6

CAPITAL ACCUMULATION, TECHNICAL PROGRESS AND TECHNIQUES OF PRODUCTION

Introduction

Economic growth and development are impossible without capital accumulation. If all the output produced by an economy was consumed, there would be no saving, no investment, and the economy would grind to a halt. In this chapter, we discuss the role of physical capital and infrastructure investment in the development process, leaving the role of human capital formation (education and health) to Chapter 7.

Growth depends not only on the quantity of capital invested but also its productivity, which largely depends on the technical progress embodied in it. We identify the different meanings of technical progress and the types of technical progress that take place – whether it is labour-saving, capital-saving or neutral – which has implications for employment and the distribution of income between wages and profits. The process of learning by doing is a form of technical progress, because it improves the productivity of factors of production.

We then explore how societies progress technologically by acquiring the capabilities to invest, innovate, undertake R&D and absorb new ideas. Some evidence is given of how backward technology is in poor countries and the challenge of the magnitude of 'catch-up'. Finally, we discuss the important issue of the choice of techniques of production in developing countries and whether labour-abundant economies could move towards the use of more labour-intensive techniques without jeopardizing the level of output and saving for future growth. Theory and evidence suggest that the potential clash between employment and output and employment and saving in the choice of *new* techniques is exaggerated.

The role of capital in development

The capital stock of a country increases through the process of net investment, which is the difference between a country's net income in an accounting period (that is, gross income minus depreciation) and how much it consumes out of that income in the same period. The essence of capital accumulation is that it enhances a country's capacity to produce goods in the future and enables it to grow faster.

There are many types of capital goods:

1. There are **plant and machinery** used in factories and offices, which yield no utility directly but produce consumption goods and services that do.
2. There is **infrastructure investment**, which partly provides goods and services directly, and at the same time makes other forms of investment more productive; for example transport facilities, telecommunications, power generation, the provision of water facilities and so on.
3. There is expenditure on **research and development (R&D)**, which may improve the productivity of labour or capital, or both. R&D can lead to new inventions and then to innovation – either **process innovation** or **product innovation**. Process innovations make the production of existing products more efficient; product innovations involve the creation of new products that not only add to utility but also enhance productivity by enabling new ways of doing things, for example information technology.
4. If capital is defined as any asset that generates an additional future stream of measurable income to society, many goods and services that might be thought of as primarily consumption goods ought strictly to be included as part of a country's capital stock. If cars, for example, or other consumer durable goods save time and make people more efficient, part of the expenditure on them should be considered as an investment. Expenditure on housing is another

example where private expenditure may be partly considered as consumption and partly investment; and the public provision of housing might be put in the category of **social capital**. Similarly, if certain types of consumption goods are necessary as incentives to induce peasant producers in the agricultural sector, or workers elsewhere, to increase their productivity, they too ought to be considered as part of the capital stock.

If it is agreed, therefore, that the only way to build up a country's productive potential and to raise per capita income is to expand the capacity for producing goods, this need not refer simply to the provision of physical capital such as plant and machinery, but also to roads, railways, power lines, water pipes, schools, hospitals, houses and even 'incentive' consumer goods such as consumer durables – all of which can contribute to increased productivity and higher living standards.

When using the production function approach to the study of the sources of growth or the macrodeterminants of growth, as described in Chapter 4, it is important to define capital as broadly as possible if the relation between capital accumulation and growth is to be properly understood. This is in addition to the point, which was also emphasized in Chapter 4, that capital is likely to be the main vehicle for the introduction of technical progress in the productive system. In other words, capital accumulation is not only important in its own right, but is the major conduit for advances in knowledge, which, in turn, are also a major determinant of productivity growth.

