APPENDIX

APPENDIX 1 THE SOLOW'S GROWTH MODEL

The Solow Model is the starting point for almost all analyses of growth. The principal conclusion of the Solow Model is that the accumulation of physical capital cannot account for the vast growth overtime in output per person.

ASSUMPTIONS

1. The production function takes the form

$$Y(t) = F(K(t), A(t)L(t))$$

where Y = output

K = capital

AL = effective labor (technology progress is known as labor-augmenting @ Harrod – Neutral)

2. Constant Return to Scale – doubling the quantities of capital and effective labor doubles the amount produced.

$$\text{For all } c \geq 0,\ F(cK, cAL) = cF(K, AL)$$

$$\text{Setting } c = 1/AL,\ F(K/AL, 1) = 1/AL.F(K, AL)$$

where K/AL = capital per unit of effective labor

F(K, AL)/AL= output per unit of effective labor

$$\text{Define } k = K/AL,\ y = Y/AL,\ f(k) = F(k,1), \text{ therefore } y = f(k)$$

Output per unit of effective labor depends only on the quantity of capital per unit of effective labor.

3. The model is set in continuous time.

4. The initial levels of K, L and A are taken as given. L and A grow at constant rates.

$$dL(t)/dt = L(t) = nL(t)$$

$$dA(t)/dt = A(t) = gA(t)$$

5. Output is divided between consumption and investment. The fraction of output devoted to I and S is exogenous and constant. Existing capital depreciates at rate δ.

Therefore K(t) = sY(t) – δK(t)

THE DYNAMICS OF THE MODEL

2 of the 3 inputs, L and A are exogenous, therefore the dynamics of K:

k = δk/δK . K + δk/δL . L + δk/δA . A

= K/AL – K/(AL)^2 . (AL + LA)

= K/AL – K/AL . L/L – K/AL . A/A

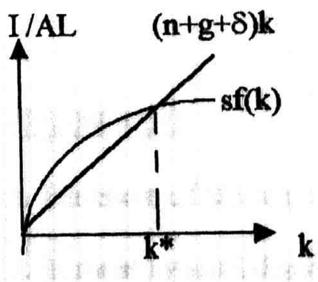
Define K/AL = k, L/L = n, A/A = g, k = sY -δK substituting the above equations,

k = (sY – δK)/AL – kn – kg

= sY/AL – δk –kn –kg

-Y/AL = f(k), therefore k = sf(k) – (n+g+δ)k ----- **Key Equation of the Solow Model**

This key equation implies that the rate of change of the capital stock per unit effective labor is the different between actual investment per unit of effective labor (sf(k)) and break-even investment (the amount of investment that must be done just to keep k at its existing level –(n+g+δ)k).

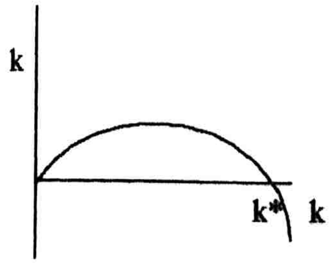


When actual I > break-even I : k is rising

When actual I < break-even I : k is decreasing

When actual I = break-even I : k is constant

The 2 lines intersect once at k = k*, where actual I = break-even I



If k is < k* : k is positive, i.e. k is rising

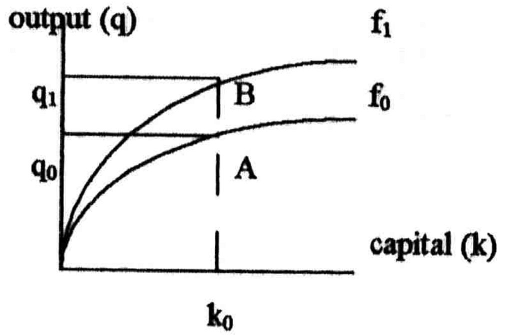
If k is > k* : k is negative, i.e. k is decreasing

If k = k* : k is zero, i.e. k is constant

Regardless of where k starts, it converges to k*.

Therefore, the Solow Model implies that regardless of its starting point, the economy converges to a Balance Growth Path (BGP)– a situation where each variable of the model is growing at a constant rate. On BGP, the growth of Y/L is determined solely by the rate of technological progress.

Improvements in technical progress is expected to increase the overall productivity and thus enable the economy to generate a larger output relative to given available resources and hence a shift to a higher growth path.



EVIDENCE

1. Fits most of the major stylized facts about growth (Kaldor, 1961)
2. In most industrialized countries, growth rates of L, K and Y are roughly constant.

