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**Growth Rates, Economic Structures, and Energy Use**  
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**Macroeconomic Policy**

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## Chapter Three

### Growth Rates, Economic Structures, and Energy Use

This chapter is about the growth and development performance of non-industrialized countries in the latter part of the twentieth century, in particular the “great divergence” of their growth rates of per capita GDP from those of the industrial world since around 1980 until the early part of the 2000s that was illustrated in Chapter 2. The goal is to explore the factors underlying observed patterns of growth, and trace out plausible lines of causation for their diversity. The analysis follows Kuznets (1966) in attempting to organize the data in such a way as to highlight salient relationships, or the lack thereof, among key economic variables.

To keep the discussion within bounds, the data are organized in terms of 12 regional groups including 57 developing and transition countries: rapidly growing East Asian economies (or the “Tigers”), Southeast Asia, China, South Asia, semi-industrialized countries (mostly from Latin America but also South Africa and Turkey with economic structures similar to their counterparts in the Western Hemisphere), the smaller Andean countries, Central America and the Caribbean, “representative” and “other” countries in sub-Saharan Africa<sup>1</sup>, the Middle East and Northern Africa, Central and Eastern Europe, and Russia and Ukraine representing the former USSR. The nations in each group are listed in Appendix 3.1.

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<sup>1</sup> The representative group is made up of four countries often discussed in the development literature, and the others are included essentially on grounds of data availability.

## ***Divergence in the Twentieth Century and Patterns of Output Growth***

To set the discussion Figure 3.1 shows GDP and sectoral per capita output growth rates by region since 1970 in constant 1990 US dollars.<sup>2</sup> We identify three cohorts of regions and countries that had similar patterns of growth:

There was *sustained growth* in the Tigers, China, Southeast Asia, and South Asia (dominated by India) at rates substantially higher than the 2% target discussed in Chapter 1. Relative to the other regions, South Asia had less robust expansion and Southeast Asia did not bounce back as strongly from the 1997 crisis as did the Tigers. These regions “diverged upwardly” from the rest of the developing world.

The second, *slow growth* group includes the semi-industrialized countries, Central America and Caribbean, Central and Eastern Europe and the Middle Eastern and Northern African region. Many of these countries had grown at fair rates in the 1970s but then experienced a crisis either in the 1980s, the 1990s, or both, followed by growth in the late twentieth and, more commonly, in the early twenty-first century. Over the period 1970-2006, the Central and Eastern European region grew at comparable rates with those recorded by South Asians (3.9% vs. 4.2% per year) but because of the transition shock around 1990 it seems more appropriate to call its case one of slow growth followed by a late recovery. It must also be mentioned that the recent expansion in the Central and Eastern European countries has benefitted a great deal from

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<sup>2</sup> We use here data in constant US dollars rather than in the purchasing power parity (PPP) terms customarily utilized in international income comparisons (as for example in Chapter 2). The reason, as explained in Appendix 3.2, is that PPP estimates distort the macroeconomic relationships that are at the heart of our analysis in this and the following chapters. When it comes to policy formation, it is far more useful to think about macro relationships in traditional “real” terms (see, on this, Chapter 1).

geopolitical advantages related to their accession to European Union at the beginning of the twenty-first century.

Finally, the two African regions (with Other Africa dominated by Nigeria), the smaller Andean economies, the Middle East and Northern Africa, and Russia and Ukraine were either *stagnant* throughout the period or experienced volatile economic expansion. Along the lines discussed in Chapter 2, data from recent years show that Representative Africa, Russia and Ukraine, and some of the smaller Andean economies (notably Peru) began to grow again.

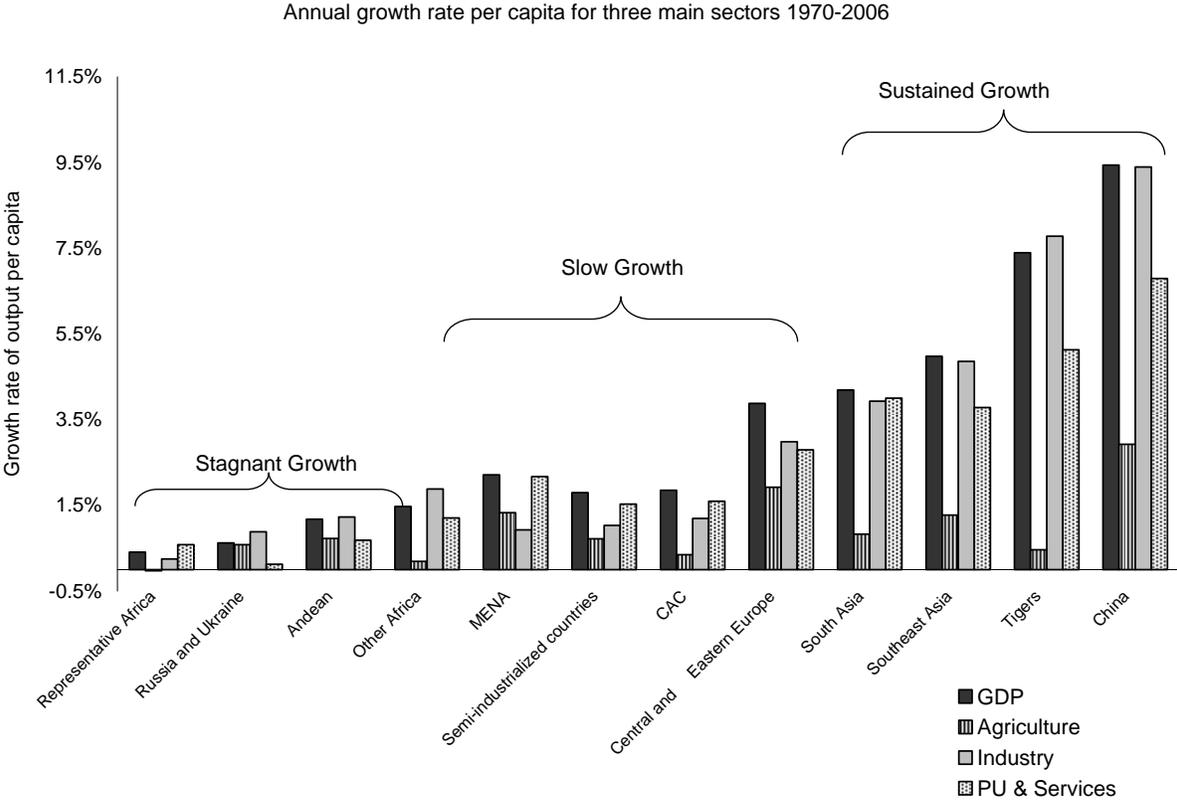


Figure 3.1: Sectoral growth rates 1970-2006  
 Source: UN National Accounts database.  
 Note: MENA stands for Middle East and northern Africa; CAC stands for Central America and the Caribbean

Differences in overall growth rates were closely associated with significant changes in the patterns of output growth. Figures 3.2 and 3.3 present scatter plots of

per capita GDP growth in agriculture and industry versus the percentage changes in their respective sectoral shares for all the regions. The rapidly growing Asian countries identified in Figure 3.1 showed substantial shifts in shares, in the classic movement from primary toward secondary and tertiary sectors.

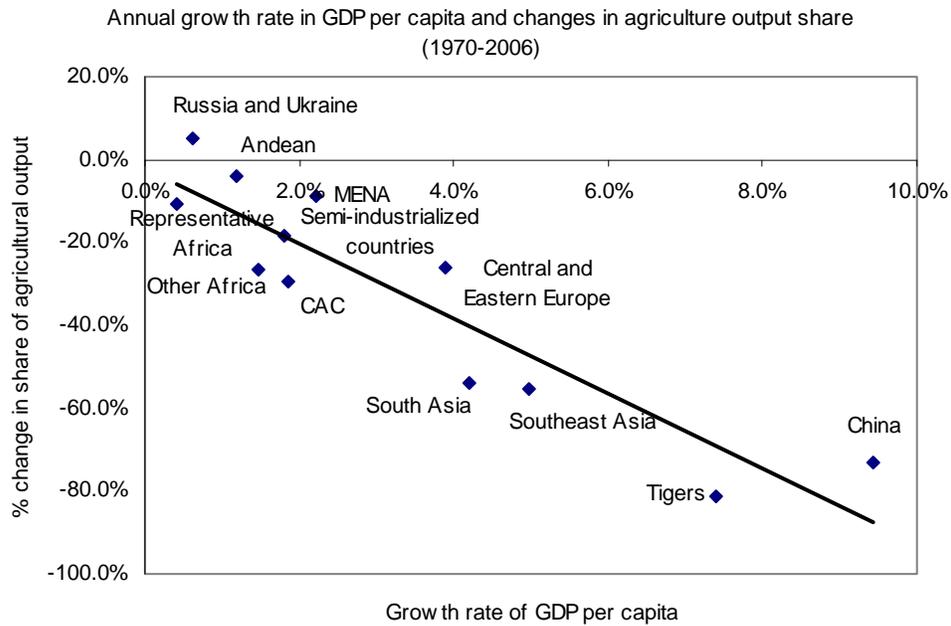


Figure 3.2: Growth performance and structural change in agriculture  
Source: UN National Accounts database.

