Is there an Uncertainty-Laffer Curve?

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Som-theme E: Financial markets and institutions

Abstract

This paper examines the impact of uncertainty on the capital-output ratio and per capita growth for a group of developed countries. Uncertainty seems to have non-linear effects on economic growth and positive effects on the capital-output ratio.

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1. **Introduction**

The relationship between uncertainty and capital stock is far from clear. One body of literature emphasizes that uncertainty has positive effects. This result is traceable to the assumptions of perfect competition and constant returns to scale (Caballero, 1991). The marginal product of capital is then a convex function of uncertainty variables and hence the higher uncertainty the higher the marginal productivity of capital. This encourages risk neutral firms to invest more (Hartman (1972) and Abel (1983)). Another body of literature points at negative effects of uncertainty. This literature argues that a firm has the right but not the obligation to buy the sequence of future cash flows that are generated by the investment project by paying a certain amount of investment costs. If investment is irreversible an increase in uncertainty raises the option value, leading to a delay in investment (e.g McDonald and Siegel (1986), Dixit and Pindyck (1994)).

As is often the case, empirical studies are lagging behind. Although most empirical studies provide support for a negative effect of uncertainty (for references see Lensink, Bo and Sterken, 2000), more empirical studies are needed to better understand how uncertainty affects investment and hence the capital stock.

This paper provides new empirical evidence on the impact of uncertainty on the aggregate capital-output ratio and per capita growth. The contribution is threefold. First, the study deals with a cross-section of developed countries. There is a lack of studies using a panel of more wealthy economies. This is unfortunate since these countries have much better capital markets, which give investors more possibilities to diversify risk. This may affect an investor's response to an increase in uncertainty. Second, the uncertainty measure is derived from information on the volatility of individual countries' stock market indices. Stock returns reflect any aspect of a firm's environment. This enables to use a general measure of uncertainty so that the problem of pinpointing the exact source of uncertainty is circumvented (Pindyck (1986, 1991) and Leahy and Whited, (1996)). A drawback is that the volatility in stock market returns may be caused by speculative bubbles instead of fundamentals (Ferderer, 1993). Finally, the paper explicitly tests for non-linear effects of uncertainty. The proposition to be tested is that low levels of uncertainty have favorable effects, whereas high levels of uncertainty negatively influence the economy. This is a well-

known phenomenon in the inflation literature, but has never been explicitly tested by the literature on the relationship between uncertainty and macroeconomic aggregates.

2 The Uncertainty Measure

The aim of the study is to examine the impact of uncertainty on per capita economic growth (*PCGROWTH*) and the capital to GDP ratio (*CAPSTGDP*) for a group of developed countries.[1] The empirical analysis refers to the 1970-1997 period. In order to employ the dynamic properties of the data, the total period is divided in five periods of five years (1970-1974; 1975-1979; 1980-1984; 1985-1989), and one seven-year time interval (1990-1997). Since recent data for the capital stock are not available, the estimates for the capital-output ratio (*CAPSTGDP*) ignore the last period.

The division of the total period in several sub-periods implies that for each time interval, and for each country in the sample, measures for uncertainty are needed. The literature distinguishes several methods to measure uncertainty (see Lensink, Bo and Sterken, 2000, chapter 6). For the problem at hand, the General Autoregressive Conditional Heteroskedastic (GARCH) model of volatility is most appropriate. A GARCH model assumes that the variance of the error terms is not constant over time, which is often documented to be the case for stock market data. The GARCH (1,1) technique is used in this paper. It comes down to jointly estimating a mean equation for the country stock market index and an additional equation for the conditional variance which depends on a lagged value of the squared error terms and a lagged value of the conditional variance.

The mean equation for each country *i* is specified as follows:

$$MSCI_{i,t} = \beta_{i,1} + \beta_{i,2}\, MSCI_{i,t-1} + \beta_{i,3} WORLD_t + \varepsilon_{i,t}$$

where *MSCI* is the Morgan Stanley monthly country index and *WORLD* is the Morgan Stanley monthly World index.[2] *t* refers to monthly time periods. *WORLD* is included in the mean equation to account for correlations of a countries stock market volatility with foreign countries stock market volatility.

The equation for the conditional variance (σ^2) is specified as:

$$\sigma^2_{i,t} = \alpha_{i,0} + \alpha_{i,1}\varepsilon^2_{i,t-1} + \alpha_{i,2}\,\sigma^2_{i,t-1}$$

The mean equation and the conditional variance equation are estimated for each sub-periods of five or seven year, yielding monthly conditional variances. The uncertainty measure per country for each sub-period is defined as the average conditional variance (*AGAR*) over the sub-period:

$$AGAR_{i,h} = \Sigma_t \sigma^2_{i,t}/n$$

where the subscript *h* is a time index referring to the 5 or 7 years period; *n* is the amount of observations in the sub-period.[3]

