does not appear very pronounced in our sample. This can be highlighted by the examination of the estimated logistic function. From results displayed in Table 3 column 1, we get the following relationship (for the mean value of the vaccination variable):

$$Logit\ U5S = 0.9\ln(GDP) - 4.5 \qquad (2)$$

which is equivalent to :

$$U5S = \frac{1}{1 + \exp^{-(0,9\ln(GDP)-4,5)}}$$ (3)

From this equation, we get the second derivative function. It is negative and increasing, which means that the curve is concave and that concavity diminishes as income increases. Nevertheless, we note that the decrease in the effect of instability may not be very strong since many observations are located on the right part of the logistic curve where concavity does not vary much (the minimum income level equals 500 PPP$). This can explain the lack of significance of the results concerning an effect of instability expected to decrease with income.

Table 4b gives the marginal impact of instability (measured from the calculations provided in Table 4a) according to several values of child survival:[7] when income instability increases by 5 points, average child survival rate decreases by 0.018 units (0.024 units for the first quartile of child survival). In other words, the average mortality rate is strongly affected since it passes from 110 to 128 per thousand (from 160 to 184 per thousand for the first quartile of child survival). Moreover, the marginal impact of income instability is 2.8 times stronger for the first quartile of child survival than for the third.

The results concerning the effects of instability in exports, climate and world prices can be analysed in a similar way: when export instability increases by 10 points, the average mortality rate passes from 110 to 119 per thousand (from 160 to 172 per thousand for the first quartile of child survival). In the same way, when agricultural production

Table 4a
Impact of instability (Ins) on under-five survival (*s*)
according to a semi-logistic specification

Specification	Derivative	$\dfrac{ds}{dIns} = \beta$	Interpretation
$\ln\left(\dfrac{s}{1-s}\right) = \alpha + \beta.Ins$	$\dfrac{1}{s.(1-s)}.ds = \beta.dIns$	$\dfrac{ds}{dIns} = \beta.s.(1-s)$	Marginal impact depending on β and on $s.(1-s)$

Source: Following the analysis of Grigoriou (2005).

Table 4b
Marginal impact of 'present instability' on child survival

	INS(GDP)	INS(X)	INS(AGRI)	INS(Pw)
Mean of U5S	-0.0036	-0.0009	-0.0019	-0.0010
First quartile of U5S	-0.0047	-0.0012	-0.0025	-0.0013
Second quartile of U5S	-0.0032	-0.0008	-0.0017	-0.0009
Third quartile of U5S	-0.0017	-0.0004	-0.0009	-0.0004

Source: Calculated from results in Columns 2, 4, 6, and 8 of Table 3.

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[7]   Indeed, the response of child survival to instability depends on child survival level, due to the logistic form applied to the child survival variable.

instability increases 10 points, the average mortality rate goes from 110 per thousand to 129 per thousand (from 160 to 185 per thousand for the first quartile of child survival). Lastly, when the instability of the world agricultural commodity prices increases 10 points, the average mortality rate rises from 110 to 120 per thousand (from 160 to 173 per thousand for the first quartile of child survival).

Table 5 presents the effect of 'past instability' (income instability then primary instabilities), which appears significant on the two samples. Table 7a gives the marginal impact of 'past instability' according to several values of child survival: when income instability increases by 5 points, the average child survival rate decreases by 0.0155 units (0.0205 units for the first quartile of child survival). In other words, the average mortality rate passes from 110 to 125 per thousand (from 160 to 180 per thousand for the first quartile of child survival).

Table 6 also shows a significant effect of 'overall instability' (except for export instability which is significant only on the large sample). Note that the coefficients of 'overall instability' are larger than the coefficients of 'past instability' (Table 5) and of 'present instability' (Table 3). Indeed, the 'overall instability' may reflect both the irreversibility effect, which is likely to occur over the period, and the effect of instability

Table 5
Effect of 'past instability' on child survival

	INS(GDP)		INS(X)		INS(AGRI)		INS(Pw)	
	1	2	3	4	5	6	7	8
Instability	-0.035**	-0.034*	-0.006***	-0.014*	-0.051***	-0.027*	-0.001***	-0.001*
	0.018	*0.021*	*0.002*	*0.008*	*0.013*	*0.016*	*0.000*	*0.000*
GDP per capita	1.038***	0.865***	0.934***	0.644***	0.853***	1.190***	0.909***	0.771***
	0.168	*0.201*	*0.104*	*0.132*	*0.137*	*0.272*	*0.087*	*0.199*
Vaccination	0.295***	0.296***	0.204***	0.127*	0.210***	0.438***	0.143**	0.276**
	0.085	*0.099*	*0.068*	*0.073*	*0.053*	*0.141*	*0.057*	*0.107*
Education		0.056		0.340***		-0.231		0.086
		0.166		*0.112*		*0.228*		*0.157*
Constant	-6.843***	-5.519***	-5.758***	-3.375***	-4.895***	-8.372***	-5.264***	-4.824***
	1.214	*1.663*	*0.753*	*1.063*	*1.008*	*2.366*	*0.643*	*1.685*
No. of obs	339	251	267	218	349	251	168	134
No. of countries	95	67	79	63	93	66	43	35
Hansen	0.024	0.013	0.054	0.312	0.174	0.366	0.374	0.103
AR1	0.000	0.001	0.000	0.001	0.035	0.001	0.005	0.000
AR2	0.496	0.240	0.306	0.115	0.419	0.544	0.408	0.464