Developing economies lay great emphasis on the importance of capital accumulation, and stress the need to raise the level of investment as a proportion of national output. A glance at any national development plan will testify to this. Development is associated with industrialization and industrialization with capital accumulation. Many famous development economists in the past have picked out investment as the most important single factor in the growth process. As we saw in Chapter 3, Rostow (1960) defines the process of 'take-off' into sustained growth in terms of a critical ratio of investment to national product, and Arthur Lewis (1955) has described the process of development as one of transforming a country from being a 5% saver and investor to a 12% saver and investor. It is common, in fact, for countries to calculate fairly precise ratios of investment to national income that will be required to achieve a particular rate of growth. These calculations involve assumptions about the normal relation between capital and output, a relation that is formally expressed in the concept of the **capital–output ratio**, which measures how much capital stock is required to produce a unit flow of output over an accounting period (normally one year). If 300 units of capital (from new investment) are required to produce an annual flow of 100 units of output, the capital–output ratio is 3.

The returns to investment in developing countries are potentially much higher than in developed countries, which already have large quantities of capital per head. In countries where specialization (the division of labour) is minimal, the scope for capital to permit more roundabout methods of production and increase productivity will be greater than where specialization has already reached a high level of sophistication. Moreover, in technologically backward countries, the rate of growth of capital required to absorb new technology is likely to be greater than in advanced countries. By definition, technologically backward countries also have a backlog of technology to make up. Furthermore, in a labour-abundant economy with a low capital–labour ratio, the very act of *capital deepening* – giving each worker a little more capital to work with – may make a substantial difference to total product, much more so than in countries where the process of capital deepening has been a continuing process for some length of time. All these factors represent important contributions that capital can make to economic progress, which may be relatively more important, the smaller the initial capital stock of a country relative to its population. It is a familiar proposition in economics that the scarcer one factor of production is in relation to another, the higher its productivity is likely to be, all other things being equal.

Capital accumulation is also seen as an escape from the so-called 'vicious circle of poverty' – a circle of low productivity, leading to low per capita income, leading to a low level of saving per head, leading to a low level of capital accumulation per head, leading to low productivity. Low productivity is seen as the source of the vicious circle of poverty, and the point where the circle must be broken by capital accumulation (see Chapters 10 and 11).

According to research by Hulten and Isaksson (2007), the amount of capital per head of the working population in high-income developed countries is $150,000 (in 2000) compared with $3,000 in low-income countries, and this difference is one of the major explanations of why labour productivity is $52,000 in rich countries and only $2,300 in poor countries.

These huge differences in the amount of capital per head are the cumulative effect of much higher levels of savings and investment in rich countries than in poorer countries that cannot, or prefer not to, save and invest. A precondition for raising the level of capital per head in poor countries is a higher level of investment. There needs to be greater incentives for investment. Case example 6.1 contains the conclusions of the World Bank's *World Development Report 2005: A Better Investment Climate for Everyone* (World Bank, 2004).

Case example 6.1

Main messages from *World Development Report 2005* on investment

The investment climate is central to growth and poverty reduction

Improving the opportunities and incentives for firms of all types to invest productively, create jobs and expand should be a top priority for governments. It is not just about increasing the volume of investment but also spurring productivity improvements that are the keys to sustainable growth:

- The goal is to create a better investment climate for everyone. A good investment climate benefits society as a whole, not just firms. And it embraces all firms, not just large or politically connected firms.
- Expanding opportunities for young people is a pressing concern for developing countries, where 53% of people live on less than US$2 a day, youths have more than double the average unemployment rate, and populations are growing rapidly.

Reducing unjustified costs is critical, but policy-related risks and barriers to competition also need to be tackled

Costs, risks and barriers to competition all matter for firms and thus for growth and poverty reduction:

- Costs associated with weak contract enforcement, inadequate infrastructure, crime, corruption and regulation can amount to over 25% of sales – or more than three times what firms typically pay in taxes.
- Firms in developing countries rate policy uncertainty as their top concern. This and other sources of policy-related risk – such as insecure property rights, macroeconomic instability and arbitrary regulation– chill incentives to invest. Improving policy predictability can increase the likelihood of new investment by over 30%.
- Barriers to competition benefit some firms but deny opportunities and increase costs to other firms and consumers. They also weaken incentives for protected firms to innovate and improve their productivity. Increasing competitive pressure can increase the probability of firm innovation by more than 50%.

