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A DYNAMIC CHILD SURVIVAL FUNCTION:

NATURAL CONVERGENCE

AND ECONOMIC POLICY

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Résumé

La convergence a été considérablement moins étudiée en matière de développement humain que de revenu. Or, parce que l'évolution des indicateurs de développement humain est bornée, leur analyse en termes de convergence peut être biaisée de façon importante. Cet article examine la question de la convergence pour la survie infanto-juvénile, en cherchant à identifier la fonction dynamique de survie de la façon la plus pertinente, compte tenu des contraintes propres à tout indicateur borné.

Cette fonction nous permet d'étudier l'impact de facteurs économiques sur la survie des jeunes enfants, et en particulier l'impact des prix relatifs. L'analyse économétrique en panel dynamique porte sur des données quinquennales couvrant la période 1965-1999 pour 100 pays. Nous utilisons la méthode des GMM système qui permet de tester la spécificité dynamique de notre modèle tout en contrôlant pour l'hétérogénéité inobservable. On ne rejette pas l'hypothèse qu'au-delà de son effet indirect par les revenus, la dépréciation réelle de la monnaie conduit à une détérioration de la survie des jeunes enfants dans les pays à faible revenu.

Abstract

Convergence has been much less studied with regards to human development than it has been done in economic growth models. However, since the evolution of human development indicators is bounded, the analyse of their convergence may be importantly biased. This paper investigates the question of child survival convergence, attempting to identify the most relevant dynamic survival function, taking into account the characteristics of any bounded indicator.

This function enables us to assess the impact of economic factors on child survival, and in particular that of relative prices. The econometric analysis relies on a dynamic panel with 5-years periods, covering 1965-1999 for 100 countries. The method used, namely the GMM System, enables us to test a dynamic model while controlling for the heterogeneity of the sample. We do not reject the assumption that that beside its effect through the level of income, real depreciation of the currency may lead to a deterioration of child survival in poor countries.

Introduction

Survival, and in particular that of young children, is the least questionable indicator of what is defined as human development. Simultaneously, the reduction of the under-five mortality can be considered as one of the less ambiguous “Millennium Development Goals”. Therefore, it is all the more important to analyze factors determining the increase in survival (of young children). The analysis can be effected in the same way as studies dealing with the factors of economic growth. The availability of reliable data on under-five mortality (proportion of children dying before the age of five), notably thanks to DHS survey, enables us to test similar assumptions with panel data. We can plan to use such estimations to test the dynamic performances of countries with regards to “human development”.

However, while the concept of (conditional) convergence has been studied considerably in the literature dealing with economic growth, it has been much less analyzed with regards to survival (or mortality). And in terms of survival, (absolute) convergence seems to be the rule in the long term. But, specifically because the evolution is limited, analyzing convergence poses specific problems of method which, if there are not correctly solved, may bias the results according to the effectiveness of the strategy implemented by each country to reduce their mortality.

This specificity is captured by a dynamic function of under-five child survival (difference between unity and the under-five mortality rate), estimated in panel with DHS data. It seems that the choice of the form of the function linking the increase in survival and its initial level (among others factors) is essential to assess the possible “convergence” and the impact of other factors as well.

We attempt to determine if the survival levels “converge” and if the speed of convergence can be considered as an expression of their “performance”.

« Natural » convergence, which corresponds to a general move towards the maximum level of survival, is then used as the reference to assess the relative effectiveness of policies implemented to reduce mortality. In that case, we are interested in the influence of economic policy variables easily quantified but largely neglected in the analysis of mortality determinants. In particular, we emphasize the role of an under-estimated factor, namely relative prices, as a determinant of under-five mortality: it seems that the increase in the relative prices of tradable goods, captured by a depreciation of the real exchange rate, could have been, for recent decades, and once controlled for the influence of the level of income per capita (on which the depreciation could have been acting), a factor of higher under-five mortality.

The paper is organized as follows. (1) Firstly, we examine the most relevant indicator in the analysis of survival (of young children), with a quick overview of the literature. (2) Secondly, we consider how these indicators can be influenced by economic policy and, in particular, the reasons why relative prices (real exchange rate) would act on child survival. (3) Thirdly, we define the specification of our model, the econometric method, and the origins of the data. (4) Lastly, we present and interpret the results.

1 –Conflicting Measures of Human Development, Illustrated by Under-Five Survival.

When measuring human development, much attention has been paid to the choice and aggregation of indicators, inevitably partial and questionable.[1] However, there is a preliminary and more basic question, which is to have a relevant measure of each indicator and then to compare it across countries or over time. The answer obviously depends on our goal: if we attempt to have a human capital indicator (that is an input indicator), the indicator will have to reflect an ability to generate incomes and therefore take into account a possible decrease in the marginal productivity of the human factor considered (education or health). If on the contrary, we try to implement a performance index, the indicator will have to capture the fact that, depending on the level of the indicator, it will be easier or harder for a country to improve it.

[1] Cf. the extensive literature since the publication of the *Human Development Report* (1989) or the works of the CDP (*United Nations Committee for Development Policy*) about the APQLI (Augmented Quality of Life Index), which became the HAI (Human Assets Index) in 2002.

When the human development indicator converges on its maximum limit, it is obvious that it is all the more difficult to improve it as we tend to that limit. Figure 1 illustrates the different ways to measure a change in life expectancy according to the concept we use.

FIGURE 1

Three Different Measures of a Same Life Expectancy Improvement

Let A, B, C be 3 countries with a life expectancy of 40, 65 and 75 years respectively, and let be the maximum life expectancy be 85 years. The following table gives three expressions of the improvement obtained for these three countries for a same increase in 6 years.

