Does Uncertainty Affect Economic Growth? An Empirical Analysis

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Source: *Weltwirtschaftliches Archiv*, 1999, Bd. 135, H. 3 (1999), pp. 379-396
Published by: Springer
Stable URL: https://www.jstor.org/stable/40440728

Does Uncertainty Affect Economic Growth? An Empirical Analysis

By

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I. Introduction

Since the seminal paper by Barro (1991) the interest in empirical growth research has increased substantially. The major goal of this type of literature is to identify the variables which have a robust effect on economic growth in a cross-section of countries (see, in particular, Levine and Renelt (1992), King and Levine (1993), Sala-i-Martin (1997a, 1997b), and Sachs and Warner (1997)). Since economic theory provides a wide class of possible determinants, the methodology to identify the "true" explanatory variables is extremely important. Usually, a large set of possible explanatory variables is constructed and regression analysis is used to identify the variables which have a statistically significant impact on economic growth. Although a common problem with this type of empirical work has been to establish the robustness of the outcomes of the empirical growth equations, Levine and Renelt (1992) and Sala-i-Martin (1997a, 1997b) provide some useful stability tests for the reliability of the results. Using the latter methodology we can focus again on the selection of the appropriate variables.

In the debate on the selection of variables none of the recent empirical growth studies considers the effect of uncertainty on economic growth. This is a remarkable empirical vacuum, given that there is now a vast theoretical literature that emphasizes the importance of uncertainty for economic growth. Most of these theoretical studies examine how uncertainty affects private investment, and hence indirectly economic growth (see, for instance, Lucas and Prescott (1971), Arrow (1968), Abel (1983), Bernanke (1983), Caballero (1991), Abel and Eberly (1994), and Dixit and Pindyck (1994)). There are also lively de-

Remark: We would like to thank Gerard Kuper, Victor Murinde and an unknown referee for useful comments.

bates on the impact of inflationary uncertainty on economic growth, the effects of exchange rate variability on trade and growth, and the consistency and predictability of fiscal policy in the long run. In addition, some studies examine the effects of uncertainty on investment at the firm level (for a survey, see Leahy and Whited (1996)). At the macro level the few examples of papers on the growth-uncertainty relationship we are aware of are the studies of Aizenman and Marion (1993) and Brunetti and Weder (1998). Aizenman and Marion look at the effects of macroeconomic uncertainty on private investment for a cross-section of countries. Brunetti and Weder examine the effect of institutional uncertainty on total investment. Both studies find evidence of a negative effect of uncertainty on investment, but do not present a robustness analysis, casting doubts on the reliability of the results.

This paper presents evidence of the effects of uncertainty on economic growth by performing a Barro-type growth regression in which different uncertainty measures are taken into account. We include measures of uncertainty related to fiscal policy, financial markets, and goods prices. We use a sample of about 100 countries over the years 1970–1995. The main innovative feature of the paper is that it uses an extreme bounds stability analysis (EBA) and a stability analysis in line with Sala-i-Martin (1997a, 1997b) in order to test for the reliability of the regression outcomes, thus heralding the application of this battery of techniques to the literature on uncertainty and economic growth.

The remainder of the paper is structured as follows. Section II explains how we measure uncertainty in a cross-section of countries. Section III gives the regression results and presents the stability tests. Section IV concludes.

II. The Measurement of Uncertainty

In order to consider the effect of uncertainty on economic growth, we first need to quantify uncertainty. There are two broad classes of techniques available to measure uncertainty in empirical studies: ex post versus ex ante approaches. The former constructs uncertainty measures based on the historical data of the process that generates the random variables of concern. This group of methods includes the measures: (1) normal statistical variance; (2) variance of the unpredictable part of a stochastic process; (3) the conditional variance estimated from the General AutoRegressive Conditional Heteroskedastic (GARCH)-type models; (4) the variance estimated from the geometric Brownian motion.

The ex ante method mainly refers to the variance derived from survey data. The main advantage of using survey data to derive uncertainty measures, compared with the methods in the ex post class, is that uncertainty measures are able to represent individual perceptions of risks based on the information available to individual agents. However, it requires a large amount of respondents to obtain reliable data if applied to more than 100 countries. Moreover, the survey data approach is based on the assumption that subjective probability distributions of events reflect objective probability distributions.

