Federal Reserve Bank of Minneapolis
Research Department

COMMENT ON ROMER, "CRAZY EXPLANATIONS FOR THE PRODUCTIVITY SLOWDOWN"

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Christiano, 11/6/87.

Comment on Romer, "Crazy Explanations for the Productivity Slowdown".

One way to think of Paul's paper is that it takes as its benchmark, or starting point, the Solow growth model, in which the factors that give rise to sustained growth in variables like output and consumption are exogenous technological progress and population growth. What the paper does is to cite a variety of evidence which is asserted to be inconsistent with the Solow model, and then to argue that this evidence can be accounted for by Paul's preferred alternative model. This involves positive externalities in capital investment and negative externalities in labor.

The evidence that receives the most attention is the analysis of long time averages of growth in output, labor, and the stock of capital. Paul states that the time averages ought to be long enough so that business cycle movements have been removed, and the growth rates are roughly in line with underlying steady state growth rates (p.183). (Some reasons for using long time averages rather than the quarterly observations are given in the paper.) Paul carries out regression and simple correlation analyses on these time averages. In my comments I'll offer a perspective on the results that is very different from Paul's

1. Regressions.

The paper regresses output growth on capital stock growth and labor growth, and reports a coefficient close to unity on capital growth and close to zero on labor. Paul argues that this is inconsistent with the implications of the Solow model, which he claims implies a coefficient of about .25 on capital growth and .75 on labor growth. He then goes on to say that his preferred model can account for this regression result. Essentially, the effect of the positive externality on capital is to raise capital's coefficient above capital's share of income, and the negative externality on labor reduces its coefficient below labor's share of income.

I disagree with the premise of this argument, which is that the empirical regression results are incompatible with the Solow model. On the contrary, they are precisely what it predicts. Furthermore, I conjecture that they are the prediction of any growth model with the so-called "balanced growth property", meaning that output growth and physical capital growth are the same in steady state (or, on average, in a stochastic setting.) In particular, they cannot be used to descriminate between any model in the class of balanced growth models. Thus, if Paul's preferred alternative model has this property, regressions like these cannot be used to descriminate between his model and the Solow model. On the other hand, if his model does not have the balanced growth property, then I don't know what its implications are for regressions like this, and I don't think the paper spells them out.

The information on pages 1-5 of the handout summarizes my argument. One way to think of the Solow model is that it assumes that the economy "decouples" in such a way that the factors that give rise to technology growth and to population growth are unrelated to decisions about hours worked and capital investment. Thus, according to it, the observed differences in output growth and per capita output growth observed among different countries reflect those countries' different g's and λ's. Since these are exogenous, the Solow model says nothing about how they are distributed. Presumably, any distribution of these variables is consistent with the Solow model, since they are, after all, exogenous. Of course, the exogeneity of the λ's and g's is not very useful if you're interested in explaining what accounts for differences in growth rates. This conference is a symptom of the fact that increasing numbers of researchers are interested in explaining these differences.

2. Correlations Between Labor Productivity Growth and Hours Growth

Figure 1 (page 182) reports the correlation analysis I referred to above. Paul's analysis of this graph assumes that the 20 year averages it reflects approximate the underlying steady state growth (p.183). From the Solow perspective, then, it is the graph of population growth and the rate of exogenous technological progress. But these are exogenous variables in this perspective, and we have no reason to believe they should be positively, negatively or uncorrelated. Thus, I don't see these results as an embarassment to the Solow perspective.

Nevertheless, in looking at Figure 1, I thought data like this might be useful for descriminating between alternative models of endogenous growth. In general, we know from the work of Romer and Lucas, that g is a function of the remaining parameters of the model, including, possibly, λ. For example, in Lucas' human capital model (with and without externalities on human capital) g is an increasing function of λ. The lines in Figure 1 would therefore seem to rule out this model. If Romer where to flesh out his preferred model, then it would imply a functional relation between g and λ that is perhaps consistent with Figure 1.

Conclusion

In conclusion, I don't think that the reported correlations and regressions on long run averages of output growth, capital growth and labor growth provide a basis for abandoning the Solow model. I think there are other reasons for doing this, but this is not one of them. Second, assuming we remain in the balanced growth environment, I doubt that "long run" regressions can be used to descriminate between alternative models. Third, correlations between growth in labor productivity and hours growth might be useful, but to interpret them requires deriving the functional relation between g and λ. I believe that this in turn requires specifying more than just the economy's production function, as this paper does.