Appendix 2: Input Data Y= Af(K,L)

obs	GDP	K	L	LNKL1	LNY1	Y
1970	11325770	2028630.	3340.000	NA	NA	3390.949
1971	11434400	2239070.	3467.000	0.061381	-0.027773	3298.067
1972	11979280	2548020.	3599.000	0.091890	0.009186	3328.502
1973	13819420	2803240.	3735.000	0.058368	0.105805	3699.979
1974	14223510	3339620.	3877.000	0.137767	-0.008492	3668.690
1975	15508330	3890280.	4020.000	0.116404	0.050261	3857.794
1976	19014900	4201760.	4177.000	0.038711	0.165534	4552.286
1977	20891470	4822350.	4340.000	0.099477	0.055837	4813.703
1978	22334980	5219830.	4542.000	0.033710	0.021320	4917.433
1979	26293520	6438500.	4700.000	0.175636	0.128973	5594.366
1980	28621730	8299160.	4816.900	0.229291	0.060276	5941.940
1981	52015500	18923430	5009.700	0.785001	0.558130	10382.96
1982	53947410	19607760	5122.800	0.013199	0.014143	10530.84
1983	58138820	20958440	5244.800	0.043080	0.051288	11085.04
1984	63844300	20378010	5564.700	-0.087291	0.034408	11473.09
1985	61988010	17685050	5624.600	-0.152443	-0.040213	11020.87
1986	57018280	14996030	5706.500	-0.179390	-0.098025	9991.813
1987	64692430	14416400	5880.800	-0.069506	0.096185	11000.62
1988	87545650	16863080	6087.500	0.122215	0.267971	14381.22
1989	92784980	22623780	6297.400	0.259976	0.024225	14733.86
1990	98186260	29190750	6686.000	0.194971	-0.003297	14685.35
1991	1.67E+08	58670430	6891.000	0.667884	0.500411	24222.01
1992	1.74E+08	58361080	7096.000	-0.034602	0.011256	24496.19
1993	1.85E+08	65539520	7341.000	0.082060	0.026978	25166.04
1994	1.94E+08	76004820	7566.000	0.117954	0.017273	25604.52
1995	2.07E+08	88517420	7645.000	0.142015	0.055248	27058.93
1996	2.21E+08	90572150	8399.300	-0.071149	-0.025863	26368.08
1997	2.34E+08	97212430	8569.200	0.050726	0.036381	27345.03
1998	2.10E+08	65924810	8599.600	-0.391925	-0.113987	24399.13
1999	2.14E+08	56010930	8741.000	-0.179277	0.004529	24509.87

Table A1 Regression Results

LS // Dependent Variable is LNY1
Date: 02/07/01 Time: 10:24
Sample: 1971 1999
Included observations: 29
Excluded observations: 0 after adjusting endpoints

Variable	Coefficient	Std. Error	T-Statistic	Prob.
C	0.023947	0.016202	1.477973	0.1510
LNKL1	0.544753	0.068295	7.976459	0.0000

R-squared	0.702065	Mean dependent var	0.068206
Adjusted R-squared	0.691031	S.D. dependent var	0.147480
S.E. of regression	0.081977	Akaike info criterion	-4.936164
Sum squared resid	0.181446	Schwartz criterion	-4.841868
Log likelihood	32.42516	F-statistic	63.62389
Durbin-Watson stat	2.031732	Prob(F-statistic)	0.000000

Table A2 Regression Results

LS // Dependent Variable is LNY1
Date: 02/07/01 Time: 10:27
Sample: 1973 1999
Included observations: 27
Excluded observations: 0 after adjusting endpoints
Convergence achieved after 3 iterations

Variable	Coefficient	Std. Error	T-Statistic	Prob.
C	0.027174	0.011380	2.387859	0.0252
LNKL1	0.532876	0.055422	9.614886	0.0000
AR(2)	-0.431656	0.183502	-2.352320	0.0272

R-squared	0.768904	Mean dependent var	0.073946
Adjusted R-squared	0.749646	S.D. dependent var	0.151331
S.E. of regression	0.075719	Akaike info criterion	-5.057014
Sum squared resid	0.137601	Schwartz criterion	-4.913032
Log likelihood	32.95835	F-statistic	39.92645
Durbin-Watson stat	2.125994	Prob(F-statistic)	0.000000

Table A3 Regression Results

LS // Dependent Variable is LNY1
Date: 02/07/01 Time: 10:29
Sample: 1971 1985
Included observations: 15

Variable	Coefficient	Std. Error	T-Statistic	Prob.
C	0.011772	0.020399	0.577120	0.5737
LNKL1	0.609480	0.088705	6.870824	0.0000

R-squared	0.784083	Mean dependent var	0.078579
Adjusted R-squared	0.767474	S.D. dependent var	0.144027
S.E. of regression	0.069451	Akaike info criterion	-5.210701
Sum squared resid	0.062705	Schwartz criterion	-5.116294
Log likelihood	19.79618	F-statistic	47.20823
Durbin-Watson stat	2.242826	Prob(F-statistic)	0.000011

Table A4 Regression Results

LS // Dependent Variable is LNY1
Date: 02/07/01 Time: 10:31
Sample: 1986 1999
Included observations: 14

Variable	Coefficient	Std. Error	T-Statistic	Prob.
C	0.031619	0.026610	1.188224	0.2577
LNKL1	0.500906	0.108700	4.608170	0.0006