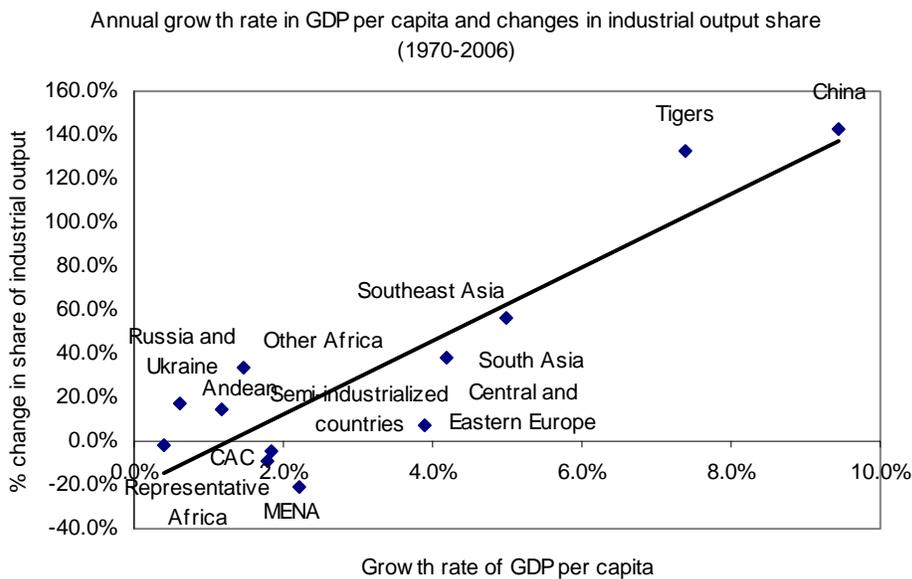


Figure 3.3: Growth performance and structural change in industry  
Source: UN National Accounts database.

Figure 3.2 for the agricultural share shows a negatively sloped regression line for the whole 12-region sample. In all regions, except Russia and Ukraine (where agriculture gained less than one percentage point over the period), agriculture tended to grow less than GDP. But contrast the results for the five fast-growing regions with those for the others. While the former show a clear relationship between faster output growth and a decreasing share, the lagging seven regions generate a random scatter – a result that will repeat itself for several other indicators of structural change. Among the rapid growers, China's agricultural share fell by an astonishing 35 percentage points over the period! In South and Southeast Asia, agriculture saw its output share decline 23 and 17 percentage points respectively. Similar observations apply to the industrial sector and service sectors with clear associations emerging for the rapid growers and ill-defined data clouds for the other regions. Growth goes hand-in-hand with a strong pattern of structural change, whereas the absence of growth does not.

The growing regions had rising industrial shares as can be observed in Figure 3.3 (less so in Central and Eastern Europe, which prior to 1970 had already been aggressively pushed toward industrial specialization). Most of the other regions suffered from stagnation or a reversal of the industrialization process. The Middle Eastern and Northern African countries in fact experienced a decline in the share of the mining sector set off by the OPEC embargo on crude oil exports to the Western world and the energy crisis of the 1970s. Since then, the region's mining and oil output in total GDP has hovered around 20% from a high of 34% in 1970.

Finally, the fast growers had predictably large service sector shares by the end of the period, in accordance with traditional development theory. The Tiger region service share, which stood at 57% in 2006, supported strong job creation as reported below. There was no apparent relationship for the lagging regions.

### ***Identifying Structural Change***

As already suggested by Figures 3.2 and 3.3, sustained growth in successful regions was associated with changes in economic structure in several dimensions. Recognizing the structural shifts that occurred in the regions with consistent growth can help chart future directions that other developing economies may be able to take. Needless to say, any economy is a unique entity with its own characteristics that require its own policies. But stylized facts show that there are dynamic movements of key macro variables that show up in connection with sustained output growth across different economic systems. The slow growers did *not* generate such changes for reasons already discussed in Chapter 1. Growth over years and decades in per capita output requires economic transformation characterized by higher productivity and increasing returns to scale. The evidence supports this point of view.

Throughout this chapter we analyze these movements from several angles, in terms of formalized decomposition exercises (algebraic details in Appendix 3.2) and more informal analysis of data on human capital accumulation and foreign direct investment (FDI).

One decomposition breaks down labor productivity growth between agricultural, industrial (manufacturing, construction and mining), and service sectors. Overall

productivity growth comes out as an average of own-rates of growth of the three sectors, weighted by output shares, along with “reallocation effects”. These effects are positive for sectors with relatively low average productivity in which employment falls or for high-productivity sectors in which employment rises.<sup>3</sup>

A second exercise focuses on growth rates of the economy-wide employment to population ratio, which is decomposed into an average of growth rates of that ratio in the three sectors weighted by employment shares. At both the national and sectoral levels, the ratio of employment to total population will rise if the growth rate of output per capita exceeds growth of labor productivity.<sup>4</sup> An economy can be considered to be performing well if it has both sustained productivity growth and a stable or rising employment-population ratio.

Third, we examine the association between capital stock and output growth. We also contrast growth rates of labor and capital productivity and ask how they feed into widely used but fundamentally misleading calculations of “total factor productivity growth” or TFPG. A simple accounting identity states that the growth rate of labor productivity is equal to the sum of the growth rates of capital productivity and the capital/labor ratio. The formula helps explain the “Asian” pattern of falling capital productivity over time. As pointed out in Chapter 1, a similar identity applies to the growth rates of labor and energy productivity. The details are presented below.

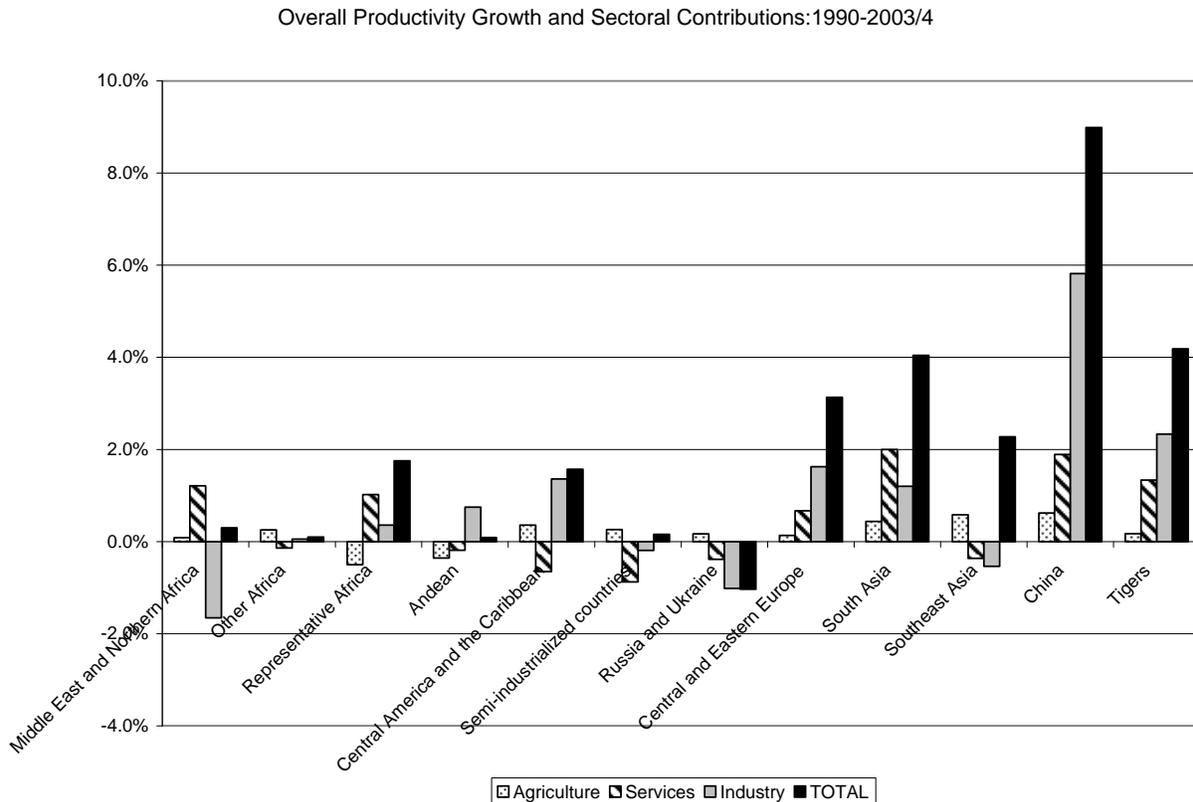
### *Labor Productivity Growth*

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<sup>3</sup> The approach follows Syrquin (1986).