In practice, many studies apply ex post methods in deriving uncertainty measures in empirical studies. For discrete observations, the variance of the unpredictable part of a stochastic process and the GARCH-type modeling of volatility are the most popular ones, especially for the studies at the macro level. Theoretically speaking, the GARCH-type modeling of volatility is able to offer a more precise measure of uncertainty in the sense that it allows the time dependence of the second moment of random variables. It is more relevant in case the time series display clustering, such as financial market data. However, the application of the GARCH-type modeling to measure volatility requires high-frequency observations and long time series. In addition, the common criticism on the GARCH-type modeling of volatility is the possible misspecification of the conditional mean equation. On the other hand, constructing uncertainty measures by computing the variance of the unpredictable part of a random variable seems to be more flexible. It has no restriction on the length of the observations. As long as the Markov property is preserved, all kinds of autoregressive processes can be applied to forecast the predictable part of the random variable of concern. The possible disadvantage of this approach is that it is based on the assumption that either the unconditional variance of a random variable is constant or the conditional variance converges to a constant term, which might not always be the case in practice.

There are not so many guidelines on the preferred approach. The choice of methods used to quantify uncertainty appears to be mainly based on the data available. Bo and Sterken (1999) compare the GARCH-type modeling of the interest rate volatility with the variance of the unpredictable part of the autoregressive process that generates the interest rate. With respect to investment equations, they find strong evidence that the latter performs at least as good as the former. Moreover, qualitative conclusions on the effect of uncertainty on investment and therefore probably also on economic growth seem to be independent of the uncertainty measure used.

Because of data restrictions, we proxy uncertainty by determining the variance of the unpredictable part of the stochastic process. Since the data set consists of annual observations, and hence are not high-frequency observations, we decided not to use a GARCH-type approach. This method of measuring uncertainty can be summarized as follows:

(1) Setting up a forecasting equation for the underlying uncertainty variable.
(2) Estimating the forecasting equation to get the unpredictable part of the fluctuations of that variable, i.e. the estimated residuals.
(3) Computing the conditional standard deviations of the estimated residuals as the uncertainty measure of the concerned variable.

This method has been applied by Aizenman and Marion (1993), Ghosal (1995b), Ghosal and Loungani (1996, 1997), and Peeters (1997).

More specifically, the forecasting equation we use is a second-order autoregressive process of the form

$$P_t = a_1 + a_2 T + a_3 P_{t-1} + a_4 P_{t-2} + e_t, \tag{1}$$

where P_t is the variable under consideration; T is a time trend; a_i ($i = 1, \ldots, 4$) are the parameters, and e_t is a white-noise error term. The precise form of the forecasting equation is important. One needs to have white-noise residuals. Equation (1) is in fact a second-order Augmented Dickey Fuller equation including a constant and a trend. Using annual data this specification yields white-noise residuals in our sample.

The equation is estimated for each country over the sample period (1970–1995). The basic data set consists of 138 countries (the countries in the Barro-Lee data set), and contains some developed and many developing countries. For each country, uncertainty with respect to an explanatory variable (e.g., P) is measured by the standard deviation of the residuals.

We concentrate on 6 types of uncertainty (see Appendix for a list of variables):

EBUD: uncertainty with respect to the budget deficit (P variable = *BUDDEF*)
ETAX : uncertainty with respect to taxes (P variable = *TAXGDP*)
EGOVC: uncertainty with respect to government consumption (P variable = *GOVCGDP*)
EEXP: uncertainty with respect to export sales (P variable = *EXPGDP*)
ERINTR: uncertainty with respect to real interest rate (P variable = *RINTR*)
EINFL: uncertainty with respect to inflation (P variable = *INFL*)

The uncertainty measures proxy for export uncertainty (EEXP), uncertainty with respect to fiscal policies (EBUD, ETAX and EGOVC), and price uncertainty (ERINTR and EINFL).

The uncertainty measure is determined per country. This implies that the forecasting equation used to determine the uncertainty measure may differ per country. Hence, in theory, it might be the case that for some countries an autoregressive process of a different order would be more appropriate. Moreover, it might be the case that for some countries the equation should not contain a trend, whereas for other countries a trend is highly appropriate. In other words, the equation used to determine the uncertainty measure may be accurate for some countries in the data set, whereas a slightly different specification would be preferred for other countries in the data set. However, the analysis would not be tractable when we allow for differences in the forecasting equation per country. Therefore, we decided to use the uniform specification of forecasting equation per country. For reasons of space it is not possible to present detailed estimation results of the forecasting equation.[1] We tested the chosen specification by also estimating the base models with uncertainty measures which are determined in a slightly different way. More precisely, we tested the robustness of the specification chosen by considering the effect of an increase in uncertainty on economic growth when the uncertainty measure is determined by a first-order autoregressive process with a trend, a third-order autoregressive process with a trend, and a second-order autoregressive process without trend. It appeared that the results are very similar so that the results do not depend on the precise order of the autoregressive process, nor on the inclusion of a trend. To give some more insights in this, we do present the results concerning a different specification of EGOVC (see Table 1a).