	A	B	C
Initial level	40	60	75
Distance to the maximum	45	25	10
(1) Absolute change	6	6	6
(2) Relative increase	15 %	10%	8 %
(3) Relative decrease in the distance to the maximum	13 %	24 %	60 %

To a same gross increase in life expectancy (1) corresponds an opposition classification depending on whether we consider;
- relative increase (2)
- performance or "achievement" (3)

Implications of the different measures in analyzing convergence are explained in the text.

As a result, it seems that the concept of “convergence” applied to human development (for our purpose, to survival) can be expressed in different, and possibly conflicting, ways, which fundamentally distinguishes the study of convergence in terms of health or of income.

Firstly, let us consider the sigma-convergence, namely the decrease in the dispersion (the standard error) of the indicator studied (in this study the survival rate). The indicator can be:

- the absolute value of the indicator (life expectancy, survival of children under-five,…): convergence means a decrease in the absolute differences;
- the logarithmic value of the indicator: convergence means a decrease in the relative differences;
- the logarithm of the distance between the actual level of the indicator and its maximum limit: convergence means a decrease in the relative differences of the distances towards the maximum level, in other words, a decrease in the relative differences between the achievement rates; in other words again, countries amongst the least advanced in terms of life expectancy, of survival, tend to get closer to the superior limit of the survival indicator relatively faster than others countries. We can note that if the indicator is survival and if the maximum is 1 (thousand per thousand), convergence means the decrease in the relative differences of under-five mortality.

The first two measures fit for income per capita or on human development as well, the third one is, on the contrary, specific to an indicator of human development. This third way of considering the convergence can imply another formulation that has already been used by Bhalla and Glewwe (1986), which is the log of the ratio of the survival rate (for their purpose life expectancy) on the difference between the maximum value and the actual value of this rate (for their purpose life expectancy) (cf. Table 1).

The two measures of “achievement” correspond respectively to the logarithmic transformation of the distance between actual and maximum survival rates, and to its logit transformation. Both of them have a positive first derivative and a positive second derivative too (by construction for the first one, above a survival rate superior to the half of its maximum level for the second one, which corresponds to the entire sample). Therefore, both are appropriate to reflect the increasing difficulties in improving the survival rate when it increases.

We prefer the second expression because it is a good measurement of achievement at any time (and not only in variation).

Table 1 - Two Measurements of Achievement in Terms of Survival

Antecedent (life expectancy)	Measurement for the survival rate	Approached Measurement when; Max(s) = 1 or min(m)=0	Derivatives characteristics towards s	Denomination
Anand and Ravallion(1993)	$-\ln(Max(s)-s_i)$ $= -\ln(m_i - \min(s))$	$-\ln(m_i)$	$x'>0$ $x''>0$	Logarithmic achievement
Bhalla and Glewwe (1986)	$\ln(\frac{s_i}{Max(s)-s_i})$	$\ln\frac{s_i}{m_i}$	$x'>0$ $x''>0$ if $s>M/2$	Logit achievement

Graphs 1.1 to 1.3 illustrate, for under-five survival (difference to the unity of under-five mortality rate), the divergent evolutions obtained according to the definition we chose. They deal with approximately 100 countries (cf. Appendix 5) for seven 5-year periods covering 1965-1999.

Figure 1.1 - Evolution of Under-Five Survival Rate Standard Error (1965-1999)

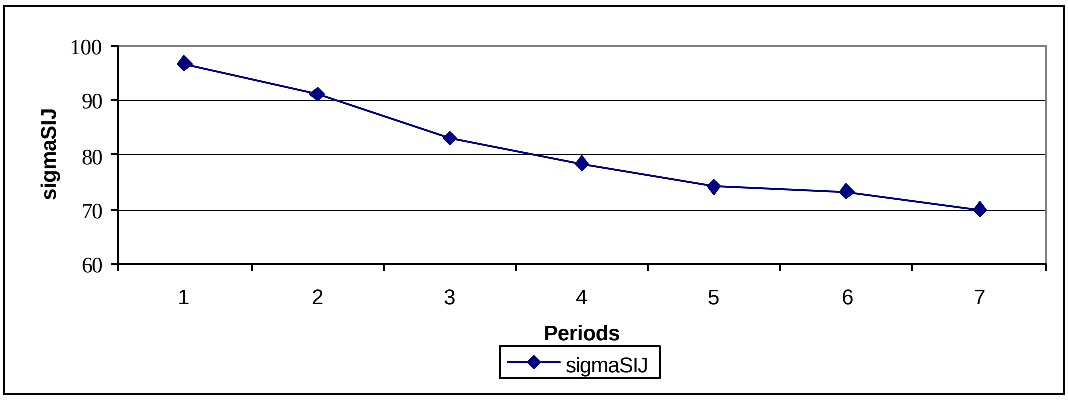


Figure 1.2 - Evolution of the Standard Error of the Logarithm of Under-Five Survival Rate (1965-1999)