R-squared	0.638937	Mean dependent var	0.057092
Adjusted R-squared	0.608849	S.D. dependent var	0.155726
S.E. of regression	0.097394	Akaike info criterion	-4.526414
Sum squared resid	0.113828	Schwartz criterion	-4.435120
Log likelihood	13.81976	F-statistic	21.23523
Durbin-Watson stat	1.951584	Prob(F-statistic)	0.000602

Table A5 Regression Results

LS // Dependent Variable is LNY1
Date: 02/07/01 Time: 10:33
Sample: 1980 1989
Included observations: 10

Variable	Coefficient	Std. Error	T-Statistic	Prob.
C	0.042023	0.034171	1.229786	0.2537
LNKL1	0.568550	0.119241	4.768059	0.0014

R-squared	0.739705	Mean dependent var	0.096839
Adjusted R-squared	0.707168	S.D. dependent var	0.188046
S.E. of regression	0.101759	Akaike info criterion	-4.393436
Sum squared resid	0.082839	Schwartz criterion	-4.332919
Log likelihood	9.777796	F-statistic	22.73439
Durbin-Watson stat	2.125532	Prob(F-statistic)	0.001412

Table A6 Regression Results

LS // Dependent Variable is LNY1
Date: 02/07/01 Time: 10:34
Sample: 1990 1999
Included observations: 10

Variable	Coefficient	Std. Error	T-Statistic	Prob.
C	0.020240	0.025920	0.780893	0.4573
LNKL1	0.529715	0.096632	5.481784	0.0006

R-squared	0.789750	Mean dependent var	0.050893
Adjusted R-squared	0.763469	S.D. dependent var	0.164564
S.E. of regression	0.080035	Akaike info criterion	-4.873726
Sum squared resid	0.051245	Schwartz criterion	-4.813209
Log likelihood	12.17925	F-statistic	30.04995
Durbin-Watson stat	1.746878	Prob(F-statistic)	0.000586

Appendix 3: Input Data TFPG = f(C,E,F,M,T)

obs	CAP	EXPTS	FC	MANUG	TER
1970	17.91000	NA	12.34152	NA	NA
1971	19.58000	-4.221900	11.11222	0.095673	NA
1972	21.27000	-6.043600	9.693272	0.086336	NA
1973	20.28000	38.72690	7.666996	0.069785	NA
1974	23.48000	18.35710	6.071922	-0.026782	NA
1975	25.09000	-14.10270	5.074362	0.253370	NA
1976	22.10000	43.49210	4.233490	0.155744	NA
1977	23.08000	6.372000	3.520636	0.055287	NA
1978	23.37000	8.603800	2.914442	0.041503	NA
1979	24.49000	37.11630	2.377219	0.056922	NA
1980	29.00000	9.165100	1.940625	1.939677	3.600000
1981	36.38000	57.18530	1.608583	0.713583	3.800000
1982	36.35000	-1.790300	1.362683	-0.001009	4.000000
1983	36.05000	9.592400	1.174413	0.039833	4.200000
1984	31.92000	16.88490	1.007302	0.084174	4.300000
1985	28.53000	-2.668700	0.901448	-0.042099	4.700000
1986	26.30000	-7.453100	0.843359	0.069308	5.100000
1987	22.28000	26.90940	0.806700	0.125067	5.100000
1988	19.26000	19.06830	0.772990	0.147039	5.100000
1989	24.38000	18.81340	0.722322	0.110369	5.200000
1990	29.73000	12.62810	0.664788	0.122591	8.800000
1991	35.15000	84.54670	0.609794	0.765568	9.000000
1992	33.57000	4.486700	0.554894	0.055141	10.10000
1993	35.48000	13.29940	0.510847	0.090358	10.20000
1994	39.23000	20.92930	0.462716	0.107627	10.50000
1995	42.79000	16.89020	0.881237	0.104461	11.10000
1996	40.90000	4.104000	0.810504	0.085213	11.90000
1997	41.49000	9.621300	0.812633	0.095325	12.80000
1998	31.42000	23.01260	0.795384	-0.180089	13.20000
1999	26.14000	6.507400	NA	0.104274	NA

Table A7 Regression Results

LS // Dependent Variable is TFPG
Date: 02/07/01 Time: 10:45
Sample: 1980 1998
Included observations: 19
Excluded observations: 0 after adjusting endpoints

Variable	Coefficient	Std. Error	T-Statistic	Prob.
C	0.100207	0.087825	1.140982	0.2745
CAP	-0.007930	0.003104	-2.554539	0.0240
EXPTS	0.002303	0.000767	3.002545	0.0102
FC	0.144185	0.074245	1.942026	0.0741
MANUG	-0.137694	0.047516	-2.897826	0.0125
TER	0.006655	0.007415	0.897559	0.3857

R-squared	0.565688	Mean dependent var	0.030710
Adjusted R-squared	0.398644	S.D. dependent var	0.078027
S.E. of regression	0.060508	Akaike info criterion	-5.357884
Sum squared resid	0.047595	Schwartz criterion	-5.059640
Log likelihood	29.94007	F-statistic	3.386474
Durbin-Watson stat	1.831784	Prob(F-statistic)	0.035390