III. Regression Results and Stability Analyses

We estimate the following cross-section model:

$$PCGROWTH = \alpha_j + \beta_{ij} I + \beta_{mj} M + \beta_{zj} Z_j + \mu, \qquad (2)$$

where *PCGROWTH* is the per capita growth rate of GDP; I is a vector of "commonly used" variables; M is the variable of interest, namely one of the uncertainty measures; Z_j is a vector of three variables taken from a pool of N available domestic and international macroeconomic variables identified by past studies as being potentially important explana-

[1] The estimation results per country can be obtained from the authors on request.

tory variables of economic growth. For each model *j*, we are interested in estimates of the coefficient β_{mj} and the corresponding standard deviation in the extreme bounds stability analysis.

We proceed by first describing which variables are commonly included in the regression (the vector of variables *I*). It can be observed that, based on Sala-i-Martin (1997a, 1997b) and many other studies, the initial level of the logarithm of per capita GDP (*LGDPPC*) and the initial secondary-school enrollment rate (*SENR*) are always included in growth regressions. Based on King and Levine (1993) we also include the money and quasi-money to GDP ratio (*MGDP*). Finally, we also include the investment to GDP ratio (*INVEST*). This proxies for some form of physical capital accumulation. Levine and Renelt (1992) show that the average share of investment has a positive and robust effect on economic growth, which suggests that the investment share should always be included in the growth regressions. However, in many growth regressions the investment share is not included (see, for instance, Barro (1991), Roubini and Sala-i-Martin (1992), Burnside and Dollar (1996), Sala-i-Martin (1997a), and Sachs and Warner (1997)). The argument for excluding the investment share is that the interpretation of parameter estimates changes in case the investment rate is included. If the investment share is included, the variable is said to affect growth via the "level of efficiency", whereas in the case of exclusion it is unclear whether it affects growth via investment or via efficiency (Sala-i-Martin 1997b). This interpretation holds for all variables, of course, but it is especially important for investment given its important role in growth theory (Sala-i-Martin 1997b). In our analysis this discussion typically holds. Uncertainty may have a direct effect on economic growth. However, through its effects on the incentives to invest, it may also indirectly affect economic growth. In order to make this distinction, we perform estimations in which *INVEST* is not included and a set of estimations in which *INVEST* is always included. Hence, the *I* vector contains *LGDPPC, SENR, MGDP*, and *INVEST* or only *LGDPPC, SENR*, and *MGDP* .

We first analyze the model in which all above-mentioned *I* variables are included. The results are presented in column 1 of Table 1. The equations show that the *I* variables are all significant and have the expected signs and magnitudes.

LGDPPC is included in order to account for the conditional convergence effect. The sign is expected to be negative. In line with Barro and Sala-i-Martin (1995: Ch. 12), Sala-i-Martin (1997a, 1997b), and many other recent empirical analyses of economic growth of a cross-section