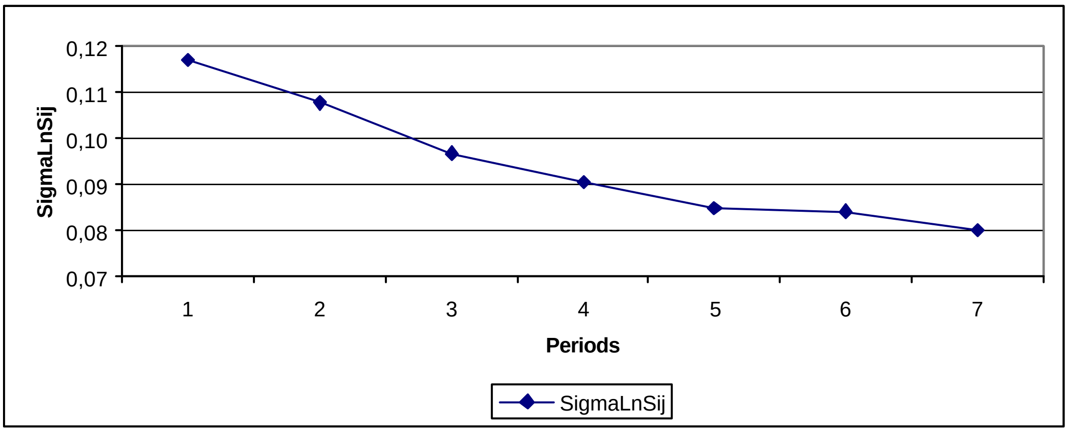
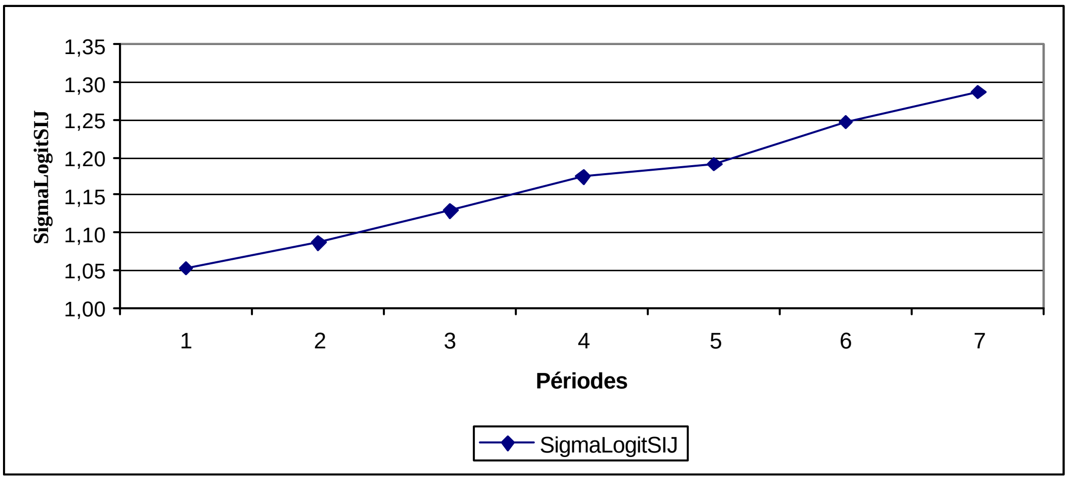


Figure 1.3 : Evolution of the Standard Error of the Logarithm of the Differences Between the Relative Achievement Rates of Under-Five Survival (1965-1999)



However, sigma-convergence is just a way of describing an evolution without any assumption according to the functional relation, which is what we try to capture with the beta-convergence. The beta-convergence corresponds to the hypothesis that the growth rate of the interest variable (usually income per capita) depends (negatively) on the prior value, due to decreasing returns: therefore, we test the relation linking the income per capita growth rate (the difference of the logs) and income per capita initial level (in logarithms), without controlling, or controlling for the influence of other factors, which leads to defining convergence as “absolute” or “conditional”. We must assume that the principle of decreasing returns fits for (the production of) survival as well as for the production of goods. Then, we test a relationship between the change and the initial level of survival, without controlling (absolute convergence) or controlling (conditional convergence) for the influence of other factors.

At the crossroad of the literature on income convergence and of the many studies on the determinants of mortality or survival, several recent studies examine the “convergence” between countries with regards to life expectancy (or any other indicator of human development), or more generally consider factors explaining rates of change of countries, factors which naturally include the prior level of the indicator.

Thus, Ram (1988) assesses the variation of life expectancy, then its logarithm, depending on its initial value (positive effect) and its initial value squared (negative effect), adding as an explanatory variable income per capita (conditional convergence). With relative or absolute difference as well (i.e variables transformed in logarithm or not), he draws the conclusion of a convergence at an accelerating rate (beyond a certain threshold). Sab and Smith (2001) test a similar relationship (in log) for the variation of life expectancy and for that of the literacy rate, respectively with their initial level and its square as explanatory variables, controlling for the evolution of each variable by the prior level of the other variable, in simultaneous equations system: they conclude to (conditional) convergence for each variable[2] [3].

[2] We find such a conclusion for convergence on education in a recent paper by Zhang and Li (2002).
[3] In a prior study (Calipel and Guillaumont 1994), the absolute variation of life expectancy was estimated as a function of its initial level and of others variables.

However, these functional forms do not seem really relevant when studying convergence, because they deal with bounded variables, as human development indicators are. As the result (convergence) is pre-determined, that convergence is quite natural. For the same reason, previous functions are not an appropriate form for the survival (production) function[4]. That is why Hobijn and Franses (2002) attempted to transform the explained variable (survival) to reflect an achievement, namely the log of the distance between the actual level of survival and the maximum level attainable.

Even though they conclude, as is natural to do (and as other authors have done), on (not conditional) convergence when they observe the gross infant mortality rate or life expectancy, they conclude on divergence when they observe the achievement indicator. However, they don't control for the influence of other factors, therefore they are not interested in conditional convergence.

Our analysis of survival convergence analysis differs from these last studies by two different ways:

- it allows the possibility of a convergence threshold (with the endogenous variable delayed and squared), as Ram does, but assesses this possibility not only for the gross level of the survival indicator (or its log), but also, and this is more relevant, in particular for conditional convergence, for the achievement index.
- it considers both accomplishments and gross levels (like Hobijn and Franses), but tests not only absolute convergence but also conditional convergence.