3 Regression results

The analysis starts by estimating the following equations:

$$(1)\ PCGROWTH = \alpha_{i,1} + \alpha_2 LGDPPCI + \alpha_3 LSEC + \alpha_4 INF1 + \alpha_5 TRAD1 + \alpha_6 AGAR + \mu$$
$$(2)\ CAPSTGDP = \alpha_{i,1} + \alpha_8 LGDPPCI + \alpha_9 LSEC + \alpha_{10} INF1 + \alpha_{11} TRADI + \alpha_{12} AGAR + \mu$$

Where *LGDPPCI* is the logarithm of the begin-of-period per capita real GDP; *LSEC* is the logarithm of the average period secondary-school enrollment rate, *INF1* is the one period lagged inflation rate, *TRAD1* is the one period lagged trade to GDP ratio and μ is an error term. The regressions use a "fixed" effect estimator, allowing the intercept to vary by country.

LGDPPC is included to account for the conditional convergence effect. The logarithmic form is suggested by theoretical derivations of the convergence rate (Barro and Sala-i-Martin, 1995). The sign is expected to be negative. *LSEC* proxies for human development and its sign is expected to be positive. *INFL1* and *TRAD1* are included since inflation and trade openness are often found to be relevant conditioning variables in the growth regressions literature.[4] The literature gives less guidance as to which variables are important for explaining *CAPGDP*. For reasons of convenience, the same independent variables as for *PCGROWTH* are used. [5]

The regression results for the base equations are presented in Table 1, equations 1 and 2. The table suggests that an increase in uncertainty negatively affects *CAPSTGDP*. This seems to confirm the negative relationship found in many other studies. The coefficient for the uncertainty proxy in the growth regression is also negative, although not significant at the usual significance levels. The next step is to reestimate the base equations by ignoring some relatively high values for *AGAR*.[6] Equations 3 and 4 ignore the observations with values of *AGAR* above 10,000. For *PCGROWTH* this implies that the number of observations decreases by four, for *CAPSTGDP* they only decrease by two since the last period is not taken into account in the estimates.[7] Quite interestingly, the regression results now suggest a positive relationship between uncertainty on the one hand, and economic growth and the capital output ratio on the other.[8]

<insert Table 1 about here>

This result indicates that some extremely high values for the uncertainty proxy causes uncertainty to have negative effects. If these extreme values are ignored, the relationship is positive. This may imply that uncertainty has non-linear effects. In order to test this proposition, the next estimates include a quadratic term. Estimation results for the entire set of observations are presented in equations 5 and 6 in Table 2. It appears that the linear term is significantly positive, whereas the quadratic term is significantly negative. This suggests the existence of an uncertainty-Laffer curve: low levels of uncertainty display positive effects, but above some level of uncertainty, uncertainty starts to have negative effects. However, these estimates may be driven by the extreme outliers. Therefore, equations 7 and 8 ignore the extremely high values for *AGAR*. With respect to *PCGROWTH* the linear term is again significantly positive and the quadratic term is significantly negative. However, this result is not robust for *CAPSTGDP*.[9]

4. Conclusions

The paper finds evidence for a positive effect of uncertainty on per capita economic growth for low levels of uncertainty, and negative effects of uncertainty on per capita economic growth for high levels of uncertainty. This suggests the existence of an uncertainty Laffer curve. There is also some evidence for a similar connection between uncertainty and the capital-output ratio. However, this relationship does not seem to be robust. If anything can

be concluded, an increase in uncertainty seems to enhance the aggregate capital-output ratio for the countries in the sample.

Appendix1: List of Variables and sources

AGAR = Uncertainty Measure. Own calculation: the mean of conditional variances over 5 year periods. The conditional variance is derived from a GARCH (1,1) estimate using monthly data for the Morgan Stanley Country Index (*MSCI)*.

$AGAR^2$ = the quadratic value of *AGAR*.

CAPSTGDP = The average aggregate capital stock to GDP ratio. Calculated by dividing figures for the real value of the aggregate capital stock by the Summers-Heston real value of GDP. Both variables are obtained from Easterly and Yu (1999). The capital stock data are originally derived from Easterly and Levine (2000). They are obtained by disaggregated investment figures.

CAPSLAB = The average aggregate capital stock to workers ratio. Obtained from Easterly and Yu (1999).

INFL1 = The one period (5 years) lagged average inflation rate. Source: Easterly and Yu (1999). Original source: Global Development Finance & World Development Indicators.

LGDPPCI = The logarithm of the begin of period value of real GDP *per capita* in constant dollars (international prices, base year 1985). Source: Easterly and Yu (1999). Original source: Penn World Table 5.6.

LSEC = The logarithm of the average secondary school enrollment rate. Source: Easterly and Yu (1999). Original source: Global Development Finance & World Development Indicators.

MSCI = Morgan Stanley Country Index. Downloaded from *DATASTREAM*.