<sup>4</sup> The original insight is Pasinetti’s (1981). The decomposition holds true if labor force participation rates are stable.

Historically, labor productivity increases have been the major contributing factor to growth in real GDP per capita. At the same time, faster productivity increases cut into employment growth unless they are offset by rising effective demand. Figure 3.4 shows the direct contribution of each of the three sectors to overall productivity growth for the period 1991-2003/4. The five rapidly growing regions had productivity growth rates exceeding – some to a significant degree – the rich country norm of 2% per year. The others fell well short, and the former USSR had negative productivity growth<sup>5</sup>. Figure 3.5 summarizes sectoral reallocation gains and together with Figure 3.4 it provides a complete picture of how each sector contributed to overall productivity growth.



<sup>5</sup> More detailed results (not presented here) show that Russia/Ukraine suffered an enormous productivity collapse (-9.7% per year) in 1991-1995, but then recovered to 5.6% (1999-2003).

Figure 3.4: Sectoral contribution to productivity growth.  
Sources: International Labour Office, GET database, for employment and World Bank, World Development Indicators 2005 database, for output.

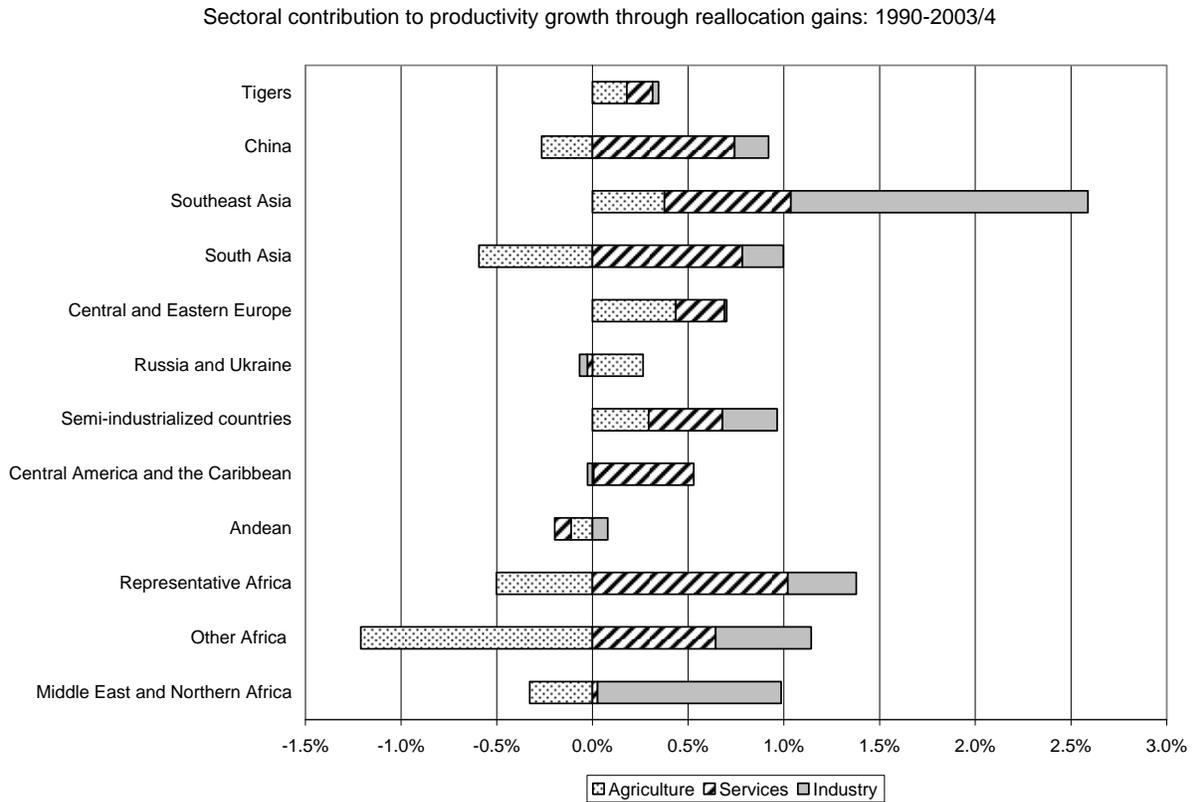


Figure 3.5: Sectoral contribution to productivity growth through reallocation gains  
Sources: International Labour Office, GET database, for employment and World Bank, World Development Indicators 2005 database, for output.

Productivity growth in agricultural sector evidently did not play a crucial role in the process. In several countries agriculture's reallocation effects were negative. The meaning is that this sector, with its relatively low average productivity, had positive employment growth. This finding is not surprising in regions such as China, South Asia, and Africa, where agriculture's share in total employment is significant, but the result is slightly discordant in the Middle East and Northern Africa. More disquieting is the sector's poor productivity performance in sub-Saharan Africa, where it employs most of the labor force.

The industrial sector's own productivity growth made a substantial contribution to the total in four of the rapidly growing regions (Figure 3.4). The direct contribution of nearly 6% per year in China is striking. Industry made a visible contribution in the two poorer Western Hemisphere regions – Central America and the Caribbean and the Andeans – but detracted from overall performance in the semi-industrialized countries, Russia and Ukraine and the Middle East and Northern Africa. The strongest reallocation contribution of industry was experienced in Southeast Asia, a clear outlier in this regard, followed by the Middle East and Northern Africa (Figure 3.5).

Services also added to productivity in the rapid growers: as with industry, a negative direct but positive reallocation contribution in Southeast Asia. Elsewhere, the direct contribution from services was typically negative with modest positive contributions from reallocation. This distinction among regions has implications for job creation, as taken up below.

Finally, from an alternative data set we were able to do decompositions for the period 1980-2000 for the four Asian regions (1986 as the starting year for South Asia). The results are in Figure 3.6. The same general pattern holds as in Figures 3.4 and 3.5, with services playing a more important role in the Tigers.

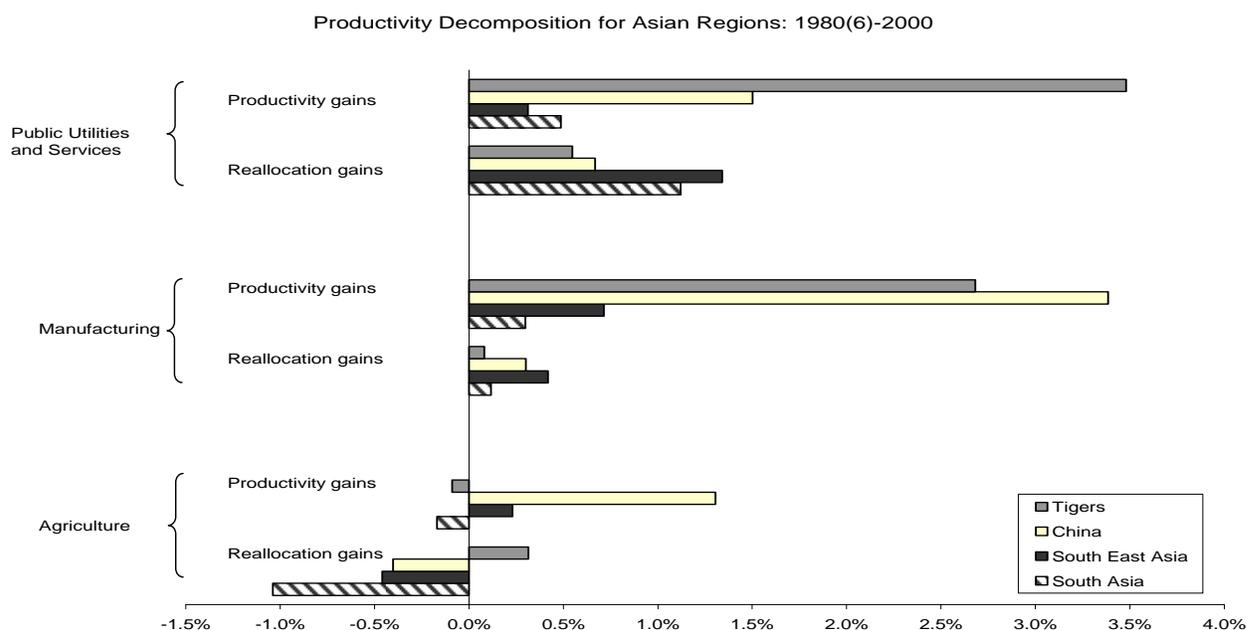


Figure 3.6: Productivity decomposition for selected Asian regions  
 Source: Employment data is from the International Centre for the Study of East Asian Development <http://www.icsead.or.jp>. Data for sectoral output is from UN National Accounts database.