Thus, our framework seems appropriate for testing the influence of other factors (than income per capita) on survival, in particular economic policy factors, which are difficult to capture through cross-section analysis.

[4] The problem was identified a long time ago in cross-section analysis of mortality or survival determinants: Anand and Ravallion (1993) use a specification where the (log of) explained variable was the distance to the maximum level. Bhalla and Glewwe (1986), covering two periods, used their own indicator which, once applied to the survival, is the ratio of survival to the distance to its upper limit.

2 – Influence of Economic Policy on Under-Five Mortality: the Role of Relative Prices.

With a good specification of the child survival function, we can test the impact of economic policies on mortality appropriately. However, there are many channels economic policy can use to influence child mortality. Often considered channels are public policy on health expenditures, health care delivery, the schooling of the mothers, vaccination, etc…These are factors which are possibly important, but to be controled for two other types of factors.

The first one corresponds to the level of income per capita. The influence of income per capita on life expectancy has been tested many times in cross-section analysis (Bidani and Ravallion (1997)), Filmer and Pritchett (1998), Hammer and Pritchett (1998), etc.) and there are many transmission channels (feeding, living conditions, health care delivery, etc.). However, income per capita is itself partly the result of an economic policy (present and past): thus, any economic policy variable can have a positive effect on the income per capita and through this on health, but also a direct effect on health, be it favorable or not.

Therefore, we have to identify and test the influence of economic policy variables that are likely to have a specific effect on child survival, controlling for the influence of income per capita. The first candidate variable is, of course, the level of public expenditure dedicated to health (in fact, the ratio of these expenditures to the GDP). But somewhat (only apparently) paradoxical is that in various cross-section analyses on the tests of the influence of these expenditures are generally not significant (Calipel and Guillaumont (1994), Filmer and Pritchett (1997), Filmer Hammer and Pritchett (1998), etc). Beyond the reasons that could explain this paradox, one should obviously test this relationship with an appropriate specification for survival. However, the availability of health expenditure data needed for a panel analysis is rather limited.

Another important economic and intermediary variable, often neglected and deserving particular attention is the evolution of the relative price of tradable goods, namely the real exchange rate (RER). We can indeed assume that the real exchange rate, independently from its effects through the level of income per capita, influences the level of survival. The main reason is that many goods whose consumption is particularly essential for health are tradable goods. This is the case for foodstuffs that are mostly tradable goods and whose price has an impact on the satisfaction of nutritional needs. We can assume that this effect of relative prices on under-five mortality has been all the more noticeable for poor households. This is also the case for medicines that are typically tradable goods, and are often imported.

We must also assume that this effect will be all the more important as the real exchange rate has its own specific influence on the income of the poor, apart from its effect on average income, an effect that is taken into account when the income per capita is included in the regression.

However, the income of the poor, even more than the average income, influences the level of under-five mortality. This effect of the real exchange rate on the income of the poor for a given level of average income corresponds naturally to its effect on the distribution of incomes, which is not well known, in both a theoretical and empirical way.

Obviously, the negative effect of a real depreciation on survival may be linked to the macro-economic conditions that induced it: in particular, if the real depreciation comes from a strong nominal depreciation of the exchange rate, that is to say with a high correlative inflation, the negative effect of the real depreciation of the exchange rate can hide the negative impact of inflation (quite plausible because of the well known relation between inflation and the income of the poor (cf. for example Dollar and Kraay (2001)). Therefore, when testing the impact of the real exchange rate, we must not only control for the impact of income per capita (influenced by the real exchange rate), but also the impact of inflation (accompanying the real exchange rate).

However, a decrease in the real exchange rate can also (or simultaneously) result from a budgetary surplus, which may in turn result from a decrease in public expenditures (including health expenditures), and therefore can have been implying directly a lower survival. We will have to, if possible, control for the influence of these other factors.

Lastly, we must consider the eventual relationship between the evolution of the real exchange rate and the openness policy of the countries. A more open trade policy can be favored by a real depreciation. According to the assumption made on the way the openness policy affects the income of the poor, the influence of the real exchange rate can be modified if the regression also includes openness policy amongst the right-hand-side variables.

3 – Panel Evolution of an Under-Five Mortality Model

The model

As indicated before, the model we propose order to estimate the factors of the survival rate evolution differs both from the traditional logarithmic model, such as the one used by Ram (with life expectancy), and from the logistic achievement model used by Hobijn and Franses (with life expectancy and infant mortality) because, alongside the delayed endogenous variable, we include explanatory variables enabling us to test conditional convergence. However, as Hobijn and Franses do for non-conditional convergence, we also estimate the traditional logarithmic model in order to compare the findings obtained with both models (in both cases, we use panel econometrics).

Let us call s_{it} the under-five rate of country i at time t;
M the superior limit of the survival rate;
m_{it} (= $1 - s_{it}$) the under-five mortality rate of country i at time t;

According to the model used, the explained variable is;

- In the traditional logarithmic model;

  $\hat{s}_{it} = \log(s_{it})$ $\quad\quad$ $\hat{s}'_i > 0$, $\hat{s}''_i > 0$

- In the achievement logistic model;

  $s^*_{it} = \log [s_{it} / (M - s_{it})]$ $\quad\quad$ $\hat{s}_i > 0$, $s'' < 0$ if $s_i < M/2$, $s'' > 0$ if $s_i > M/2$

  if we set[5] M = 1

  $s^*_{it} = \log s_{it} - \log m_{it}$

[5] We assume that M is 1000, corresponding to a minimum value of m_i set to zero. We prefer having zero rather than five (usual assumption) because while it doesn't change the results, it doesn't impose an arbitrary threshold and it enables us to keep the countries of our sample that have an under-five rate of five per thousand.

