

## Lecture Handout 1

### 1. The “Facts” on economic growth

The attached Table of growth rates back to year 1000 is from Angus Maddison (2001), *The World Economy: A Millennial Perspective*, Paris: OECD.

The first Figure, showing development paths over the past two centuries, is from Angus Maddison (1995), *Monitoring the World Economy 1820-1992*, Paris: OECD.

The second Figure, showing the growth rates for 110 countries since 1960 plotted against their level of development in 1960, uses data from the Penn World Table.

Maddison’s “facts” must be qualified by recognition of problems of definition and measurement of economic output – should we include leisure, environmental amenity, health etc. See recent issues of the United Nations Development Programme’s “*Human Development Report*” which is available online through the library catalogue.

There are also considerable problems of comparing real output / income across countries whose price structures vary hugely. The index number problem in international comparisons is analysed in Dowrick, Steve and John Quiggin (1997), “True measures of GDP and convergence” *American Economic Review* 87 (1, March): 41-64.

### 2. The growth accounting approach

Maddison’s explanations for growth are based partly on the growth accounting approach which breaks down observed growth of output into components due to growth of labour and capital and other inputs. These are sometimes referred to as the ‘proximate’ causes of growth. The growth theories that we shall examine throughout the course attempt to explain the underlying factors that drive the growth of inputs and technology.

The growth accounting formula is derived by differentiating an aggregate production function with respect to time. Here I simplify to three inputs: two paid inputs: capital, K, and labour, L, and other inputs, aggregated to R, which are not paid. These other inputs might include the state of productive knowledge.

$$Y_t = f(K_t, L_t, R_t) \quad (1)$$

$$\frac{d \ln Y}{dt} = \frac{dY}{dt} \cdot \frac{1}{Y} \equiv \hat{Y} = \frac{f_K}{Y} \frac{dK}{dt} + \frac{f_L}{Y} \frac{dL}{dt} + \frac{f_R}{Y} \frac{dR}{dt} \quad (2)$$

$$\hat{Y} = \left( \frac{Kf_K}{Y} \right) \hat{K} + \left( \frac{Lf_L}{Y} \right) \hat{L} + r \quad (3)$$

where the ‘hat’ notation,  $\hat{z}_t$ , is used to represent the proportional or logarithmic rate of growth, and  $r$  is the growth impact of the unmeasured inputs. This term is sometimes referred to as the ‘Solow residual’, or as the rate of growth of MFP (multi-factor productivity) or TFP (total-factor productivity).

In equation (3) the bracketed terms on the right hand side define the elasticity of output with respect to capital and labour. If factor and product markets are perfectly competitive, capital and labour are paid their marginal products and the elasticities are equal to each factor’s share in national income,  $s_K$  and  $s_L$ . If the production function exhibits constant returns to scale with respect to capital and labour, these factor shares sum to unity, in which case we can write (3) as the conventional growth accounting formula:

$$\hat{Y} = s_K \hat{K} + (1 - s_K) \hat{L} + r \quad (4)$$

This formula is often used to measure the rate of MFP growth, using data on factor shares and the growth rates of output, capital and labour.

Of course there is no reason why the assumptions on competitive markets and constant returns to scale should hold in practice. Some studies choose to use equation (3) to estimate the output elasticities econometrically and hence to estimate MFP growth.

The production function is sometimes written in terms of special cases where the unobserved factor is defined as technology,  $A_t$ , which might be factor neutral or factor augmenting. For example:

$$Y_t = A_t^{FN} f(K_t, L_t) \quad \text{where } A_t^{FN} \text{ represents factor-neutral technology} \quad (5)$$

or

$$Y_t = f(K_t, [A_t L_t]) \quad \text{where } A_t \text{ represents labour-augmenting technology} \quad (6)$$

Note that taking logs of (5) and differentiating with respect to time yields a growth equation identical to the growth accounting formula (3) with  $r = \hat{A}_t^{FN}$ , i.e. the growth rate of factor-neutral technology is, by assumption, equivalent to the Solow residual or MFP growth.