The bottom line on productivity growth is that the two non-agricultural sectors made solid contributions to the total in the fast-growing regions, even as their overall importance in the economy rose. Elsewhere the results were a mixed bag, with no clear patterns emerging. Insofar as it is measured by average labor productivity growth, technological advance was evident in the successful regions and absent or, at best, sporadically present in other corners of the world.

A common route taken by mainstream models of economic growth is to link productivity and ultimately economic growth to the accumulation of human capital. The question to ask is if rapid GDP growth in the regions surveyed in this book was associated with the pace of human capital accumulation, measured by average years of schooling? Figure 3.7 presents a scatter plot of GDP growth per capita vs. growth in average years of schooling. All regions raised their education levels, some quite

substantially. At best, the regression line suggests a very weak positive relationship (certainly not significant in statistical terms) between output expansion and educational growth. As in Figures 3.2-3.3, and in contrast to the picture for physical capital accumulation in Figure 3.9 below, the slow-growing regions inhabit an amorphous data cloud. They did no worse at accumulating human capital than the others but they saw scant returns in growth. In fact some did considerably better at increasing years of schooling than the fastest growing region, China.

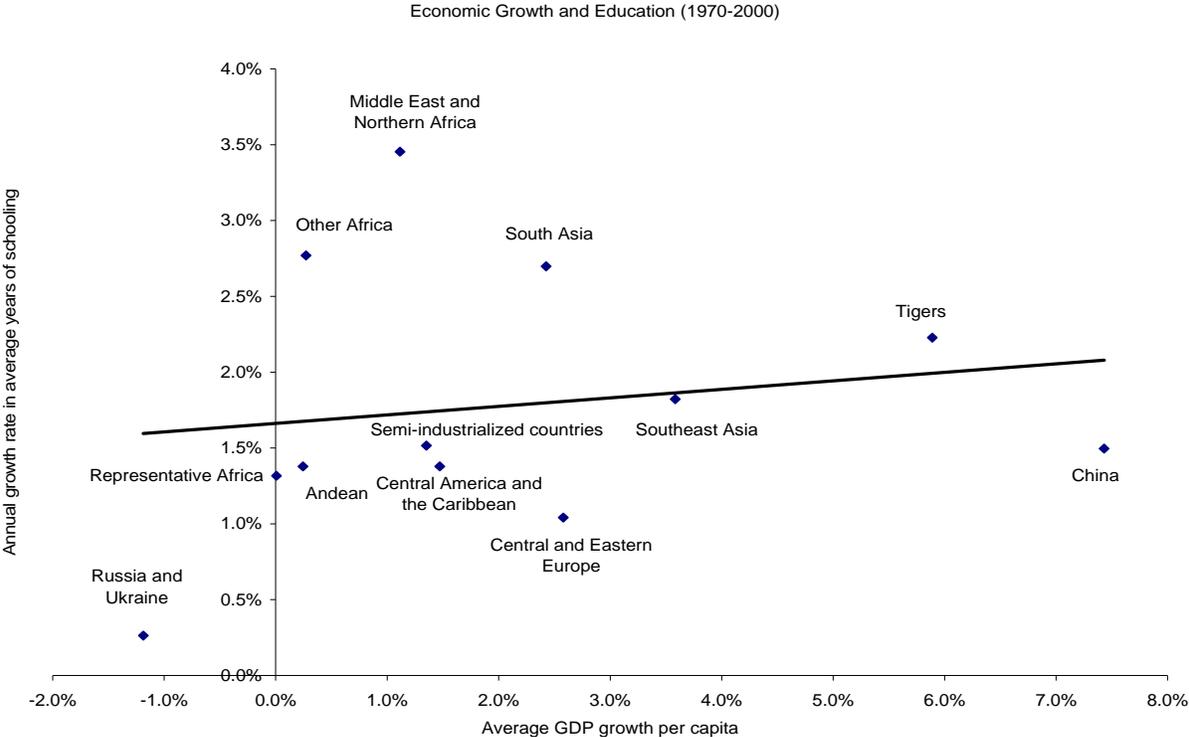


Figure 3.7: Economic growth and educational improvements  
 Sources: Data on education is from Barro and Lee (2000) <http://www.cid.harvard.edu/ciddata/ciddata.html>; data on growth rates of GDP per capita is from UN National Accounts database.

Education is a public good that should be supported for many reasons, but over the medium run its contribution to more rapid real income growth appears to be modest.

More human capital may be a necessary or an enabling condition for sustained output growth, but it is clearly not sufficient.

*Employment Growth Patterns*

Figure 3.8 summarizes results regarding shifts in sectoral employment to population ratios in terms of their contributions to changes in the economy-wide ratio. Regional growth rates of the overall ratio hovered around zero, with more positive than negative values. As noted above, at both the sectoral and national levels, the ratio(s) will grow when the growth rate of output per capita exceeds labor productivity growth. The ratio(s) will also tend to rise when population growth is negative, as was the case in Central Eastern Europe and the former Soviet Union.

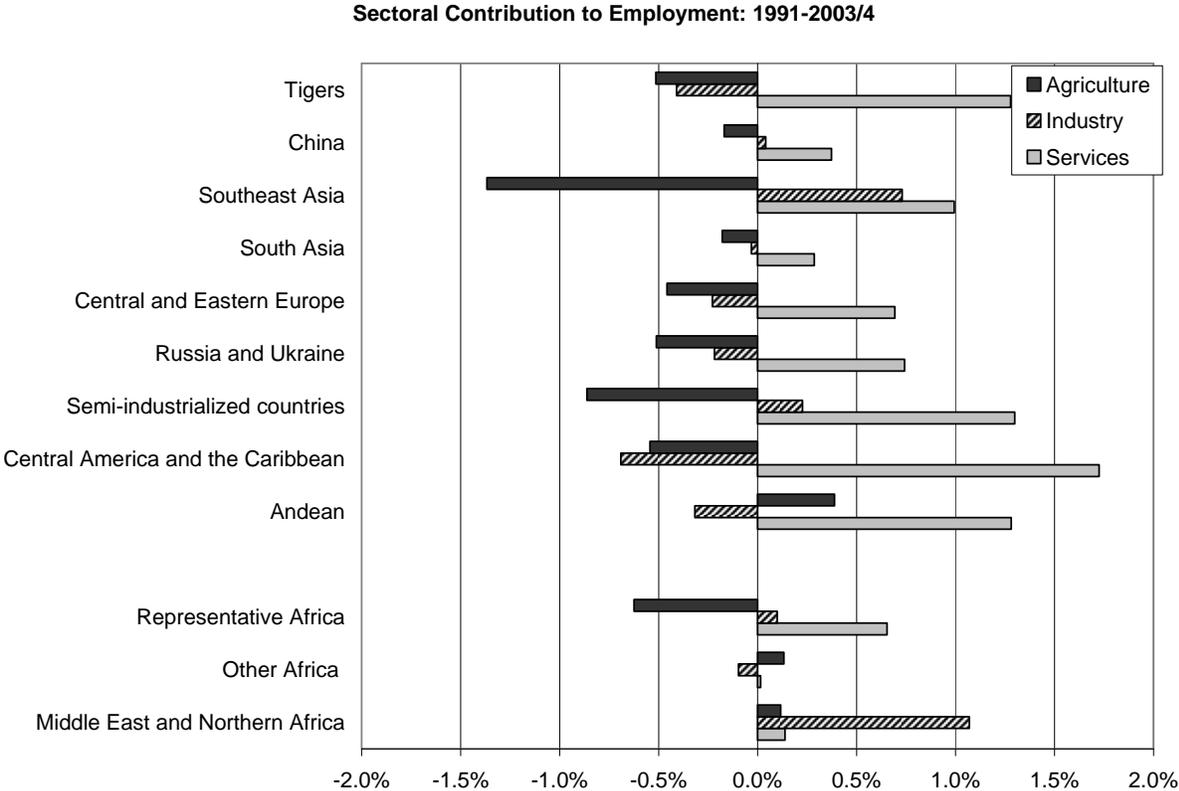


Figure 3.8: Sectoral shifts in employment/population ratios.