In both cases, as Ram does, and as income convergence analysis proposes to do, we introduce as delayed variable the value of the survival indicator next to its squared value in order to emphasize a possible threshold of convergence, or if the threshold is beyond the sample, to show a convergence at a changing rate (higher and higher) when the value of the indicator increases. At this stage of the analysis, we include the delayed income per capita as the only control variable or as the only factor “conditioning” convergence (y_{it-1} and $\hat{y}_{it-1} = \log y_{it-1}$).

We can write both models respectively as follows:

(1) $d\hat{s}_{it} = \hat{s}_{i-t} - \hat{s}_{it-1} = a + b\hat{s}_{it-1} + c\hat{s}_{it-1}^2 + f\hat{y}_{it-1} + ?_i + e$

(2) $ds^*_{it} = s^*_{it} - \hat{s}^*_{it-1} = a' + b's^*_{it-1} + c's^*_{it-1}{}^2 + f'\hat{y}^*_{it-1} + ?'_i + e'$

(3) giving $s^*_{it} = a' + (1 + b')\, s^*_{it-1} + c's^*_{it-1}{}^2 + f'y^*_{it-1} + ?'_i + e'$

We can compare our findings obtained with both models, taking into account the fact that, for the logical reasons presented above, we would prefer model (2) to model (1). [6]

By construction, we expect a lower threshold from which there is convergence with model (1), using the logarithmic transformation, than with model (2), using a logit transformation. In fact, in the first case, we are interested in the evolution of the distance covered, and in the second case in the evolution of the distance covered relative to that still to cover.

Econometric Method

This is a panel analysis, using both cross-section (100 countries) and longitudinal (6 sub-periods of 5 years) information.

[6] The preferred model reveals a benchmark for assessing the policy implemented by the different countries in terms of survival: the deviation from the estimated value of survival evidences the impact of the policy once controlled for income per capita and for the delayed value of survival, which reflects in part the past policy (and the past income as well). Removing the delayed endogenous variable, we obtain the expected value of survival depending only on the past income. Compared to the actual value, this gives an idea of the “survival performance” of the countries, a concept close what has been used by Bhalla and Glewwe, or studies from the CERDI on development strategy (Guillaumont and alii., 1988).

Let the following dynamic model be $y_{it} = a.y_{it-1} + b.x_{it} + ?_i + e_{it}$ (1) ;
The estimation of this dynamic model with traditional OLS with country dummies (Least Square Dummy Variables) or with the estimator WITHIN of the country fixed effects model can induce several biases.

The first type of bias concerns traditional biases emphasized by studies dealing with growth, such as the endogeneity of explanatory variables, error of measure or omitted variables.

The second sort of bias, specific to the dynamic nature of this type of model, relies on the coefficient associated to the delayed dependent variable variable (convergence coefficient *a*). As a matter of fact, y_{it-1} is, by definition, correlated with the specific effect country $?_i$ in the context of a LSDV estimator, and $\overline{y}_{i.}$ (individual average) is correlated with $\overline{e}_{i.}$ with the estimator WITHIN. The LSDV estimator is usually considered as having an upward bias on the coefficient *a* whereas the WITHIN estimator has a downward bias (cf. among other studies Blondel and Bond (1998) or Bond, Hoeffler and Temple (2001)).

Then, to correct these biases, many authors have used an instrumental variables method, namely the GMM estimator, and in particular the first difference GMM applied to dynamic models in panel (cf. Holtz-Eakin, Newey and Rosen (1988), Arellano and Bond (1991), Caselli, Esquivel and Lefort (1996)). The idea is to transform equation (1) in first differences to suppress unobserved specific constant country effects, and then to instrument the right-hand-side variables using the values of the variables in level, delayed by at least two periods.

However, for dynamic panel studies with a finite sample, some authors emphasized that the first difference GMM estimator can be biased and be a weak estimator (Alonso-Borrego and Arellano (1996), and that it will be all the weaker as the number of periods is small. Blundell and Blond (1998) show that in that case, the first difference GMM estimator has an important bias downward, because the delayed levels of the series are too weak instruments.

Therefore, we use the GMM System estimator that combines delayed first difference series of y_{it} to instrument the level series of y_{it} and the delayed level of the series y_{it} to instrument the first difference of y_{it} (cf. Arellano and Bover (1995), Blundell and Bond (1998)). Blundell and Bond (1998), Bond, Hoefler and Temple (2001) emphasize the use of this method to study convergence with a dynamic panel, with five or six sub-periods of five years.

So, we shall use the GMM System method for our estimations, with usual tests. We also present our findings with LSDV and WITHIN estimator. We expect the estimation of the convergence to be biased downward by the latter and upward by the former, which enable us to surround the convergence threshold estimated with GMM System for each of our estimates.

Our estimates cover 100 countries for seven sub-periods of five years (1965-69 to 1995-99). The data come from the World Bank (World Development Indicator 2002) for GDP per capita and the World Health Organization (Ahmad, Lopez and Inoue 2000) for data on under-five mortality (cf. Appendix 5).

4- Findings and interpretations

The results presented in this table allow us to compare both specifications.