continued overleaf

Case example 6.1 **Main messages from *World Development Report 2005* on investment –** *continued*

Progress requires more than changes to formal policies

Over 90% of firms claim gaps between formal rules and what happens in practice, and the informal economy accounts for more than half of output in many developing countries. Creating a better investment climate requires governments to bridge these gaps and to tackle the deeper sources of policy failure that undermine a sound investment climate. This requires efforts to:

- Restrain corruption and other forms of rent-seeking that increase costs and distort policies
- Build policy credibility to give firms the confidence to invest
- Foster the public trust required to enable and sustain policy improvements
- Ensure policy responses are crafted to fit local conditions.

Investment climate improvements are a process, not an event

Government policies and behaviours influencing the investment climate cover a wide field. But everything does not have to be fixed at once, and perfection on even a single policy dimension is not required. Significant progress can be made by addressing the important constraints facing firms in a way that gives them the confidence to invest – and by sustaining a process of ongoing improvements.

Because constraints differ widely across and even within countries, priorities need to be assessed in each case. Reform processes benefit from effective public communication and other measures to build consensus and maintain momentum.

Source: World Bank, 2004.

Technical progress

The term 'technical progress' is used in several different senses to describe a variety of phenomena, but three in particular can be singled out:

1. Economists use the term to refer to the *effects* of changes in technology, and specifically to the role of technical change in the growth process. It is in this sense that the term was used in Chapter 4; that is, as an umbrella term to cover all those factors that contribute to the growth of 'total' factor productivity.
2. Technical progress is used by economists in a narrow specialist sense to describe the *character* of technical improvements, and is often prefaced for this purpose by the adjectives 'labour-saving', 'capital-saving' or 'neutral'.
3. Technical progress is used more literally to refer to *changes* in technology itself, defining technology as useful knowledge pertaining to the art of production. Used in this sense, the emphasis is on describing improvements in the design, sophistication and performance of plant and machinery, and the economic activities through which improvements come about – by R&D, invention and innovation.

Having already discussed technical progress in the first sense in Chapter 4, we concentrate here on the narrow specialist descriptions of technical progress, and on how societies progress technologically.

Capital- and labour-saving technical progress

The classification of technical progress as to whether it is capital-saving, labour-saving or neutral owes its origins primarily to the work of Harrod (1948) and Hicks (1932). Their criteria of classification differ, however. **Harrod's classification of technical progress** employs the concept of the capital–output ratio. Given the rate of profit, technical change is said to be capital-saving if it lowers the capital–output ratio, labour-saving if it raises the capital–output ratio, and neutral if it leaves the capital–output ratio unchanged.

The nature of technical progress by this criterion will be an amalgam of the effect of 'pure' technical change on factor combinations on the one hand and the effect of the substitution of capital for labour on the other (as, for example, relative factor prices change). As such, Harrod neutrality at the aggregate level is quite consistent with capital-saving technical progress at the industry level. In fact, most of the evidence for advanced countries suggests that *if* technical progress is neutral in the aggregate in the Harrod sense, this must be due to substitution of capital for labour because 'pure' technical advance has saved capital. The substitution of capital for labour takes place because as countries become richer, the price of labour relative to capital tends to rise, which not only induces a 'pure' substitution effect but also encourages inventive effort towards saving labour, which is becoming relatively expensive (and scarce).

Hicks's classification of technical progress takes the concept of the marginal rate of substitution between factors, which is the rate at which one factor must be substituted for another, leaving output unchanged. The marginal rate of substitution is given by the ratio of the marginal products of factors. Holding constant the ratio of labour to capital, technical progress is said to be:

- **capital-saving** if it raises the marginal product of labour in greater proportion than the marginal product of capital
- **labour-saving** if it raises the marginal product of capital in greater proportion than the marginal product of labour
- **neutral** if it leaves unchanged the ratio of marginal products.