Table 1 – *Uncertainty and Economic Growth*

	1	2	3	4	5	6	7
	Base model 1 (with the investment share)						
LGDPPC	−0.007	−0.005	−0.007	−0.006	−0.006	−0.007	−0.007
	(−3.43)	(−1.97)	(−3.54)	(−3.44)	(−3.56)	(−2.86)	(−3.30)
SENR	0.04	0.03	0.04	0.03	0.03	0.04	0.04
	(3.44)	(2.01)	(3.37)	(2.45)	(2.60)	(2.96)	(3.42)
MGDP	0.03	0.03	0.02	0.03	0.03	0.03	0.02
	(3.09)	(4.10)	(2.41)	(3.30)	(3.02)	(2.68)	(2.63)
INVEST	0.137	0.161	0.172	0.145	0.162	0.134	0.137
	(4.78)	(5.21)	(5.91)	(5.78)	(5.23)	(4.55)	(4.68)
CONST	0.013	−0.001	0.015	0.015	0.011	0.013	0.013
	(1.11)	(−0.08)	(1.33)	(1.41)	(0.99)	(1.01)	(1.06)
Ad. Var.		*EBUD*	*ETAX*	*EGOVC*	*EEXP*	*ERINTR*	*EINFL*
		−0.003	−0.006	−0.005	−0.003	−1.2E-05	-5.97E-06
		(−3.26)	(−2.66)	(−4.82)	(−2.61)	(−0.113)	(−1.72)
Statistics							
R^2	0.52	0.61	0.57	0.62	0.57	0.50	0.53
Obs.	95	72	89	95	95	86	95
MDEPV	0.013	0.012	0.013	0.013	0.013	0.013	0.013
SDDEPV	0.019	0.020	0.019	0.019	0.019	0.019	0.019
F	26.10	23.08	24.53	31.28	26.31	18.29	21.83
	Base model 2 (without the investment share)						
LGDPPC	−0.007	−0.004	−0.007	−0.006	−0.006	−0.007	−0.007
	(−2.83)	(−1.33)	(−2.59)	(−2.84)	(−2.81)	(−2.47)	(−2.72)
SENR	0.03	0.03	0.04	0.03	0.03	0.03	0.03
	(2.95)	(1.70)	(2.74)	(2.02)	(2.34)	(2.51)	(2.94)
MGDP	0.05	0.06	0.04	0.05	0.05	0.05	0.05
	(5.85)	(4.99)	(5.23)	(5.84)	(6.26)	(5.43)	(5.51)
CONST	0.034	0.019	0.040	0.037	0.035	0.037	0.033
	(2.34)	(1.23)	(2.57)	(3.02)	(2.54)	(2.18)	(2.31)
Ad. Var.		*EBUD*	*ETAX*	*EGOVC*	*EEXP*	*ERINTR*	*EINFL*
		−0.003	−0.004	−0.004	−0.0015	3.39E-05	-5.94E-06
		(−3.62)	(−1.71)	(−4.10)	(−1.09)	(0.32)	(−1.63)
Statistics							
R^2	0.39	0.45	0.39	0.47	0.40	0.38	0.40
Obs.	95	72	89	95	95	86	95
MDEPV	0.013	0.012	0.013	0.013	0.013	0.013	0.013
SDDEPV	0.019	0.020	0.019	0.019	0.019	0.019	0.019
F	20.84	15.37	14.83	21.83	16.82	13.80	16.35

Note: Dependent variable: *PCGROWTH*. R^2 = adjusted R^2; Obs. = amount of observations; MDEPV = mean of the dependent variable; SDDEPV = standard deviation of the dependent variable; F = F-statistic. The t-values are between parentheses. t-values are based on White heteroskedasticity-consistent standard errors (this applies to all tables).

of countries, we test the *logarithm* of real per capita GDP. The logarithmic form is suggested by theoretical derivations of the convergence rate (see, e.g., Barro and Sala-i-Martin (1995: Chapter 2) and Barro and Sala-i-Martin (1991)).[2] It appears that for both models *LGDPPC* is highly significant and has the correct sign. The coefficient on *LGDPPC* is about 0.007, which suggests that for each country the convergence to its steady state is achieved at 0.7 percent rate per year. Sala-i-Martin (1997b) finds a convergence rate of 1.3 percent per year. A similar convergence rate is suggested by the studies of Roubini and Sala-i-Martin (1991) and Sachs and Warner (1997). In many studies of Barro, the convergence rate seems to be even somewhat higher: between 2 and 2.5 percent (see Barro and Sala-i-Martin 1995). Hence, the implied convergence rate suggested by our study is low as compared to other studies. Obvious explanations for this are differences in the set of countries, the estimation period, as well as the group of fixed variables included in the base regression. Probably it is also caused by the fact that, in contrast to the above mentioned studies, we have used World Bank data on GDP per capita growth and the initial level of GDP per capita. The other studies mentioned above use Summers and Heston estimates for per capita GDP growth rates and GDP per capita. Barro and Sala-i-Martin (1995: 445) show that the speed of convergence using Summers-Heston data is about twice as high as the speed of convergence using World Bank data.

SENR proxies for the initial stock of human capital. The sign is expected to be positive. It should however be noted that, although almost all growth studies include a measure of human capital, this variable is not always robust. Moreover, the initial stock of human capital is also often approximated by the primary school enrollment rate. Theoretically it is not clear which variable is to be preferred. We estimated the base models by using both the primary and the secondary school enrollment

[2] It should be noted that in many studies the initial GDP per capita, and not the log of the inital GDP per capita is included in the model (see, for instance, Barro (1991) and Levine and Renelt (1992)). Roubini and Sala-i-Martin (1992) test both the initial GDP per capita and the log of the initial GDP per capita. They show that the results are essentially the same. The only advantage of using the logarithmic transformation is that the coefficient can be interpreted as an elasticity, and consequently gives direct information about the speed of convergence towards the steady-state growth rate. Given the fact that we are not primarily interested in the speed of convergence, for our study it does not really matter whether we do or do not use logs. We estimated the equations using the initial level of GDP per capita as well as by using the log of GDP per capita. Also in our case the results did not really differ. In the text we presented the results using the log of GDP per capita, but the other estimates can be obtained on request.

rate. The outcomes appear to be similar. We have presented the results for the secondary school enrollment rate since *SENR* performed somewhat better than the primary school enrollment rate.[3] Our base model estimates suggest a coefficient on *SENR* between 0.03 and 0.04, which is in line with several recent growth regressions. Compare, for instance, Roubini and Sala-i-Martin (1992) and Barro (1991). They find the coefficient for *SENR* to be between 0.006 and 0.035.