Table 3 : Compared Models of Under-Five Survival Convergence

	Explained Variable					
	Survival logarithmic transformation			Logit achievement		
	LSDV	WITHIN	GMM-SYS	LSDV	WITHIN	GMM-SYS
$\hat{s}_{i,t-1}$ or s^*_{it-1}	5.46***	3.50**	11.75**	1.13***	1.03**	1.13***
Standard-error	(1.27)	(0.93)	(5.62)	(0.02)	(0.04)	(0.06)
p-value	(0.00)	(0.028)	(0.037)	(0.00)	(0.028)	(0.00)
$\hat{s}^2_{it-1}$ or s^{*2}_{it-1}	-0.34***	-0.20*	-0.82*	-0.02***	-0.02***	-0.03***
p-value	(0.00)	(0.095)	(0.051)	(0.00)	(0.00)	(0.00)
THRESHOLD	*749*	*562*	*725*	*943*	*672*	*926*
LnY_{it-1}	0.002***	0.001	0.009***	0.030***	0.046*	0.048
p-value	(0.001)	(0.709)	(0.004)	(0.00)	(0.071)	(0.400)
F-test(p-value)	0.00	0.00	0.00	0.00	0.00	0.00
R^2	0.98	0.920		0.990	0.930	
p-values associated to the F-test represent the probability of rejecting the assumption of a joint significance of the coefficients. *Regressions are with robust standard errors.* *, ** and *** represent significance thresholds of 10, 5 and 1% respectively						
Sargan			0.474			0.163
ar(1)			0.086*			0.000***
ar(2)			0.468			0.521
p-value indicating the probability of the validity of all instruments used, to reject an AR(1) process, to reject an AR(2) process respectively						
Obs	600	600	600	600	600	600
Countries	100	100	100	100	100	100

* *Instruments used for the GMM estimation are* $\Delta\hat{s}_{i,t-1}$, $\Delta\hat{s}^2_{it-1}$, $\Delta\ln Y_{i,t-1}$, *for the level equations, (respectively* Δs^*_{it-1}, Δs^{*2}_{it-1}, $\Delta\ln Y_{i,t-1}$*),* $\hat{s}_{i,t-2}$, $\hat{s}^2_{it-2}$, $\ln Y_{it-2}$, *(respectively* s^*_{it-2}, s^{*2}_{it-2}, lnY_{it-2}*) and other delays for the differenced equations.*

All the coefficients are significant and have the expected sign, the coefficient associated to the delayed variable being positive, the coefficient of the quadratic term being negative, for both specifications. Standard tests are correct and tend to validate the robustness of our estimates. Furthermore, the threshold we have from our GMM System estimation is surrounded by our LSDV and WITHIN estimates.

We can compute thresholds from which there is convergence. This threshold corresponds to an under-five survival rate of 725 per thousand when we use the traditional logarithmic transformation (such as Ram, 1998), of 926 per thousand if we use the logit transformation of the variable sij. These findings are as expected. In other words, Ram's specification tends to bias the results toward convergence, *by construction.*

Moreover, the coefficient associated to income per capita has a positive significant sign, which implies that once controlled for initial life expectancy, a higher income implies a more important increase in life expectancy.

Table 4

	Survival Thresholds	Percentage of points out of convergence area
$\hat{s}_i$	725	3.6%
s_i^*	926	48.3%

We can now include economic policy variables in our model in order to test their impact on the convergence of the countries of our sample in terms of under-five mortality. Economic policy variables included are:

- the real effective exchange rate[7] (computed by the CERDI from the bilateral nominal exchange rate and consumption price indexes from IFS) equals 100 in 1990, and is then transformed for each country depending on the average of the series, taking into account the fact that the base year can change for each country,

[7] The value of foreign currency expressed in domestic currency units

- the inflation rate (change of the log of the consumption price indexes from the GDF 2001), the budgetary surplus or deficit (IFS 2001) and, whatever its limits are, the openness indicator developed by Sachs and Warner[8] (1995).

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[8] According to the indicator of Sachs and Warner, a country is considered as closed if one of the following assertions is correct: (1) average tariff rate superior to 40%, (2) non-tariff trade barrier covering more than 40% of imports, (3) socialist economic system, according to Kornaï's classification ; (4) State monopoly on the main exports; (5) premium on the parallel exchange market superior to 20% for the 70's or the 80's. Cf. the criticisms of this indicator by Edwards (1998) or Guillaumont (2001).

Table 5 – Economic Policy conditioning Under-Five Survival Defined on Achievement (GMM System Estimation)

	i	ii	iii
s^{*}_{it-1}	1.18***	1.18***	1.18***
standard-error	0.039	0.05	0.04
p-value	(0.00)	(0.00)	(0.00)
s^{*2}_{it-1}	-0.034***	-0.04***	-0.04***
p-value	(0.00)	(0.00)	(0.00)
threshold	*934*	*927*	*924*
lny_{it-1}	0.039***	0.042	0.041***
(p-value)	(0.003)	(0.241)	(0.004)
$reer_{t-1}$	0.107**	0.083**	0.068**
(p-value)	(0.025)	(0.039)	(0.015)
inf_{t-1}		-0.054*	-0.048
(p-value)		(0.075)	(0.116)
sb_{t-1}		-0.291	-0.273
p-value		(0.295)	(0.450)
sw_{t-1}			0.014
p-value			(0.554)
sargan (p-value)	0.341	0.971	0.999
ar(1) (p-value)	0.000***	0.000***	0.000***
ar(2) (p-value)	0.757	0.716	0.602
p-value indicates the probability for all instruments to be valid, to reject an ar(1) process and to reject an ar(2) process respectively			
no. obs	508	416	390
no. individs	93	83	76
all estimates are with robust standard-errors *, ** and *** represent significant thresholds of 10, 5 and 1% respectively			