These definitions are illustrated in Figures 6.1, 6.2 and 6.3, respectively.

It will be recalled from Chapter 4 that technical progress on a production function map is represented by shifts in the function towards the origin, showing that the same output can be produced with fewer inputs, or that the same volume of inputs can produce a greater output. According to the shape of the new production function, fewer of either one or both factors will be required to produce the same output. In the case of neutral technical progress, a quantity of both factors can be dispensed with. In the case of non-neutral technical progress, if only one factor is

Figure 6.1 Capital-saving technical progress

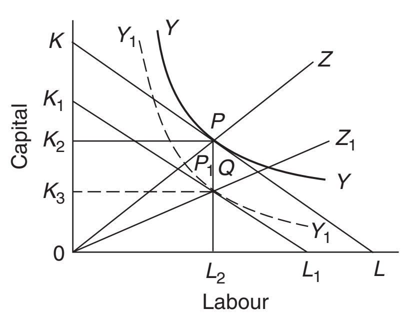


Figure 6.2 Labour-saving technical progress

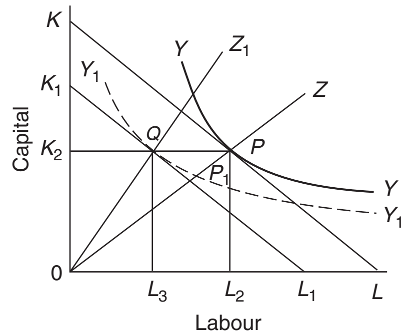
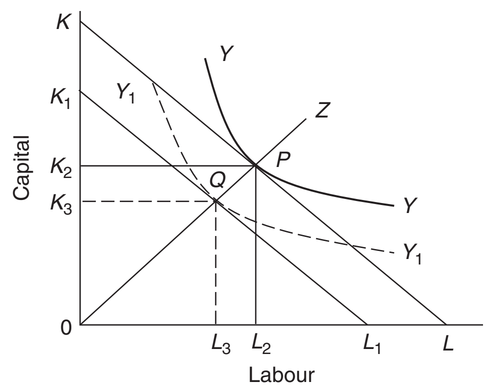


Figure 6.3 Neutral technical progress



saved, technical progress is said to be *absolutely* labour- or capital-saving. If fewer of both factors are required, technical progress is said to be *relatively* labour- or capital-saving.

Consider first **neutral technical progress** (Figure 6.3). The ray from the origin, or expansion path, 0*Z*, goes through the minimum cost point of tangency between the production function *YY* and the factor–price ratio line *KL*. With neutral technical progress the production function shifts to Y_1Y_1 such that the new point of tangency at the same factor–price ratio lies on the same expansion path. This means that the ratio of marginal products is the same at the same capital–labour ratio, and equal proportionate amounts of the two factors are saved. The condition for neutral technical progress is simply that the new production function is parallel to the old.

With **labour-saving technical change** (Figure 6.2) the ratio of the marginal product of capital to the marginal product of labour rises so as to shift the minimum cost point of tangency from the old expansion path 0*Z* to a new expansion path $0Z_1$. At P_1, where the new production function (Y_1Y_1) cuts the old expansion path, the ratio of the marginal product of labour to capital is lower than at *P*. P_1 is not an equilibrium point and it will pay producers to move to point *Q*, substituting capital for labour. The ratio of marginal products has not remained unchanged at a constant labour–capital ratio, and L_2L_3 labour is saved. The isoquants have been so drawn as to keep the volume of capital the same, but this is for expositional purposes only.

Capital-saving technical progress (Figure 6.1) may be described in an exactly analogous fashion. In this case, the ratio of the marginal product of labour to the marginal product of capital rises and the shift in the production function (to Y_1Y_1) is such that the minimum cost point of tangency now lies to the right of the old expansion path. At P_1, where the new production function cuts the old expansion path, the ratio of the marginal product of labour to capital is higher than at P. Again, P_1 is not an equilibrium point and it will pay producers to move to point Q, substituting labour for capital. The ratio of marginal products has not remained unchanged at a constant labour–capital ratio, and in this case K_2K_3 capital is saved.