Table 3-1a. Growth of Per Capita GDP, Population and GDP: World and Major Regions, 1000-1998  
 (annual average compound growth rates)

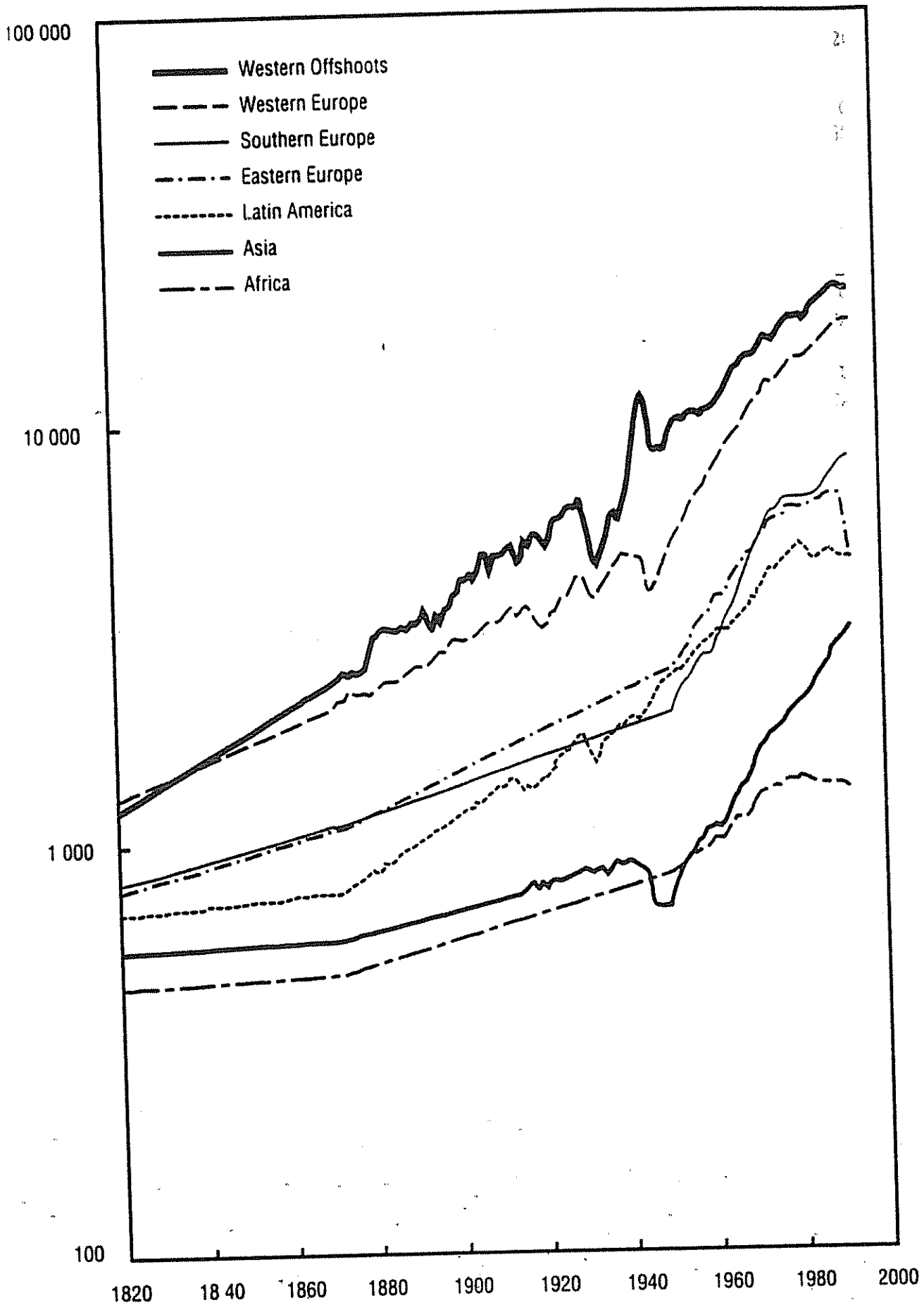
	1000-1500	1500-1820	1820-70	1870-1913	1913-50	1950-73	1973-98
<b>Per capita GDP</b>							
Western Europe	0.13	0.15	0.95	1.32	0.76	4.08	1.78
Western Offshoots	0.00	0.34	1.42	1.81	1.55	2.44	1.94
Japan	0.03	0.09	0.19	1.48	0.89	8.05	2.34
Asia (excluding Japan)	0.05	0.00	-0.11	0.38	-0.02	2.92	3.54
Latin America	0.01	0.15	0.10	1.81	1.42	2.52	0.99
Eastern Europe & former USSR	0.04	0.10	0.64	1.15	1.50	3.49	-1.10
Africa	-0.01	0.01	0.12	0.64	1.02	2.07	0.01
World	0.05	0.05	0.53	1.30	0.91	2.93	1.33
<b>Population</b>							
Western Europe	0.16	0.26	0.69	0.77	0.42	0.70	0.32
Western Offshoots	0.07	0.43	2.87	2.07	1.25	1.55	1.02
Japan	0.14	0.22	0.21	0.95	1.31	1.15	0.61
Asia (excluding Japan)	0.09	0.29	0.15	0.55	0.92	2.19	1.86
Latin America	0.09	0.06	1.27	1.64	1.97	2.73	2.01
Eastern Europe & former USSR	0.16	0.34	0.87	1.21	0.34	1.31	0.54
Africa	0.07	0.15	0.40	0.75	1.65	2.33	2.73
World	0.10	0.27	0.40	0.80	0.93	1.92	1.66
<b>GDP</b>							
Western Europe	0.30	0.41	1.65	2.10	1.19	4.81	2.11
Western Offshoots	0.07	0.78	4.33	3.92	2.81	4.03	2.98