Sources: International Labour Office, GET database, for employment and World Bank, World Development Indicators 2005 database, for output.

The most striking outcome in Figure 3.8 is the apparent *similarity* of all 12 regions in the sense that services showed a rising employment to output ratio everywhere, rather strongly except in Other Africa, the Middle East and Northern Africa, and (to an extent) South Asia (dominated by India). The details, however, differed between fast- and slow-growing regions.

For the rapid growers, the positive contribution of services to employment growth shows that output per capita grew faster than the sector's rising productivity levels that underlie its positive contributions to growth overall (in Figure 3.4). Positive reallocation gains were due to the fact that services have relatively high average productivity. In the slower growing regions, direct contributions of services to economy-wide productivity were generally negative (in five of the seven slow growth or stagnant regions), indicating that a large part of the job creation in services was in low-productivity or informal activities. Underemployment in services turned out to be the major mechanism to absorb the excess supply of labor in these economies. Still, given the higher average productivity of services, reallocation effects (reflected in Figure 3.8) added to overall productivity growth. Only in the Middle East and Northern Africa and in Southeast Asia was the industrial sector a strong provider of jobs (a fact explaining Southeast Asian industry's strong reallocation contribution to overall productivity growth in Figure 3.4).

Consistent with Figures 3.1 and 3.4, industry's rate of productivity growth tended to exceed its growth in demand per capita. An old structuralist observation in

development economics is that the industrial sector is the main motor for productivity increases but not for job creation.

Finally, relative to total population, agriculture was a net source of labor *supply* in nine regions, very strongly in Southeast Asia, and a source of net demand – or, to be precise, an absorber of underemployment— in the Middle East and Northern Africa, Other Africa, and (especially) in the smaller Andean countries.

### *Capital Productivity and Total Factor Productivity Growth (TFPG)*

To analyze the role of capital accumulation in growth, we computed capital stock growth rates for the regions by cumulating real gross fixed capital formation over time from a postulated initial level of the capital stock (capital-output ratio of 2.5) with a depreciation rate of 5%. As discussed more fully in Appendix 3.2, after a decade or two such estimates of the capital growth rate should be insensitive to the parameters because capital stock growth tends to converge to investment growth over time.<sup>6</sup>

Figure 3.9 compares growth rates of output and the capital stock. In contrast to most other indicators discussed herein, there is a clear positive association between the two growth rates across *all* regions – a standard empirical result. This relationship is usually thought to emerge from the supply side, but it could also be attributed to demand. In a simple demand-driven growth model, if investment increases at a certain rate, then output and (as just indicated) the capital stock will ultimately grow at that rate as well. The fact that the slope of the putative relationship between the two growth rates

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<sup>6</sup> A caveat: our capital stock series for the former-USSR and Central and Eastern Europe begin in 1990, which means that the estimated growth rates are less reliable than those for other regions where the base year was 1970.

in Figure 3.9 is close to one argues more for demand- than supply-side causality. In the latter, the slope would lie below 45 degrees, with a less than one-for-one partial impact of faster capital growth on output growth.<sup>7</sup>

Also note that the capital growth rate exceeded output growth in the Tigers, China, Southeast Asia and the former USSR. In other words, these regions had *falling* capital productivity. Such an outcome can be expected in the rapidly growing Asian regions where industrial restructuring took place towards capital-intensive industries. Nevertheless these findings can also be said to be the outcome of accounting requirements. As noted in Chapter 1 and demonstrated in Appendix 3.2, a theorem of accounting demonstrates that the difference between labor and capital productivity growth rates must be equal to the difference between capital and labor growth rates. If capital grows faster than labor, then labor productivity has to grow faster than capital productivity.<sup>8</sup> If the capital to labor ratio rises very rapidly, then capital productivity growth may even have to be negative. This outcome is sometimes said to characterize an “Asian” pattern of growth, or a “Marx bias” in technical progress. It can also result from negative labor force growth as in the former USSR and Eastern Europe.

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<sup>7</sup> That is, the 45-degree slope would not fit a neoclassical aggregate production function. It could be “explained” by a constant capital-output ratio, but that in turn is inconsistent with the “Asian” pattern of falling capital productivity discussed immediately below.

<sup>8</sup> This sort of “decreasing returns” to more capital is built into many mainstream and heterodox growth models, which mostly serve to rationalize the accounting identity described in the text. As noted in Chapter 1, falling capital productivity (in PPP terms) characterized many now industrialized countries in their rapid growth periods in the nineteenth and early twentieth centuries.

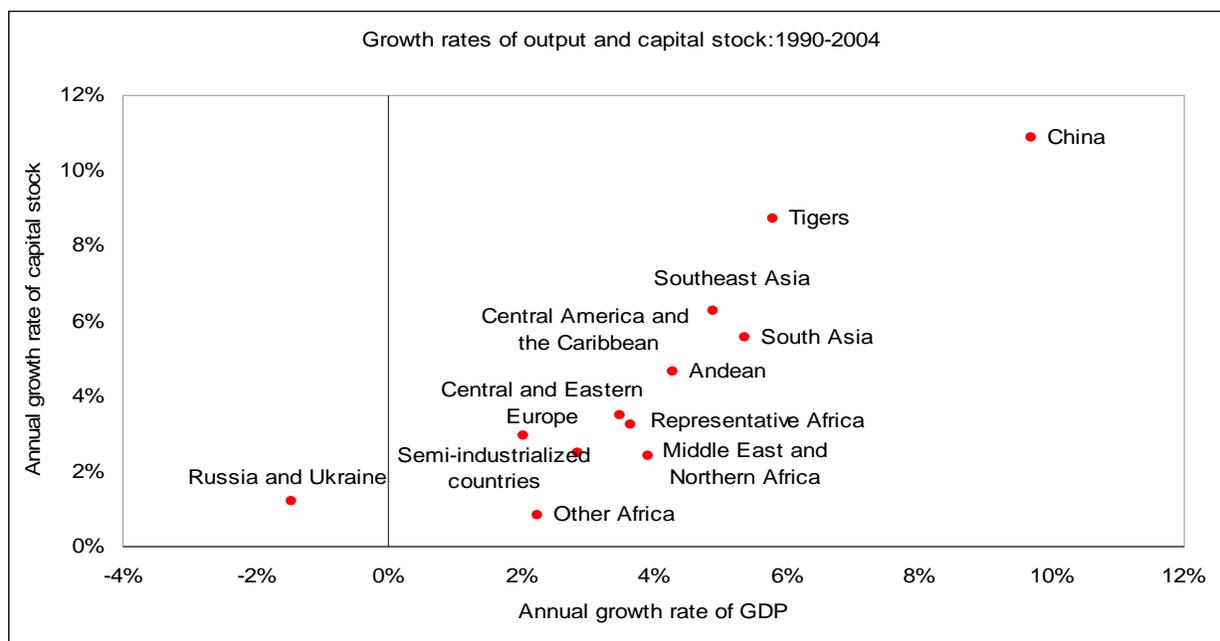


Figure 3.9: Output and capital stock growth rates, 1990-2004.  
 Sources: GFCF and GDP data comes from World Development Indicators 2005 database; employment data is from International Labour Office, GET database

Capital and labor productivity growth rates are plotted in Figure 3.10. Again note the contrast between regions. The rapid growers all had negative or nearly zero capital productivity growth rates and rising labor productivity which could have resulted from better technology “embodied” in new capital goods. Detailed data show that China’s capital productivity fell more rapidly over time. The former USSR lost on both fronts and the rest had small, mostly positive, growth of both indicators.