As with Harrod technical progress, it is difficult to know what form Hicks technical progress takes in practice, largely because of identification problems. While the classification is analytically distinct, how does one distinguish empirically between a change in factor proportions due to a shift in the production function and a change in factor proportions due to a change in relative prices? Hicks himself seemed to be of the view that technical progress is relatively labour-saving, but the indirect evidence we have for this is slight. For example, given the magnitude of the rise in the price of labour relative to capital and an elasticity of substitution close to unity, labour could not have maintained or increased its share of the national income (as it has done slightly in some advanced countries) if technical progress was markedly biased in the labour-saving direction. If technical progress is biased in one direction or another, its major impact will be on factor utilization if the price of factors is not flexible. The type of technology employed, and the factor proportions it entails, must bear a major responsibility for the high level of unemployment and underemployment in developing countries, as described in Chapter 3. We examine the case for the use of more labour-intensive techniques of production later in this chapter.

How societies progress technologically

Improvements in the art of production, which is the most literal interpretation of technical progress, result from a combination of **R&D**, **invention** and **innovation**. R&D and invention are the activities that 'create' knowledge, and innovation is the activity that applies new knowledge to the task of production. These are all basically economic activities. But the study of the way in which societies progress technologically, and the speed of progress, is not only the preserve of the economist.

The economist can identify the mainsprings of progress, but their pervasiveness and acceptance in societies is not a purely economic matter. The spread of new knowledge, for example, depends on its rate of *adoption* and *diffusion* and this raises questions of individual motivation, the willingness of societies to assimilate new ideas and to break with custom and tradition, which impinge heavily on territory occupied by development sociologists. The relative importance of different factors contributing to progress, and the speed of progress itself, will vary from country to country according to the stage of development and a whole complex of socioeconomic forces. Moreover, many of the mainsprings of technological progress are not mutually exclusive. At the risk of excessive simplification, attention here will be confined to four main sources of progress that are of potential significance to any society.

One major source of improvement in technology and progress is the **inventive and innovative activity** of the population. All societies are endowed to some degree with a potential supply of inventors, innovators and risk-takers, and in the absence of imported technology and personnel, it is on the emergence of this class of person that technological progress will primarily depend during the early stages of development. Economic backwardness in many countries may quite legitimately be traced back to a relative shortage of inventors, innovators and risk-takers. It is fairly well established that some cultures and some environments are more amenable to change than others, and have, in the past, produced a greater supply of entrepreneurs. One of the major sources of growth during Britain's Industrial Revolution was technological progress fostered by an abundant supply of inventors, innovators, entrepreneurs and risk-takers. The great Austrian economist **Joseph Schumpeter** (1934, 1943) laid great stress on the role of the entrepreneur and innovation in the development process. Ultimately, however, it is the lag between the creation of knowledge and its adoption, and the rate of dissemination of new knowledge, that most directly affects the rate of measured technical progress between countries; and these two facets of innovation are influenced by the attitudes of society to change.

For Schumpeter, progress results from what he called the **process of creative destruction**, which is bound up with innovation and instigated by competition. Innovation, in turn, is the driving force behind competition. But innovation requires decision-takers and hence his complementary stress on the role of the entrepreneur. A characteristic of many poor countries is a shortage of decision-takers, a relative lack of competitive spirit, and a general aversion to risk-taking. These may be partly cultural traits and also partly, if not mainly, a function of the stage of development itself. The characteristics commonly associated with business dynamism are themselves a function of business and, more particularly, the form of organization we call 'capitalism'.