Japan	0.18	0.31	0.41	2.44	2.21	9.29	2.97
Asia (excluding Japan)	0.13	0.29	0.03	0.94	0.90	5.18	5.46
Latin America	0.09	0.21	1.37	3.48	3.43	5.33	3.02
Eastern Europe & former USSR	0.20	0.44	1.52	2.37	1.84	4.84	-0.56
Africa	0.06	0.16	0.52	1.40	2.69	4.45	2.74
World	0.15	0.32	0.93	2.11	1.85	4.91	3.01

Source: Appendices A and B

Table 3-1b. Levels of Per Capita GDP and Interregional Spreads, 1000-1998  
 (1990 international dollars)

	1000	1500	1820	1870	1913	1950	1973	1998
Western Europe	400	774	1 232	1 974	3 473	4 594	11 534	17 921
Western Offshoots	400	400	1 201	2 431	5 257	9 288	16 172	26 146
Japan	425	500	669	737	1 387	1 926	11 439	20 413
Asia (excluding Japan)	450	572	575	543	640	635	1 231	2 936
Latin America	400	416	665	698	1 511	2 554	4 531	5 795
Eastern Europe & former USSR	400	483	667	917	1 501	2 601	5 729	4 354
Africa	416	400	418	444	585	852	1 365	1 368
World	435	565	667	867	1 510	2 114	4 104	5 709
Interregional Spreads	1.1:1	2:1	3:1	5:1	9:1	15:1	13:1	19:1

Figure 1.1. Levels of GDP per capita by region, 1820-1992



Source: Appendices A, C, and G.

Angus Maddison (1995)

Monitoring the World <sup>21</sup> Economy: 1820-1992

PARIS: OECD

# AVERAGE ANNUAL GROWTH 1960-2000

Source: Penn World Table v6.1