* *Instruments used for the GMM estimates are* $\Delta\hat{s}_{i,t-1}$, $\Delta\hat{s}^{2}_{it-1}$, $\Delta \ln Y_{i,t-1}$,?$REER_{i,t-1}$, ?$INF_{i,t-1}$?$SB_{i,t-1}$, ?$SW_{i,t-1}$ *for the level equations, (respectively* Δs^{*}_{it-1}, Δs^{*2}_{it-1}, $\Delta \ln Y_{i,t-1}$?$REER_{i,t-1}$, ?$INF_{i,t-1}$?$SB_{i,t-1}$, ?$SW_{i,t-}$*)*, $\hat{s}_{i,t-2}$, $\hat{s}^{2}_{it-2}$, $\ln Y_{it-2,}$ $REER_{i,t-2}$, $INF_{i,t-2}$ $SB_{i,t-2}$, $SW_{i,t-2-}$ *(respectively* s^{*}_{it-2} , s^{*2}_{it-2} , $lnY_{it-,}$, $REER_{i,t-2}$, $INF_{i,t-2}$, $SB_{i,t-2}$, $SW_{i,t-2}$*)and others delays for differenced equations.*

As emphasized in Table 5, convergence coefficients are approximately stable when including economic policy variables, the coefficient associated to income per capita remaining positive and significant.

The coefficient associated with the real exchange rate (with the value of foreign currency expressed in domestic currency units) is positive and significant, and is robust to any specification change, which means that all other things being equal, a real appreciation (depreciation) leads to an improvement (deterioration) of health in the country, according to the assumptions presented above. The coefficient associated with the REER is still significant and positive after controlling for the influence of income per capita, inflation rate, budgetary surplus or deficit and openness, which induces the following comments:

- The influence of the REER appearing in the regression operates through relative prices and incomes, independently from the impact of the average income per capita: a real depreciation can favor an increase in the GDP, while having a negative direct impact on health, but the global impact cannot be assessed with the model used in this study;
- The influence of the REER is hardly attenuated when including other economic policy variables in the regression: this means that the impact of a real depreciation is independent of the negative effect of inflation (associated to a nominal depreciation) on health due to its social consequences.
- The influence of the budgetary surplus or deficit and of openness is not significant according to their measure (even if their coefficient have the expected signs).

Even though the instrumental method enables us to feel safe towards an endogeneity bias due to any omitted variable, it might seem surprising no to introduce public health expenditures as a determinant of child survival. Such data are very rare, and in particular for a panel of countries including African countries for a long period, as shown by the Appendix X. However, using the Global Development Network, we compute averages for 5-years periods, with the approximation that when there is no observation but one, the period average will have that value. Furthermore, it implies a dramatic decrease in our sample: the number of countries included in our sample was 93 when introducing the REER, 62 when introducing public health expenditures beside the REER.

Introducing the share of the GDP allocated to the health expenditures don’t cast doubt over our findings on the impact of the REER on the under five survival.

Table 6 – Introducing the Public Health Expenditures in the Survival function Defined on Achievement (GMM System Estimation)

	i	ii
s^{*}_{it-1}	1.13***	1.153***
standard-error	0.048	0.062
p-value	(0.00)	(0.00)
s^{*2}_{it-1}	-0.021***	-0.025***
p-value	(0.004)	(0.009)
threshold	*954*	*957*
$\ln y_{it-1}$	0.018	0.0101
(p-value)	(0.148)	(0.426)
$\ln PHE_{t-1}$	-0.00365	0.002
(p-value)	(0.725)	(0.869)
$reer_{t-1}$		0.10**
(p-value)		(0.036)
sargan (p-value)	0.663	0.999
ar(1) (p-value)	0.00***	0.000***
ar(2) (p-value)	0.617	0.494
p-value indicates the probability for all instruments to be valid, to reject an ar(1) process and to reject an ar(2) process respectively		
n°. obs	275	239
n°. ind	70	62
all estimates are with robust standard-errors *, ** and *** represent significant thresholds of 10, 5 and 1% respectively		

* Instruments used for the GMM estimates are $\Delta\hat{s}_{i,t-1}$, $\Delta\hat{s}^{2}_{it-1}$, $\Delta\ln Y_{i,t-1}$,?$REER_{i,t-1}$, ? $\ln DSpib_{t-1}$ for the level equations, (respectively Δs^{*}_{it-1}, Δs^{*2}_{it-1}, $\Delta\ln Y_{i,t-1}$?$REER_{i,t-1}$, ? $\ln DSpib_{t-1}$), $\hat{s}_{i,t-2}$, $\hat{s}^{2}_{it-2}$, $\ln Y_{it-2}$, $REER_{i,t-2}$, $\ln PHE_{t-2}$ (respectively s^{*}_{it-2}, s^{*2}_{it-2}, $\ln Y_{it-2}$, $REER_{i,t-2}$, $\ln PHE_{t-2}$) and others delays for differenced equations.

Conclusion

This study is only an initial attempt to deal with macroeconomic determinants of under-five mortality in a logical conceptual framework. It allows us to draw three preliminary conclusions.

Our findings confirm that when analyzing convergence of human development indicators, it is essential to take into account the fact that human development indicators are bounded. Il might have strong implications in the search of the best way (or the lowest cost) to reach the Millennium Development Goals.

The analysis of survival convergence can be strengthened thanks to panel data and GMM System estimations: this method seems to be appropriate to test the influence of economic policy variables while controlling for the heterogeneity of the sample. However, in further work, it will be useful to identify specific reactions in some country sub-samples (Africa) to economic policy variables, etc.

The study of the influence of the real exchange rate itself should be more detailed and deepened, because of the many transmission channels it uses. However, our model doesn't lead to reject the hypothesis that beside its indirect (and probably opposite) effect through the level of income, real depreciation of the currency may lead to an increase (or a lower decrease) in child mortality in poor countries.