MGDP measures financial development of a country. As said before, the inclusion of *MGDP* is mainly based on the work of King and Levine (1993), who show that financial development has a robust and significant effect on economic growth. King and Levine use different indicators for financial development. Since our study does not primarily deal with the effects of financial development and economic growth, we only consider the effect of one measure of financial development. We use the most well-known indicator, the money and quasi money to GDP ratio, which is seen as a measure of financial depth. This measure is comparable to the ratio of liquid liabilities of the financial sector to GDP (*LLY*) used by King and Levine (1993). They find a coefficient on *LLY* which varies between 0.024 and 0.033, which is comparable to the coefficient on *MGDP* in our study. Our base models suggest a coefficient on *MGDP* between 0.03 and 0.05.

Finally, the coefficient on *INVEST* is 0.134 in base model 1, which is in line with Levine and Renelt (1992) and Sala-i-Martin (1997b). In these studies the coefficient on *INVEST* is between 0.09 and 0.175. Hence, based on the regression results as presented in column 1 in Table 1, and the comparison of our outcomes with that of other recent growth regressions, our base model appears to perform reasonably in line with well-known results in the literature.

Next, we add, one by one, the different uncertainty measures. These results are shown in columns 2–7 in Table 1. The tables suggest that most uncertainty variables have a negative effect on economic growth. Only uncertainty with respect to the real interest rate does not seem to have a significant effect on economic growth. The results, in general, apply both to the model in which *INVEST* is taken into account as well as to the model in which *INVEST* is not included. This suggests that uncertainty not only affects economic growth via the investment level, but also via the level of efficiency. The model including *INVEST* outperforms the

[3] The regression results using the primary enrollment rate can be obtained on request. It appears that the coefficient for the primary school enrollment rate is somewhat lower than that of *SENR*.

Table 1a – *Uncertainty and Economic Growth: Different Specifications of Uncertainty Measure*

	1	2	3	4
LGDPPC	−0.0065 (−3.44)	−0.0064 (−3.36)	−0.0065 (−3.46)	−0.0064 (−3.42)
SENR	0.028 (2.45)	0.027 (2.47)	0.027 (2.43)	0.028 (2.51)
MGDP	0.026 (3.30)	0.026 (3.02)	0.027 (3.36)	0.027 (3.37)
INVEST	0.1451 (5.78)	0.1442 (5.71)	0.1443 (5.73)	0.144 (5.72)
CONST	0.0153 (1.41)	0.0148 (1.36)	0.0153 (1.42)	0.0150 (1.38)
Ad. Var.	*EGOVC*	*EGOVC1*	*EGOVC3*	*EGOVNT*
	−0.0047 (−4.82)	−0.0045 (−4.77)	−0.0048 (−4.90)	−0.0044 (−4.76)
Statistics				
R^2	0.62	0.61	0.62	0.62
Obs.	95	95	95	95
MDEPV	0.013	0.013	0.013	0.013
SDDEPV	0.019	0.019	0.019	0.019
F	31.28	30.86	31.58	31.77

Note: See Table 1 for an explanation of the symbols.

model excluding *INVEST*. Except for the model including *EBUD*, all *I* variables retain their significance, signs, and magnitudes.

As mentioned in the previous section, we tested the uncertainty measure by estimating the base models using a different specification of equation (1). Table 1a gives the result for base model 1 when *EGOVC* is determined by using a first-order autorogressive process with a trend (*EGOVC1*), a third-order autoregressive process with a trend (*EGOVC3*), and a second-order autoregressive process without a trend (*EGOVNT*). The table clearly shows that the results are very similar.

We also estimated a set of equations in which we include *INVEST* as well as an interaction term between *INVEST* and the different uncertainty measures. The interaction term tests whether the positive effect of an increase in investment on economic growth is affected by uncertainty. If the interaction term is negative, and the coefficient on *INVEST* is still positive, this would suggest that the positive effect of investment on economic growth is partly undone by a more uncertain environment. The regression results of this set of regressions are presented in Table 2. The table gives some evidence for a negative effect of uncertainty on economic growth via this channel: in four out of the six cases the interaction term is significant with a negative sign, while the other variables retain their original significance and magnitudes.