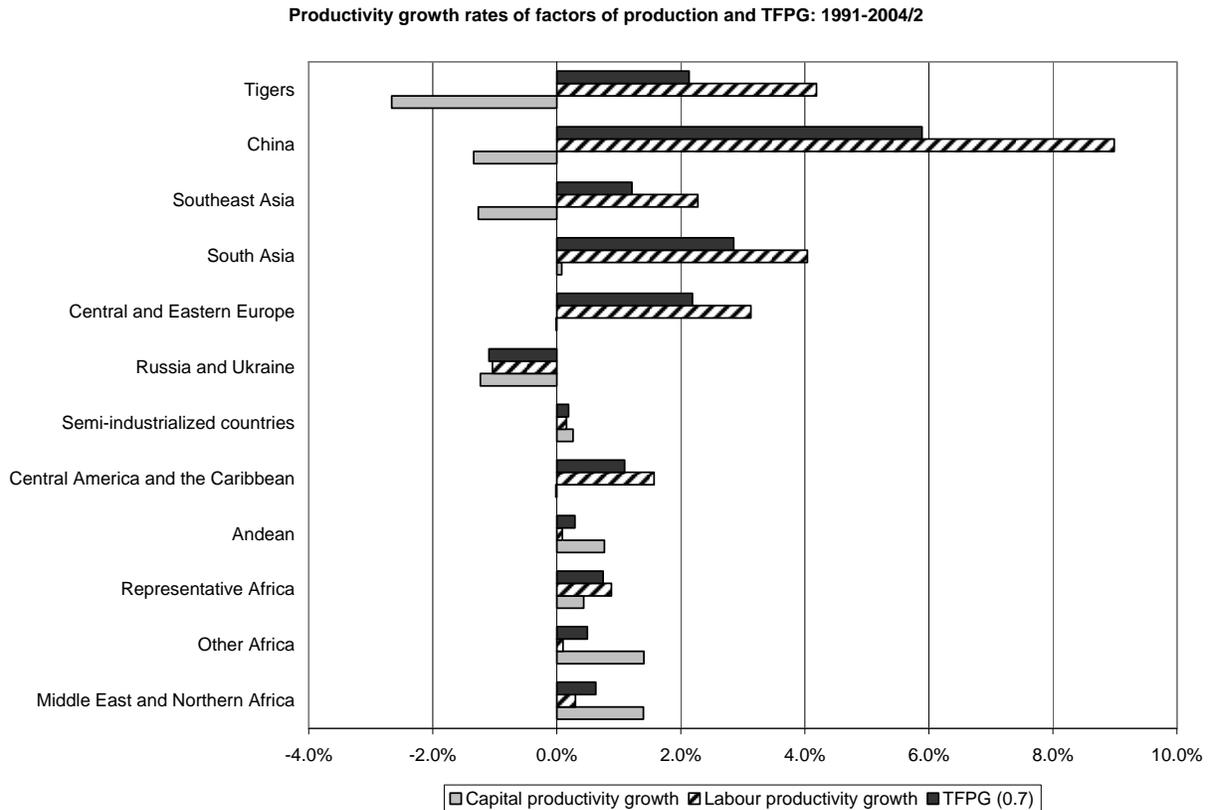
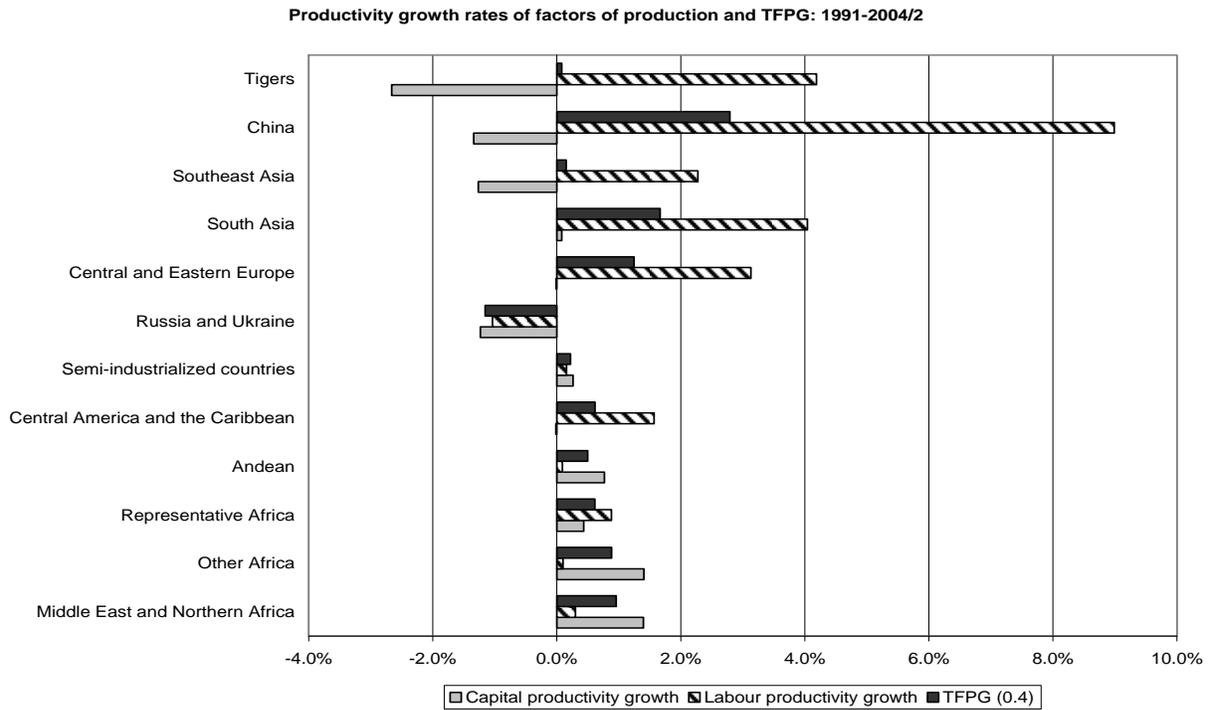


Figure 3.10: Capital and labor productivity growth rates and TFPG.  
 Sources: GFCF and GDP data comes from World Development Indicators 2005 database; employment data is from International Labour Office, GET database

Much of the academic literature focuses on “total factor productivity growth” (TFPG) or the “residual.” In chapter 1 we pointed out the dubious way in which the share of remunerated labor is calculated in developing countries and the equally inadequate interpretation of a negative TFPG in rapidly growing economies. As an exercise, Figure 3.10 shows estimates of TFPG for labor shares of 0.4 and 0.7 (the standard number) respectively. Either way, because of their negative capital productivity growth, TFPG in the rapidly growing regions fell well short of labor productivity growth. For the lower labor share, TFPG in the Tigers and Southeast Asia was close to zero. Such findings are often used to portray the failings of the “Asian model,” but mostly they reflect an accounting identity and the arbitrary nature of the TFPG indicator.

A more interesting question would be to ask whether the rapid growth of the capital stock in these economies impacted labor productivity through embodied technical change (and the slow growth of the capital stock the poor productivity performance of other regions), but this is a question we cannot directly address with our data set.

What we can ask however is whether foreign direct investment, which is often touted as a potential source of technologically upgraded physical capital, managerial know-how, and global commercial networks, has any impact on productivity and economic growth. However, it is not obvious in this regard what level of FDI is “significant”. As a share of GDP, for example, how large does FDI have to be or how rapidly should it grow to generate important repercussions on output growth?

FDI tends to fluctuate over time although as a share of GDP it remains insignificant or modest at best in most of the developing world. More exactly, for the fast growing Tigers FDI as a share of GDP increased from 1.6% in 1970 to 3.1% by 2004. Somewhat similar patterns appeared in Southeast Asia and China – which absorbed a very substantial share of the worldwide total— but not in South Asia, where FDI/GDP peaked at a mere 0.9% in 1997. Central and Eastern Europe experienced a late but sharper increase of FDI as a share of GDP than Southeastern Asia: from 0.4% in 1990 to 4.8% in 2000 and 4 % in 2004. Russia received relatively little FDI: it peaked at 1.7% of GDP in 1999.

Central America and the Caribbean had strong fluctuations – nearly 4% in the 1970s down to 0.4% in 1982, back to above 4% in the 1990s with the assembly/tourism boom, and then some decline. Latin America saw a modest 2% toward the end of the period. Some members of the slow-growing group of economies did similarly or a little better than the fast-growers in garnering FDI, without a lot of apparent pay-off. The smaller Andean countries were up to 5.5% in 1993 and 3% in 2004, with no positive impact on growth. Finally, Africa and the Middle East and Northern Africa got negligible quantities of FDI.