There is an enormous technological divide in the world economy, which acts as a serious barrier to narrowing the gap between rich and poor countries. A small number of countries (accounting for about 15% of the world's population) produce nearly 50% of the world's technological innovations. A number of other countries (containing 50% of the world's population) are able to adopt some or all of these technologies. The remaining countries (containing one-third of the world's poorest people) are almost entirely excluded from technological progress. These latter countries are also the areas of the world most affected by low agricultural productivity, malnutrition and disease. They need technology to raise productivity and to improve health, but cannot afford or assimilate it.

The major channels of technical diffusion across countries are trade (see Grossman and Helpman, 1991) and foreign direct investment (FDI) (see Keller, 2004, for a survey of the impact of these channels on economic performance). Countries can import technology embodied in intermediate imports or final goods, they can obtain it on licence from patent holders, or they can attract FDI, which brings technology with it. The spread of technology and ideas may also be expected to come about naturally in the general process of commercial intercourse and the exchange of information through trade. This is one of the dynamic gains from trade (see Chapter 15). But not all countries have equal access to technology. Geography, culture, institutions and the quality of human capital matter. The speed with which modern technology is absorbed by economically backward countries will depend on the same class of factors as the diffusion of knowledge within countries, which, in the final analysis, amounts to the receptiveness of all sections of the community to change, and the ability to assimilate new ways of doing things. Some economists argue that the World Bank should focus more of its lending to countries specifically for knowledge creation and assimilation.

New technology and its diffusion could lead to greater divergence in the world economy if richer countries are more adept at adopting foreign technology than poorer countries. This underlines the importance of identifying the major determinants of technical diffusion. The two most important variables are human capital and R&D, which determine absorptive capacity. According to a study by Fagerberg et al. (2007), of 90 countries over the period 1980–2002, the superior growth of innovative activity is the main factor behind the difference in economic performance between the newly industrializing countries of Asia on the one hand, and Latin America and Africa on the other. Growth rate differences between open economies can be explained in terms of technological competitiveness, which is the capacity to absorb technology and to exploit knowledge from elsewhere; price competitiveness, which is a function of new technologies that reduce costs; and non-price competitiveness, which largely depends on product innovation.

Learning

A third means by which societies progress technologically, gradually raising their efficiency and productivity, is through the process of **learning by doing**, which refers to the accumulation of experience by workers, managers and owners of capital in the course of production, which enables productive efficiency to be improved in the future. It is a learning process that Adam Smith referred to when discussing the benefits of **division of labour** (see Chapter 4). Smith stressed the importance of the division of labour for three main reasons: as a means of improving the dexterity of workers, to save the time lost in the absence of specialization, and to encourage the invention of machines that facilitate and abridge labour to improve the productivity of labour. All these advantages of the division of labour are part of a learning process. Labour improves its skill through specialization and work experience, and becomes more adept at the job in hand. Managers see deficiencies in organization, which can subsequently be remedied; and on the basis of accumulated knowledge, they are also able to embody more productive techniques in the capital stock.

Learning may be regarded as either endogenous or exogenous, or both, depending on the factor of production considered. If existing labour and existing capital are subject to a learning process, then learning by doing may be regarded as exogenous and part of disembodied technical progress. If, however, it is assumed that learning enters the productive system only through the addition of new factors, then learning by doing must be regarded as endogenous. This is the basis of Kenneth Arrow's capital model (1962), from which the term 'learning by doing' originates. His hypothesis with respect to capital is that, at any moment of time, new capital goods incorporate all the knowledge then available, based on accumulated experience, but once built, their productive efficiency cannot be altered by subsequent learning.

The endogenous model may be appropriate in the case of capital but is much less relevant in the case of labour. It is in relation to labour that most research into the learning process has been conducted. The notion of the **learning curve**, or progress function, which has been found in many industries, relates direct labour input per unit of output to cumulative output as the measure of experience. Typically, labour input per unit of output is found to decline by 10–20% for each doubling of cumulative output, with a corresponding rise in the productivity of labour. For any one product, of course, learning cannot go on at the same rate forever, but since product types are constantly changing, it is probably safe to conclude that at the aggregate level, over time, there is no limit to the learning process.