Table 2 – *Uncertainty and Economic Growth: Estimates with Interaction Term*

	1	2	3	4	5	6
LGDPPC	–0.005	–0.007	–0.007	–0.007	–0.007	–0.007
	(–2.10)	(–3.58)	(–3.73)	(–3.54)	(–2.83)	(–3.29)
SENR	0.03	0.04	0.03	0.03	0.04	0.04
	(1.97)	(3.41)	(2.45)	(2.69)	(2.96)	(3.41)
MGDP	0.03	0.02	0.03	0.03	0.03	0.02
	(4.09)	(2.25)	(3.12)	(3.02)	(2.63)	(2.60)
INVEST	0.196	0.208	0.187	0.185	0.135	0.138
	(6.52)	(6.52)	(6.89)	(5.03)	(4.52)	(4.69)
CONST	–0.008	0.006	0.009	0.005	0.013	0.012
	(–0.60)	(0.62)	(0.82)	(0.44)	(0.98)	(1.04)
Interaction term	*EBUD*	*ETAX*	*EGOVC*	*EEXP*	*ERINTR*	*EINFL*
	–0.014	–0.027	–0.022	–0.008	–7.8E-05	-3.2E-05
	(–3.19)	(–3.09)	(–4.93)	(–1.46)	(–0.154)	(–1.82)
Statistics						
R^2	0.61	0.59	0.62	0.55	0.50	0.53
Obs.	72	89	95	95	86	95
MDEPV	0.012	0.013	0.013	0.013	0.013	0.013
SDDEPV	0.020	0.019	0.019	0.019	0.019	0.019
F	23.19	25.99	32.22	23.96	18.30	21.87

Note: The interaction term refers to an interaction term between *INVEST* and one of the uncertainty measures. For instance, the interaction term *EBUD* is measured as INVEST*EBUD. See also Table 1.

To test the reliability of the above results, a group of domestic and international macroeconomic variables is added to the estimations as presented in Tables 1 and 2. The selection of the set of domestic and international macroeconomic variables, out of which the *Z* variables are drawn, is based on those identified by Sala-i-Martin (1997a) as being important for economic growth. The following variables are included in the various models estimated:

(1) Political variables: We consider an index for civil liberties (*CIVIL*), an index of political rights (*PRIGHTS*), a war dummy (*WARDUM*), and a measure of political instability (*PINSTAB*).
(2) Policy variables to measure market distortions: We use the black market premium (*BMP*), the inflation rate (*INFL*), and the standard deviation of inflation (*STDINFL*).

(3) Measures of openness: We have included the trade to GDP ratio (*TRADE*), an alternative measure of free trade openness (*FREE-OP*), and the export to GDP ratio (*EXPGDP*).
(4) Financial development indicators: We include some other proxies for financial development, such as credit to the private sector as a percentage of GDP (*CREDITPR*), the deposit rate (*DEPR*), the real interest rate (*RINTR*), and the real exchange rate (*REXCHR*).
(5) Indicators of capital flows: We include the foreign aid to GDP ratio (*AIDGDP*), bank lending as a percentage of GDP (*BANKL*), and foreign direct investment as a percentage of GDP (*FDI*).
(6) Foreign debt indicators: We include the debt to GDP ratio (*DEBTGDP*) as well as the debt service to GDP ratio (*DEBTS*).
(7) Some other policy variables: The government budget deficit as a percentage of GDP (*BUDDEF*), government expenditures as a percentage of GDP (*GOVCGDP*), and taxes as a percentage of GDP (*TAXGDP*).

Hence, the total pool of *Z* variables contains 22 variables. We perform, for each uncertainty measure, regressions for all possible combinations of three out of the above-presented set of 22 variables. This implies that 1540 (22!/(19! 3!)) estimates have been performed per uncertainty measure.

The procedure of the Extreme Bounds Analysis (EBA) is as follows. For each regression *j*, we find an estimate β_{mj} and a standard deviation σ_{mj}. The lower extreme bound is the lowest value of $\beta_{mj} - 2\sigma_{mj}$, whereas the upper bound is the maximum value of $\beta_{mj} + 2\sigma_{mj}$. If the upper extreme bound for variable *M* is positive and the lower extreme bound is negative (i.e., the sign of the coefficient β_{mj} changes), then variable *M* is not robust according to the EBA analysis.