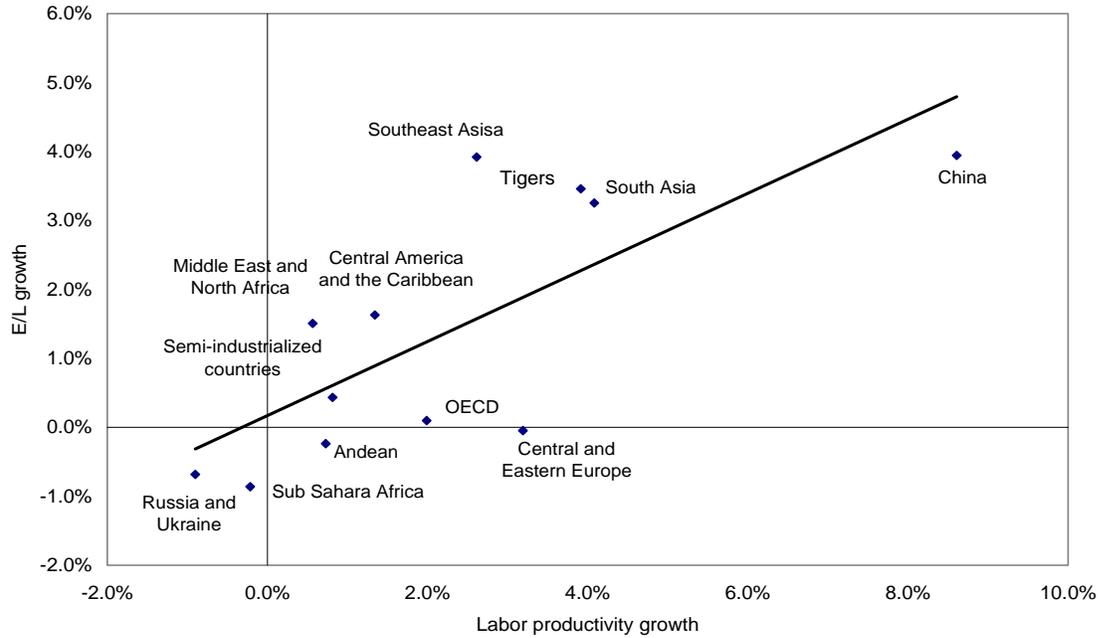
The above narrative on the shares of FDI in GDP reveals that a positively sloped relationship between FDI and GDP growth is likely to show up for Asia, as usual – with the exception of South Asia in this case. The remaining regions demonstrate their usual blob of data points. A relatively large FDI inflow may possibly have a slightly stronger association with growth than rising education, but the relationship is still very weak.

## *Energy Productivity Growth and Energy/Labor Ratios*

There is an old idea, perhaps dating to the nineteenth century “energetics” movement (Martinez-Alier with Schlüpmann, 1991; Mirowski, 1989), that the crucial factor behind rising labor productivity and per capita income is increasing use of energy. One can make this statement a bit more precise by comparing growth rates of labor productivity, energy productivity, and the energy/labor ratio. As noted above, the latter two growth rates must add up to the first as an algebraic identity.

For our 12 regional groups and the rich countries in the OECD, Figure 3.11 presents two scatter diagrams of growth rates of labor productivity and the energy/labor ratio, for the periods 1970-1990 and 1990-2004 (energy from fossil fuel sources only). As with the growth rate of capital stock, there appears to be a positive relationship between increasing energy use per worker and labor productivity growth, with a steeper slope and a better fit in the latter period. Similar results show up when growth rates are compared at the individual country level. The slope of the relationship in the latter period is around 0.6, implying a substantial contribution of more energy use to higher labor productivity.

Growth of energy to labor ratio and labor productivity: 1990-2004



Growth of energy to labor ratio and labor productivity: 1970-1990

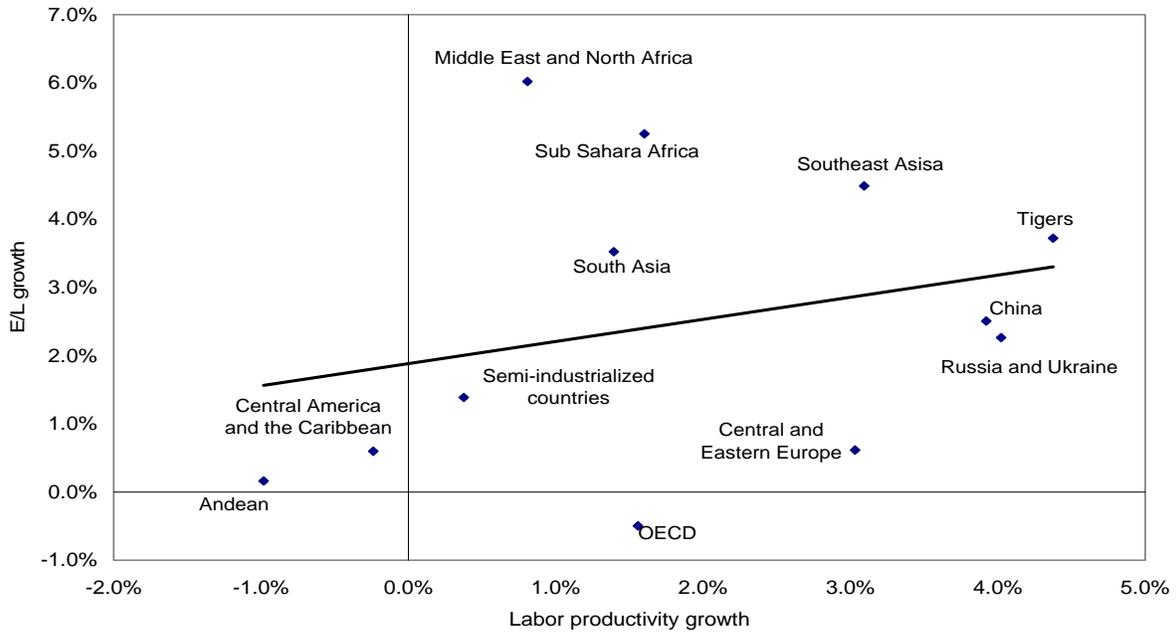


Figure 3.11: Growth rates of labor productivity and the energy/labor ratio.

Sources: Energy data is from United Nations Energy Statistics Yearbook, GDP levels are from UN

National Accounts, employment is from Groningen Growth and Development Center <http://www.ggdc.net/>

The data behind Figure 3.11 show a wide range of annual energy/labor ratios –

from 0.01 (77 gallons of gasoline) in sub-Saharan Africa to 0.67 (5150 gallons) in Saudi Arabia in 2004. The ratio is 0.58 in the US and less than 0.3 in Western European countries, the Tigers, and Japan (as discussed in chapter 1, the numbers are in units of terajoules of energy per worker per year).

In the context of global warming, the numbers are far from encouraging. For example, at China's growth rate of the energy/labor ratio of 4% per year, it would take the economy around 35 years to attain Sweden's "moderate" ratio of 0.16, with energy productivity rising 4% per year more slowly than labor productivity. As its per capita income rises and possibilities for appropriating more advanced technologies and taking advantage of surplus labor recede, China's labor productivity growth rate will almost certainly decline, perhaps creating even greater reliance on energy.

As observed in Chapter 1, developing countries might have to reduce their fossil fuel energy/labor ratios by one percent per year to hold greenhouse gas emissions in check. A handful of countries are in this range, but they are stagnant with negligible or negative labor productivity growth.

The key policy question is whether in the near future rich country energy/labor ratios can be reduced (or energy productivity increased relative to labor productivity) substantially by technological innovation and social rearrangements. In the recent period, there has been no significant downward trend in the ratios in the industrialized world. But if such innovations do work out, then perhaps they can be passed to developing economies before the momentum of their population growth overwhelms all possibilities for combating global warming. Given the environmental constraints and considering that only 16% of the world's population lives in rich countries and almost all

population growth is in the poor ones, realistic prospects for successful economic performance and poverty alleviation may not be very bright.

### ***Appendix 3.1: Countries in the Regional Groups***

1. Representative Africa: Ghana, Kenya, Uganda and Tanzania
2. Other Africa: Cameroon, Ethiopia, Ivory Coast, Mozambique, Nigeria, Zimbabwe
3. Central America and the Caribbean: Costa Rica, Dominican Republic, El Salvador, Guatemala, Jamaica
4. Smaller Andean countries: Bolivia, Ecuador, Peru
5. Semi-Industrialized countries: Argentina, Brazil, Chile, Colombia, Mexico, Venezuela, Turkey, South Africa
6. South Asia: Bangladesh, India, Pakistan, Sri Lanka
7. China
8. Southeast Asia: Indonesia, Philippines, Thailand, Vietnam
9. Tigers: South Korea, Malaysia, Singapore, Taiwan
10. Middle East and Northern Africa: Algeria, Egypt, Morocco, Tunisia, Iran, Iraq, Jordan, Saudi Arabia, Syria, Yemen
11. Former-USSR: Russian Federation, Ukraine
12. Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia

### **Appendix 3.2: Decomposition Techniques**

It is often illuminating to trace through how macro aggregates shift over time by temporally “decomposing” accounting identities that link them together. In this appendix we present procedures for investigating changes in labor productivity across producing sectors, employment generation by sectors, interactions between labor and capital productivity growth at the economy-wide level, and net borrowing by major institutional sectors.<sup>9</sup>

Available data on output and employment come at yearly intervals. Growth rates have to be computed in discrete time, with formulas that can become quite complicated. To simplify an algebraic presentation as much as possible, we consider only observations at times 0 and 1. The growth rate of (say) the variable  $X$  is “X-hat” or  $\hat{X} = (X_1 - X_0) / X_0$  with the subscripts standing for points in time. At time 0, the relevant identity for decomposing labor productivity growth is  $\sum_i X_0^i = X_0$  with the  $X_0^i$  as output levels by sector ( $i = 1, 2, \dots, n$ ). Let  $\theta_0^i = X_0^i / X_0$  be the share of sector  $i$  in real output in period zero. Similarly for employment:  $\varepsilon_0^i = L_0^i / L_0$  with  $\sum_i L_0^i = L_0$ . The level of labor productivity in sector  $i$  is  $X_0^i / L_0^i$  with an exact growth rate between times 0 and 1 of  $\xi_L^i = (1 + \hat{L}^i)^{-1} (\hat{X}^i - \hat{L}^i) \approx \bar{X}^i - \hat{L}^i$ . In the literature, terms such as  $(1 + \hat{L}^i)^{-1}$  are often said to represent “interactions.”