Infrastructure investment

Another major type of investment that is very important to developing countries is infrastructure investment. Just as the productivity of physical capital depends on investment in human capital, so it also depends on the existence of infrastructure investment, for example in transport and power facilities. Good infrastructure improves productivity and reduces production costs in the private sector. Apart from this obvious benefit, the adequacy of infrastructure can make a crucial difference to a country's development programme in a number of ways, such as diversifying production, expanding trade, improving environmental conditions, and reducing poverty.

For poor farmers, improved infrastructure will reduce input costs, increase agricultural output and reduce traders' monopoly by improving access to markets. Over half of African farmers are cut off from national and world markets because of poor infrastructure and market access. Better transport means greater access to public services, including schools, hospitals and other healthcare facilities. In this way, infrastructure investment can help to meet some of the Sustainable Development Goals in the field of education, health and gender equality that we discussed in Chapter 2. Research at the World Bank (2005) across 73 countries shows that a 10% improvement in a country's infrastructure index is associated with a 5% reduction in child mortality, a 3.5% reduction in infant mortality, and a 7.8% reduction in maternal mortality (linked to safer water supply, sanitation and easier access to hospitals). Piped water promotes gender equality by freeing women who traditionally spend hours a day collecting water from wells.

Research at the macro-level shows a significant positive effect of infrastructure investment on output, productivity and growth. Calderón et al. (2015) take a panel of 88 developed and developing countries over the period 1960–2000 and estimate an output elasticity with respect to a multidimensional index of different types of infrastructure of between 0.07 and 0.10. The results are highly significant and robust and mean that, on average, a doubling of infrastructure investment would increase total output (GDP) by about 10%. Likewise, Arslanalp et al. (2011) of the World Bank have studied the impact of public investment (mainly infrastructure) on economic growth across 48 developed and developing countries over the period 1960–2001 and find a significant positive impact, allowing the responsiveness of output to public capital to vary with the initial stock of public capital itself. The elasticity of growth tends to be higher, the lower the initial level of public capital, rising to nearly 0.2 and then falling close to zero.

Currently, developing countries spend nearly a $1 trillion a year on new infrastructure – transport, power, water, sanitation, telecommunications, irrigation and so on, equal to 20% of total investment and approximately 5% of GDP – and the need for such investment is still huge. One billion people still lack access to clean water, 2 billion people lack access to sanitation (including 500 million in India alone) and electric power, and transport facilities are still rudimentary in many developing countries. The Asian Development Bank has estimated that $8 trillion of investment is needed between 2010 and 2020, mainly for roads, electricity and telecommunications. To meet this need in Asia, China announced in 2015 the establishment of a new **Asian Infrastructure Investment Bank (AIIB)**, based in Beijing, with 57 founding member countries and initial capital of £50 billion, expected to rise to over $100 billion. It is seen by the USA as a rival to the World Bank (largely controlled by the USA) and so has not joined; neither has Japan, which has a hold on the Asian Development Bank. Given the need for infrastructure investment, however, none of these banks should see themselves as rivals, but as complements.

Most infrastructure investment is undertaken by governments. The public sector owns, operates and finances virtually all infrastructure because it is either regarded as a natural monopoly or a public good. Without competition and accountability, however, there can be a great deal of inefficiency and waste. The underutilization of capacity can be a major problem in transport and power because of lack of maintenance. The World Bank (1994) calculates that raising operating efficiency to best-practice levels could save over $50 billion a year, and that the greater private provision of infrastructure and the recoupment of costs from users could reduce government subsidies by over $100 billion.

The World Bank (1994) has called for a shift of emphasis 'from increasing the quantity of infrastructure stocks to improving the quality of infrastructure services', and a change of thinking from the view that infrastructure services can only be provided by government. It makes three major recommendations:

1. The wider application of commercial principles, including managerial autonomy and the setting of performance targets.
2. The introduction of more competition, for example arranging for suppliers to compete for an entire market.
3. The increased involvement of users so that suppliers respond to user needs.