The results of the EBA analysis are given in the columns *High* and *Low* in Table 3. Results for *ERINTR* are not presented, since the base regressions already show that *ERINTR* does not have a significant effect on economic growth. It can be seen that in all cases there is a sign switch, so that none of the uncertainty measures robustly affects economic growth when the EBA analysis is used. However, this is not remarkable given the fact that 1,540 estimates per uncertainty measure are done, and the EBA analysis implies that, if in only one of the 1,540 regressions the measure is not significant, the analysis indicates "not robust." For this reason, Sala-i-Martin (1997a, 1997b) comes up with an alternative robustness test. His analysis comes down to looking at the entire distribution of the coefficient β_m, instead of a zero-one (ro-

Table 3 – *Stability Test*

	R^2	Coef	St. error	CDF	High	Low	Percent
			Base model 1, including INVEST				
EBUD	0.64	–0.003	0.0009	0.998	0.003	–0.010	0.83
ETAX	0.62	–0.005	0.0020	0.996	0.005	–0.018	0.88
EGOVC	0.66	–0.005	0.0012	1.000	0.004	–0.016	0.96
EEXP	0.66	–0.004	0.0009	1.000	0.002	–0.014	0.96
EINFL	0.58	–6.6E-06	12.6E-06	0.709	4.78E-04	-5.67E-04	0.29
			Base model 2, excluding INVEST				
EBUD	0.53	–0.003	0.001	0.998	0.004	–0.010	0.83
ETAX	0.47	–0.004	0.002	0.960	0.006	–0.019	0.53
EGOVC	0.53	–0.004	0.001	0.998	0.006	–0.016	0.88
EEXP	0.50	–0.003	0.001	0.986	0.005	–0.014	0.53
EINFL	0.46	–10.58E-06	12.98E-06	0.791	4.82E-04	–5.78E-04	0.13
			Based on a model with an interaction term between INVEST and the uncertainty proxy				
EBUD	0.63	–0.012	0.004	0.997	0.017	–0.043	0.82
ETAX	0.63	–0.025	0.008	0.999	0.017	–0.079	0.97
EGOVC	0.66	–0.021	0.005	1.000	0.022	–0.078	0.96
EEXP	0.64	–0.013	0.004	0.999	0.011	–0.008	0.66
EINFL	0.58	–1.1E-04	0.760E-04	0.929	16.51E-04	–42.94E-04	0.40

Note: R^2: the average adjusted R^2 of all regressions; Coef: the average coefficient of all regressions; St. error: the average standard error of all regressions; CDF: cumulative distribution function; High: the highest value for the coefficient plus 2 times the standard error; Low: the lowest value for the coefficient minus two times the standard error; Percent: the percentage of all cases in which the coefficient for the uncertainty measure is significant at the 90 percent level.

bust-fragile) decision and calculating the fraction of the cumulative distribution function lying on each side of zero. By assuming that the distribution of the estimates of the coefficients is normal and calculating the mean and the standard deviation of this distribution, the cumulative distribution function (CDF) can be calculated. His methodology starts by computing the point-estimates of β_{mj} and the standard deviation σ_{mj} per regression. The mean estimate of the coefficient and the average variance are then calculated as $\bar{\beta}_m = (\sum \beta_{mj})/n$ and $\bar{\sigma}_m^2 = (\sum \sigma_{mj}^2)/n$.

The mean estimate of the coefficient and the average standard error are the mean and the standard deviation of the assumed normal distribution. In Table 3, the mean estimate is given by the column Coef, the mean standard deviation by the column St. error. Finally, by using a table for the (cumulative) NORMAL distribution, it can be calculated which fraction of the cumulative distribution function is on the right or left hand side of zero. In Table 3 CDF denotes the largest of the two areas. If CDF is above 0.95, it is concluded, according to this analysis, that the uncertainty measure has a robust effect on economic growth.

Using the latter stability analysis, it appears that four of the uncertainty measures, *EBUD*, *ETAX*, *EGOVC*, and *EEXP* have a robust and negative effect on per capita economic growth. This applies for the models in which *INVEST* is included, for the model in which it is not included, and for the models in which the uncertainty measures are interacted with *INVEST*. *EINFL* does not have a robust effect on economic growth.

Finally, we present in the last columns of both tables the percentage of all regressions for which the uncertainty measure is significant at the 90 percent level. The four "robust" uncertainty measures have a significant effect on per capita growth in the majority of the regressions. It also appears that in a few regressions *EINFL* has a significant negative effect, suggesting that also inflationary uncertainty is important for explaining economic growth.