After a bit of manipulation, an exact expression for the rate of growth of economy-wide labor productivity emerges as

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<sup>9</sup> More detail on the analysis to follow is in Rada and Taylor (2006) and Taylor and Rada (2006).

$$\xi_L = (1 + \hat{L})^{-1} \sum_i [\theta_0^i (\hat{X}^i - \hat{L}^i) + (\theta_0^i - \varepsilon_0^i) \hat{L}^i] \quad . \quad (1)$$

Aside from the interaction term  $(1 + \hat{L})^{-1}$ ,  $\xi_L$  decomposes into two parts. One is a weighted average  $\sum_i \theta_0^i (\hat{X}^i - \hat{L}^i)$  of sectoral rates of productivity growth as conventionally measured. The weights are the output shares  $\theta_0^i$ . The other term,  $\sum_i (\theta_0^i - \varepsilon_0^i) \hat{L}^i$ , captures "reallocation effects." If  $\theta_0^i > \varepsilon_0^i$  sector  $i$  has a bigger share in output than employment, implying that it has relatively high average productivity. Positive employment growth in that sector (or a negative  $\hat{L}^i$  in a sector with  $\theta_0^i < \varepsilon_0^i$ ) will increase productivity overall, in line with established theories about dualism in development economics.

For the record, another expression for  $\xi_L$  emerges after rearrangement of (1),

$$\xi_L = (1 + \hat{L})^{-1} \sum_i [\varepsilon_0^i (\hat{X}^i - \hat{L}^i) + (\theta_0^i - \varepsilon_0^i) \hat{X}^i] \quad . \quad (2)$$

In (2), sectoral productivity growth rates are weighted by employment shares, and the reallocation effect is stated in terms of output growth rates. The message is basically the same as in (1).

Turning to employment generation, a fundamental insight is that if a sector creates jobs over time, then (if interaction terms are ignored) its growth rate of output per capita must exceed its growth rate of labor productivity. To see the details we can start with the identity  $\phi_0 = L_0 / P_0 = \sum_i (L_0^i / X_0^i) (X_0^i / P_0)$  in which  $P_0$  is the population at time zero. That is,  $\phi_0$  is the share of the population employed at time 0. Labor-output ratios

(inverse average productivity levels) by sector are  $b_0^i = L_0^i / X_0^i$  and sectoral output levels per capita are  $\chi_0^i = X_0^i / P_0$ .

After grinding, the growth rate of  $\phi$  can be expressed as

$$\hat{\phi} = \sum_i \varepsilon_0^i (\hat{\chi}^i + \hat{b}^i + \hat{\chi}^i \hat{b}^i)$$

with the  $\varepsilon_0^i$  being the sectoral employment shares introduced above and  $\hat{\chi}^i \hat{b}^i$  as a (presumably small) interaction term. Each sector's growth rate of labor productivity is  $\xi_L^i = (1 + \hat{L}^i)^{-1} (\hat{X}^i - \hat{L}^i)$  so that it is related to the growth rate of the labor/output ratio as  $\hat{b}^i (1 + \hat{X}^i) = -\xi_L^i (1 + \hat{L}^i)$ . A final expression for  $\hat{\phi}$  becomes

$$\hat{\phi} = \sum_i \varepsilon_0^i [\hat{\chi}^i - \xi_L^i (1 + \hat{\chi}^i) (1 + \hat{L}^i) (1 + \hat{X}^i)^{-1}] \quad , \quad (3)$$

with the terms multiplying  $\xi_L^i$  capturing the interactions.

The lead term (typically accurate to two or three significant digits) is

$$\hat{\phi} = \sum_i \varepsilon_0^i (\hat{\chi}^i - \xi_L^i) \quad .$$

The growth rate of the employment/population ratio is a weighted average of differences between sectoral growth rates of output per capita and productivity. Sectors with higher shares of total employment  $\varepsilon_0^i$  contribute more strongly to the average. One might expect that  $\hat{\chi}_i > \xi_L^i$  in a “dynamic” sector, with the inequality reversed in one that is “declining” or just “mature.”

Next we consider labor and capital productivity in tandem on an economy-wide basis. Exact expressions for the growth rates of the two variables are

$$\xi_L = (1 + \hat{L})^{-1} (\hat{X} - \hat{L}) \approx \bar{X} - \hat{L} \quad \text{and} \quad \xi_K = (1 + \hat{K})^{-1} (\hat{X} - \hat{K}) \approx \bar{X} - \hat{K} .$$

The growth of capital stock is given by the standard equation  $\hat{K} = (I_0 / K_0) - \delta$  in which  $I_0$  is gross fixed capital formation

and  $\delta$  is a “radioactive” depreciation rate (approximately equal to the inverse of the average lifetime of a capital good).

We estimated the capital stock growth rates used in the text by running the accumulation equation forward through time from an initial guess at the level of capital (from a capital to output ratio of 2.5) and a depreciation rate of 0.05. After a decade or so, the computed growth rates were insensitive to these parameters. This outcome is more or less built into the algebra. If investment grows at a rate  $g$ , for example, then the capital stock growth rate will converge to that value, independent of initial conditions and the value of  $\delta$ .

Usually, labor and capital productivity growth rates are lumped together into a number called “total factor productivity growth” (TFPG) or, more realistically, the “residual”  $\xi$ . It is defined from the equation

$$\hat{X} = \alpha_0(\hat{L} + \xi_L) + (1 - \alpha_0)(\hat{K} + \xi_K) = \alpha_0\hat{L} + (1 - \alpha_0)\hat{K} + \xi \quad (4)$$

in which  $\alpha_0$  is the share of labor in total factor payments. Evidently,  $\xi$  is a weighted average of capital and labor productivity growth rates,

$$\xi = \alpha_0\xi_L + (1 - \alpha_0)\xi_K \quad (5)$$

Equation (4) can be derived by taking the first difference of the factor payments identity built into the national accounts,  $X_0 = \omega_0 L_0 + r_0 K_0$  (in which  $\omega_0$  and  $r_0$  are real wage and profit rates respectively), or else from the usual mainstream mumbo-jumbo about an aggregate production function and associated marginal productivity factor demand equations.

Also, because

$$\frac{X_0 / L_0}{X_0 / K_0} = \frac{K_0}{L_0}$$

the expression

$$\xi_L - \xi_K = \hat{K} - \hat{L} \tag{6}$$

will hold to a good approximation. In words, if growth rates of labor and capital are pre-determined then the growth rate of labor productivity implies the growth rate of capital productivity or vice-versa. If capital grows much more rapidly than labor and there is positive labor productivity growth, then the growth rate of capital productivity may well be negative. Empirical implications of this observation are discussed in the text.

One final point worth emphasizing is that all the discussion is framed in terms of macro aggregates measured in real market prices, *not* in terms of purchasing power parity. The rationale is to keep the analysis as close as possible to normal macroeconomic discourse.

When used in international comparisons, PPP calculations basically revalue the labor content of output by sector. For example, the dollar cost of an up-market haircut in Mumbai at the current rupee/dollar exchange rate might be \$5. A similar service in New York City could run \$50. A PPP re-computation of Indian GDP raises the labor cost for the Mumbai barber to something closer to that of her New York counterpart.

Comparisons of income levels in these terms have become the accepted methodology, as in the results reported in Figure 2.1. However, PPP computations also move macro aggregates far away from their “normal” market price levels. Non-traded goods are re-valued in comparison to traded goods, the residential capital stock rises and non-residential falls, imports change relative to exports, and so on. In the text, we focus on standard macroeconomics, and for that reason we eschew PPP.