Comment on Romer

"Crazy Explanations for the Productivity Slowdown"

Central equation of Solow Model:

$$Y(t) = K(t)^{\alpha} \left[z(t) L(t) \right]^{(1-\alpha)}$$

$$z(t) = \exp(gt)$$

On steady state growth path:

$$\hat{Y} = g + \lambda$$

$$\hat{K} = g + \lambda$$

$$\hat{L} = \lambda$$

λ ~ exogenous rate of population growth

g ~ exogenous rate of "technology" growth

$\hat{Y}_i, \hat{L}_i, \hat{K}_i$ ~ long run sample average for country (subperiod) i, $i = 1, 2, 3, \ldots$

Approximately,

$$\hat{Y}_i = g_i + \lambda_i$$
$$\hat{K}_i = g_i + \lambda_i$$
$$\hat{L}_i = \lambda_i$$

Regression:

$$\hat{Y}_i = c + \beta_1 \hat{K}_i + \beta_2 \hat{L}_i + \varepsilon_i$$

UNIQUE OLS SOLUTION:

$$c = 0, \ \beta_1 = 1, \ \beta_2 = 0,$$

if $\mathrm{Var}\begin{pmatrix} \lambda_i \\ g_i \end{pmatrix}$ nonsingular.

Example

ECONOMY i, $i=1,\ldots,500$:

(Tastes) $$E_0 \sum_{t=0}^{\infty}\left(\frac{1}{1.01}\right)^t \left\{\ln C_t^i - .00263\left(L_t^i / N_t^i\right)\right\}$$

(Techn.) $$C_t^i + K_{t+1}^i - (1-.018)K_t^i \leq \left(Z_t^i L_t^i\right)^{.61}\left(K_t^i\right)^{.39}$$

$$N_t^i = N_{t-1}^i \exp(\lambda_i)$$

$$Z_t^i = Z_{t-1}^i \exp(g_i + \eta_t) \qquad \eta_t \sim NID(0, .019^2)$$

$$\lambda_i \sim UNIFORM(.001, .005)$$

$$g_i \sim UNIFORM(.001, .005)$$

FOR EACH i, generated 1 realization

$$\{\hat{Y}_t^i, \hat{K}_t^i, \hat{L}_t^i, t=1,\ldots,112\}$$

$$\hat{Y}^i = \frac{1}{112}\sum_{t=1}^{112}\hat{Y}_t^i \qquad \hat{K}^i = \frac{1}{112}\sum_{t=1}^{112}\hat{K}_t^i$$

$$\hat{L}^i = \frac{1}{112}\sum_{t=1}^{112}\hat{L}_t^i$$

(4)

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RATS Version 2.03.  10/09/86
  Copyright (C) 1986,1985,1984 by VAR Econometrics
cal 1 1 1
all 0 100,1
ieval end = (100,1)
open data romer
data(org=obs,format='(3(3x,g12.6))') 1,1 end ydot hdot kdot
ols ydot 1,1 end                                  ↑    ↑    ↑
#hdot kdot                                        Ŷ    L̂    K̂


DEPENDENT VARIABLE      1      YDOT
FROM      1:  1  UNTIL    100:  1
OBSERVATIONS              100      DEGREES OF FREEDOM      98
R**2                .96881295      RBAR**2            .96849472
SSR            .18797528E-04      SEE             .43796290E-03
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Q(  30)=    21.3781        SIGNIFICANCE LEVEL  .875693
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***      *******     ***   ***    ************    ************    ************
  1       HDOT         2    0     .4483241E-01    .3708859E-01    1.208792
  2       KDOT         3    0     .9907294        .1874989E-01    52.83920


ols ydot 1,1 end
#constant hdot kdot


DEPENDENT VARIABLE      1      YDOT
FROM      1:  1  UNTIL    100:  1
OBSERVATIONS              100      DEGREES OF FREEDOM      97
R**2                .97203841      RBAR**2            .97146188
SSR            .16853433E-04      SEE             .41682938E-03
DURBIN-WATSON  1.78453325
Q(  30)=    29.4539        SIGNIFICANCE LEVEL  .493859
NO.       LABEL      VAR   LAG     COEFFICIENT    STAND. ERROR     T-STATISTIC
***      *******     ***   ***    ************    ************    ************
  1       CONSTANT     0    0    -.4361232E-03    .1303793E-03   -3.345033
  2       HDOT         2    0     .1048039        .3959097E-01    2.647166
  3       KDOT         3    0    1.026049         .2073498E-01    49.48397


end

         NORMAL COMPLETION OF JOB
                   HALT AT     0
                       0 ERRORS          0 WARNINGS
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