PCGROWTH = The average real per capita growth rate. Calculated from real GDP *per capita* data in constant dollars. Source: Easterly and Yu (1999). Original source: Penn World Table 5.6 (Summers-Heston data). Missing data calculated from 1985 GDP *per capita* and GDP *per capita* growth rates (Global Development Finance & World Development Indicators).

TRADE1 = The one period (5 years) lagged average value of exports plus imports divided by GDP for the 1970-1997 period. Source: World Bank (1999).

Appendix2: Countries in the Sample

Australia, Belgium, Austria, Canada, Denmark, France, Hong Kong, Italy, Japan, Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, United Kingdom and United States,

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Table 1: Uncertainty, per capita economic growth and the capital-output ratio

Equation	1	2	3	4
Dep. Var.	*PCGROWTH*	*CAPSTGDP*	*PCGROWTH*	*CAPSTGDP*
LGDPPCI	-0.064462 (-5.33)	0.001944 (0.008)	-0.085825 (-6.62)	-0.221884 (-0.74)
LSEC	0.023812 (1.24)	0.208360 (1.25)	0.011891 (0.80)	0.323963 (2.44)
INF1	-0.001132 (-3.93)	0.005146 (1.80)	-0.001113 (-3.83)	0.005353 (2.33)
TRADE1	0.000138 (1.09)	0.006836 (2.08)	0.000256 (2.70)	0.007208 (2.37)
AGAR	-1.03E-07 (-1.45)	-1.73E-05 (-2.49)	5.75E-06 (2.89)	6.44E-05 (2.53)
adj. R^2	0.68	0.85	0.74	0.88
F	45.64	86.73	55.73	107.59
Obs.	78	57	74	55

t-values between parenthesis. They are based on White Heteroskedasticity consistent standard errors. This also holds for Table 2.

Table 2: The uncertainty-Laffer curve

Equation	5	6	7	8
Dep. Var.	*PCGROWTH*	*CAPSTGDP*	*PCGROWTH*	*CAPSTGDP*
LGDPPCI	-0.070327 (-5.75)	-0.098691 (-0.42)	-0.090429 (-8.00)	-0.163658 (-0.54)
LSEC	0.024519 (1.30)	0.370620 (2.44)	0.012040 (0.80)	0.242578 (1.60)
INF1	-0.001084 (-3.70)	0.005517 (2.23)	-0.000679 (-2.18)	0.003049 (1.24)
TRADE1	0.000160 (1.35)	0.005633 (2.03	0.000220 (2.93)	0.009236 (2.50)
AGAR	1.11E-06 (2.02)	4.34E-05 (3.22)	1.61E-05 (5.36)	-1.18E-05 (-0.17)
$AGAR^2$	-7.57E-12 (-2.28)	-1.69E-09 (-4.58)	-2.13E-09 (-4.26)	1.33E-08 (1.42)
adj. R^2	0.69	0.88	0.76	0.89
F	39.26	86.01	50.42	87.19
Obs.	78	57	74	55

[1] For a list of countries see Appendix2

[2] I had to use monthly indices since weekly or daily country indices are not available for the entire estimation period, 1970-1997. Leahy and Whited (1996) suggest that using monthly, weekly or daily returns do not affect the qualitative results.

[3] I also proxied the uncertainty measure by using the median of the conditional variances over the sample period and by using the standard deviation of the residuals of the mean equation over the sub-period. This did not change the qualitative results since the correlation coefficient between the three measures appears to be above 0.9.

[4] I also estimated the equations without *INF1* and *TRAD1*. This did not affect the results concerning the uncertainty proxy. Note that many studies use the Sachs-Warner dummy to proxy for uncertainty. Moreover, many studies show the relevance of political variables. I have not considered the Sachs-Warner dummy or different proxies for political stability since for my set of developed countries the values of these dummies are almost the same for all countries. For instance, the Sachs-Warner dummy is 1 for all countries in the data set.

[5] I tested for multicollinearity between the different explanatory variables by considering correlation coefficients. There does not seem to be a problem.

[6] The mean for *AGAR* (2730) is substantially higher than the median (149), which reflects that *AGAR* suffers from skewness.

[7] The ignored observations refer to Hong Kong and Sweden.

[8] I have done some sensitivity tests by varying the threshold for *AGAR* above which I ignore observations between 500 and 10000. In almost all of these estimates the coefficients for *AGAR* were significantly positive. This especially holds for the estimates concerning *PCGROWTH*. Most importantly, I never found a significant negative sign for *AGAR* anymore.

[9] I did sensitivity tests by varying the threshold value of *AGAR* between 10.000 and 500. The Laffer curve outcome appears to be quite robust for *PCGROWTH*, but not for *CAPSTGDP*. The turning point of the Laffer curve can be estimated for the uncertainty-*PCGROWH* relationship. It equals 3790 for the estimate in which extreme values for *AGAR* are ignored. However, note that since most of the observations are on the left-hand side of the top, the precise value of the optimum is unreliable. I also tested whether the outcome still holds when the uncertainty measure is proxied as AGAR over the mean of the index. This gave qualitatively the same results.