IV. Summary and Conclusion

This paper examines the effect of different uncertainty measures on per capita GDP growth for a cross-section of countries for the 1970–1995 period. The results clearly confirm the relevance of uncertainty for economic growth. Four out of the six measures for uncertainty considered appear to have a robust and negative effect on economic growth. The uncertainty measures directly related to fiscal government policies, i.e., the uncertainty with respect to government expenditures, taxes, and the budget deficit, are highly significant and have a robust and negative effect on per capita growth. Sales uncertainty, as measured by exports, also has a robust and negative effect on economic growth. We also find some evidence for a significant and negative effect of inflationary uncertainty on economic growth. It should be noted that our results indicate that monetary uncertainty is less damaging for economic growth than fiscal uncertainty. Our results support the notion that predictability of especially fiscal policy and credibility of governments stimulate economic growth by lowering uncertainty. Policy that stabilizes trade also helps in creating more growth per capita. These outcomes underline the utmost importance of a stable macroeconomic environment for per capita economic growth.

Appendix: List of Variables

AIDGDP = development aid as a percentage of GDP
BANKL = bank and trade related lending as a percentage of GDP
BMP = black market premium, calculated as (black market rate/official rate) – 1
BUDDEF = overall budget deficits, including grants, as a percentage of GDP
CIVLIB = index of civil liberties
CREDITPR = credit to the private sector as a percentage of GDP
DEBTGDP = the external debt to GDP ratio
DEBTS = total external debt service as a percentage of GDP
DEPR = the deposit rate (%)
EBUD = uncertainty with respect to government budget deficit
EEXP = uncertainty with respect to exports
EGOVC = uncertainty with respect to government consumption expenditures
EGOVC1= uncertainty with respect to government consumption expenditures, different specification
EGOVC3= uncertainty with respect to government consumption expenditures, different specification
EGOVNT= uncertainty with respect to government consumption expenditures, different specification
ERINTR = uncertainty with respect to real interest rate
ETAX = uncertainty with respect to taxes
EXPGDP = exports of goods and services as a percentage of GDP
FDI = foreign direct investment as a percentage of GDP
FREEOP = measure of free trade openness (calculates as 0.528–0.026 log(AREA) –0.095 (DIST), where
AREA = size of land and DIST = average distance to capitals of 20 major exporters in the world
GOVCGDP = government consumption as a percentage of GDP
INFL = the annual inflation rate
INVEST = average investment to GDP ratio over 1970–1995 period
LGDPPC = logarithmic value of GDP per capita in 1970
MGDP = average money and quasi money to GDP ratio over the 1970–1995 period
PCGROWTH = average real per capita growth rate over 1970–1995 period
PINSTAB = measure of political instability
PRIGHTS = index of political rights

REXCHR = real exchange rate
RINTR = real interest rate
SENR= primary school enrollment rate in 1970
STDINFL = the standard deviation of the annual inflation rate, calculated from the inflation figures
TAXGDP = total taxes as a percentage of GDP
TRADE = exports plus imports to GDP ratio, measuring the degree of openness
WARDUM = dummy variable giving a one to countries that participated in at least one external war during the period 1960–1985, and a zero to all other countries.

The source for all variables is *World Development Indicators*, 1997 (World Bank, available on CD-Rom), except for BMP, CIVLIB, FREEOP, PINSTAB, PRIGHTS and WARDUM which are obtained from the Barro-Lee data set, and the uncertainty measures which are calculated by the authors. The variables coming from the Barro-Lee data set refer to averages for the 1970–1990 period. Unless otherwise stated, all other variables refer to averages over the 1970–1995 period.

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Abstract: Does Uncertainty Affect Economic Growth? An Empirical Analysis. – This paper investigates the effect of uncertainty on economic growth. We construct measures of export uncertainty, government policy uncertainty and price uncertainty to augment a growth model, and using econometric techniques we test for robustness of the effects of these measures on economic growth in a cross-section of 138 developing and developed economies during the 1970–1995 period. The result clearly shows a robust and negative effect of uncertainty on economic growth. These results underline the importance of export stability and policy credibility. JEL no. O40, D81, E62

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Zusammenfassung: Beeinflußt Unsicherheit das wirtschaftliche Wachstum? Eine empirische Untersuchung. – Die Verfasser untersuchen den Einfluß von Unsicherheit auf das wirtschaftliche Wachstum. Sie entwickeln Maße für die Unsicherheit am Beispiel der Exporte, Regierungspolitik und Preise, um ein Wachstumsmodell auszubauen. Danach testen sie ökonometrisch die Robustheit der Wirkungen dieser Maße auf das wirtschaftliche Wachstum eines Querschnitts von 138 Industrie- und Entwicklungsländern in der Zeit von 1970 bis 1995. Das Ergebnis zeigt deutlich einen robusten und negativen Einfluß von Unsicherheit auf das wirtschaftliche Wachstum. Dies unterstreicht die Bedeuting stabiler Exporte und einer verläßlichen Politik.