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APPENDIX 1

We have the following dynamic model to estimate (with the variables $\hat{s}$ and s*) :

$\Delta\hat{s}_{it,t-1}$ = a + b. $\hat{s}_{it-1}$ + c. $\hat{s}^2_{it-1}$ + f.lnY$_{it-1}$ + ?$_i$ + e$_{it}$

Actually, the estimated model is:

$\hat{s}_{it}$ = a + b'. $\hat{s}_{it-1}$ + c. $\hat{s}^2_{it-1}$ + f.lnY$_{it-1}$ + ?$_i$ + e$_{it}$

Therefore, what we observe to assess convergence is not b, but b'-1 (that is why we leave error standards under the coefficients with p-values), and the coefficient c.

Thus, we obtain;

$$\frac{\partial(\Delta\hat{s}_{it,t-1})}{\partial\hat{s}_{it-1}} = b + 2.c.\hat{s}_{it,t-1}$$

And, $b+2.c.\hat{s}_{it,t-1} = 0$ if and only if $\hat{s}_{it-1} = \frac{-b}{2c}$ that is $sij_{t-1} = e^{-b/2c}$ as $\hat{s}_{it-1} = \ln(sij_{it-1})$

With the logit transformation of under-five survival, s*, we have:

$$\frac{\partial(\Delta s^*_{it,t-1})}{\partial s^*_{it-1}} = b + 2.c.s^*_{it-1}$$

And, $b+2.c.s^*_{it-1} = 0$ if $s^*_{it-1} = \frac{-b}{2c}$

And as $s^*_{it} = \ln\left(\frac{sij_t}{MAX - sij_t}\right)$, therefore $sij_{t-1} = MAX \times \frac{e^{-b/2c}}{1+e^{-b/2c}}$

APPENDIX 2 : Name of the variables

$\hat{s}$	Logarithmic transformation of under-five survival
s*	Logit transformation of under-five survival
THRESHOLD	Threshold from which there is convergence
LnY_{t-1}	Log of real income per capita delayed for one period
$REER_{t-1}$	Real effective exchange rate (*au* certain) delayed for one period
$LnPHE_{t-1}$	Log of the share of public health expenditures in the PIB delayed for one period
Inf_{t-1}	Inflation rate delayed for one period
SB_{t-1}	Budgetary deficit or surplus delayed for one period
SW_{t-1}	Openness indicator of Sachs and Warner delayed for one period

APPENDIX 3: origin of under-five mortality data

Data on under-five mortality have been published in the WHO bulletin volume 78, n°10, 2000, by Ahmad, Lopez and Inoue.

Estimates of the probability of dying before the age of five are mostly based on the *World Fertility Survey* (WFS) and *Demographic and Health Survey* (DHS) reports as well as on prior studies, in particular, Hill and Pebley (1989), Hill(1987), United-Nations (1988), (1992), Hill and Yazbeck (1993), Sullivan, Rutstein and Bicego (1994), Bicego and Ahmad (1996), Hill and al.(1999).

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APPENDIX 4

Data availability on public health expenditures (share of public health expenditures in GDP).

The three following tables indicate the number of countries with at least 5, 10, 15, 20 or 25 observations (yearly series), according to three sources:

- Data from the World Development Indicators (WDI 2002);
- Data from the Global Development Network (GDN), which refers to the Government Financial Statistic (GFS).
- A working paper from Shantayanan Devarajan, Andrew Sunil Rajkumar and Vinaya Swaroop (1998) « What does Aid to Africa finance ? »

Table 1, 2 and 3 rely respectively on as much countries as possible (206), on African countries (51), and on the countries included in Devarajan et al. (1998) (16 sub-Saharan African countries).

Table1- Data availability on health expenditures for as much countries as possible

	WDI	GDN
> 5 observations	155	98
> 10 observations	80	78
> 15 observations	-	60
> 20 observations	-	44
> 25 observations	-	26

Table2- Data availability on health expenditures for African countries

	WDI	GDN
> 5 observations	40	21
> 10 observations	5	17
> 15 observations	-	10
> 20 observations	-	5
> 25 observations	-	-

Table3- Data availability on health expenditures for African countries in Devarajan et al.

	WDI	GDN	Devarajan et al.
> 5 observations	15	9	16
> 10 observations	4	9	16
> 15 observations	-	7	9
> 20 observations	-	3	5
> 25 observations	-	-	1

APPENDIX 5: list of the countries

Argentina
Australia
Austria
Burundi
Belgium
Benin
Burkina Faso
Bangladesh
Bulgaria
Bahamas, The
Bolivia
Brazil
Barbados
Botswana
Central African Republic
Canada
Switzerland
Chile
China
Cote d'Ivoire
Cameroon
Congo, Rep.
Colombia
Costa Rica
Denmark
Dominican Republic
Algeria
Ecuador
Egypt, Arab Rep.
Spain
Finland
Fiji
France
Gabon
United Kingdom
Ghana
Gambia, The
Greece
Guatemala
Guyana
Honduras
Haiti
Hungary
Indonesia
India
Ireland
Iceland
Israel
Italy
Jamaica
Japan
Kenya
Korea, Rep.
Kuwait
Sri Lanka
Lesotho
Luxembourg
Latvia
Morocco
Madagascar
Mexico
Mali
Malta
Mauritania
Mauritius
Malawi
Malaysia
Niger
Nigeria
Nicaragua
Netherlands
Norway
Nepal
New Zealand
Pakistan
Panama
Peru
Philippines
Papua New Guinea
Portugal
Paraguay
Russian Federation
Rwanda
Saudi Arabia
Senegal
Singapore
Solomon Islands
Sierra Leone
El Salvador
Sweden
Syrian Arab Republic
Chad
Togo
Thailand
Trinidad and Tobago
Tunisia
Turkey
United States
Venezuela, RB
South Africa
Congo, Dem. Rep.
Zambia
Zimbabwe