Notes: Estimator: GMM system;
Dependent variable: logit of under-five survival rate (S);
INS(GDP): Instability of per capita income, constant dollars, base year 2000;
INS(X): Instability of exports of goods and services, constant dollars, base year 2000;
INS(AGRI): Instability of agricultural production per capita;
INS(Pw): Instability of international agricultural prices;
Instability is measured on each period (t-1);
All variables are expressed in logarithms except instability;
Periods: 1980-84, 1985-89, 1990-94, 1995-99;
Standard errors, corrected for heteroskedasticity, appear below the coefficients;
* significant at 10%, ** significant at 5%, *** significant at 1%.

over the previous years. Table 7b gives a marginal impact of 'overall instability' on child survival: when income instability increases 5 points, the average child survival rate decreases by 0.037 units (0.049 units for the first quartile of child survival). So, the average mortality rate is strongly affected since it expands from 110 to 147 per thousand (from 160 to 209 per thousand for the first quartile of child survival).

Table 6
Overall effect of past and present instability on child survival

	INS(GDP)		INS(X)		INS(AGRI)		INS(Pw)	
	1	2	3	4	5	6	7	8
Instability	-0.096***	-0.082**	-0.006**	-0.018	-0.085***	-0.052**	-0.014**	-0.012**
	0.024	0.035	0.003	0.011	0.027	0.024	0.006	0.006
GDP per capita	0.868***	0.789***	0.845***	0.677***	0.800***	1.064***	0.828***	0.764***
	0.104	0.208	0.108	0.177	0.127	0.230	0.087	0.220
Vaccination	0.135**	0.202**	0.212***	0.280***	0.229***	0.402***	0.302***	0.242*
	0.061	0.083	0.068	0.091	0.052	0.123	0.078	0.127
Education		0.110		0.154		-0.153		0.118
		0.159		0.144		0.199		0.187
Constant	-4.560***	-4.350***	-5.080***	-4.009***	-4.264***	-7.104***	-5.043***	-4.450**
	0.743	1.591	0.773	1.403	0.961	1.978	0.690	1.962
No. of obs	328	248	262	214	349	251	168	134
No. of countries	94	67	77	62	93	66	43	35
Hansen	0.030	0.068	0.085	0.047	0.082	0.293	0.253	0.283
AR1	0.000	0.000	0.000	0.000	0.001	0.000	0.007	0.001
AR2	0.883	0.554	0.610	0.867	0.247	0.318	0.263	0.127

Notes: Estimator: GMM system;
Dependent variable: logit of under-five survival rate (S);
INS(GDP): Instability of per capita income, constant dollars, base year 2000;
INS(X): Instability of exports of goods and services, constant dollars, base year 2000;
INS(AGRI): Instability of agricultural production per capita;
INS(Pw): Instability of international agricultural prices;
Instability is measured on each period (on t-1 and t);
All variables are expressed in logarithms except instability;
Periods: 1980-84, 1985-89, 1990-94, 1995-99;
Standard errors, corrected for heteroskedasticity, appear below the coefficients;
* significant at 10%, ** significant at 5%, *** significant at 1%.

Table 7a
Marginal impact of 'past instability'

	INS(PIB)	INS(X)	INS(AGRI)	INS(Pw)
Mean of U5S	-0.0031	-0.0013	-0.0025	-0.0001
First quartile of U5S	-0.0041	-0.0017	-0.0033	-0.0001
Second quartile of U5S	-0.0028	-0.0012	-0.0022	-0.0001
Third quartile of U5S	-0.0014	-0.0006	-0.0011	0.0000

Source: Calculated from results in Columns 2, 4, 6, and 8 of Table 5

Table 7b
Marginal impact of 'overall instability'

	INS(PIB)	INS(X)	INS(AGRI)	INS(Pw)
Mean of U5S	-0.0074	-0.0016	-0.0047	-0.0012
First quartile of U5S	-0.0098	-0.0021	-0.0064	-0.0016
Second quartile of U5S	-0.0066	-0.0014	-0.0043	-0.0011
Third quartile of U5S	-0.0034	-0.0008	-0.0021	-0.0005

Source: Calculated from results in Columns 2, 4, 6, and 8 of Table 6.

5   Conclusion

In this paper, we argue that macroeconomic instabilities are likely to affect under-five survival beyond their effect through lower economic growth. First, they have an irreversible influence on child mortality due to asymmetry in the reaction of child health to the ups and downs in economic variables. Moreover, they may involve a stronger income inequality (as the 'almost poor' people are more likely to suffer from income shocks), which reduces the average child survival rate.

Our econometric analysis made it possible, controlling for the impact of average income, to establish several results concerning to the relation between instabilities and under-five survival: average income instability—as well as primary instabilities (relating to climate, world commodity prices, exports) that are the main exogenous sources of income instability—appear to have a direct effect ('present instability') on child survival in the developing countries of the sample. This effect proved to be of quite a large scale, since increasing income instability by 5 points is likely to involve an 16 per cent increase in the mortality rate. Moreover, income instability also appears to have an effect on child survival in the longer run ('past instability'), although of lesser magnitude.

These results, although in conformity with our assumptions, must, however, be regarded as provisional and exploratory. The analysis here presented can be extended in several directions. One is to work out a specification of the relation, making it possible to test the existence of thresholds and other non-linearities: is there a minimum level of instability above which the effect matters? Is there a level of per capita income beyond which the effect of instability is no longer significant? What are the factors conditioning the effect of instability? It would also be interesting to compare the direct effects of macroeconomic instability on child survival with those resulting from a lower economic growth.

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