Technology and the developing countries

Most technological improvement originates from developed countries. The Organisation for Economic Co-operation and Development (OECD) countries spend over $800 billion a year on R&D, and account for more than 90% of patents issued. If developing countries are to develop their own technology, there needs to be the right institutional environment, including an incentive structure through patents, sound infrastructure, political stability to attract investment funds, and the availability of credit. Some of the technological leaders among developing countries include Singapore, Taiwan, India, South Korea, Malaysia, China, Mexico, Thailand, Philippines and Brazil, measured by the share of medium- and high-technology manufactures in total manufacturing value-added.

Technology is currently making a contribution to development in three major fields: agriculture, health, and information and communications technology (ICT). In agriculture, the impact of the Green Revolution in the 1960s and 1970s has now diminished, but on the horizon is biotechnology with the potential to end world hunger through the use of genetically modified (GM) foods and crops. The advantage of GM technology is that it allows the transfer of traits between unrelated species. For example, a gene in one species associated with the ability to resist drought can be directly transferred into the genetic code of another species. We now have GM crops more resistant to viruses and insects and more tolerant of herbicides; in the future, we could have food with extra vitamins and protein, and even vaccines to combat malnutrition and disease. In the late 1990s, China gave 26 approvals for GM crops, including transgenic peppers, tomatoes, rice and cotton. China has the advantage of being an authoritarian regime. Other countries – including India, China's main economic rival – have had to deal with public protests against GM technology, with invasion of field trials and burning of GM crops.

In health, new technology and advances in medicine have been the biggest single factor in reducing mortality and increasing life expectancy in developing countries. Important discoveries include vaccines against influenza, smallpox, polio, measles, tuberculosis, antibiotics (penicillin), and oral rehydration therapy – which was originally developed in Bangladesh and has saved millions of babies from dying from diarrhoea. Biotechnology and genomics offer new ways to cure disease by altering genes that contribute to cancer, or boosting genes that might fight it.

ICT can provide enormous benefits to developing countries, both as consumers and producers. Any task that can be digitized can now be done at a distance, which gives the opportunity for low-cost countries to develop ICT industries. India's software industry now employs nearly 2 million people. Call centres are one of the fastest-growing industries in the subcontinent. For consumers, access to information through the internet can be of benefit in almost any field – for weather information in agriculture, the dissemination of knowledge in healthcare and the tracking of diseases, and for distance learning in education. Telephone banking is revolutionizing access to finance and credit in African countries.

Case example 6.2 describes the World Bank's views on bridging the technology divide between rich and poor countries.

Case example 6.2

Bridging the technology divide

Technological progress – improvements in the ways that goods and services are produced, marketed, and brought to market – is at the very heart of human advancement and development. It has helped reduce the share of people living in absolute poverty in developing countries from 29% in 1990 to 18% in 2004. As a result, the technology gap between rich and poor countries has narrowed, although it remains wide. Low-income countries employ only one-fourth the technology used in high-income countries.

Technological progress in developing countries (that is, low-income, lower middle-income, and upper middle-income countries) outstripped progress in high-income countries between the early 1990s and 2000s. Of course, the initial level of technology in lower income countries was much lower to begin with.

The very strong technological progress developing countries have enjoyed has come mainly from adopting and absorbing existing technologies. Compared with the size of their economies, they perform relatively little new-to-the-world innovation.

The diffusion of technology across developing countries has been facilitated by their increased exposure to foreign technologies. Over the past 15 years, FDI levels and imports of high-tech and capital goods have doubled as a percentage of GDP – in part because of contacts with well-educated migrant populations living abroad.

Slow diffusion within countries means that, although individual cities may be technology leaders, the use of technology in a country as a whole may be low. For instance, while more than one in two urban Indian families has mobile phone access, only one in 10 in the rural sector does.

Partly as a result of this increased exposure, newer technology – such as mobile phones, computers and the internet – now spreads much more quickly. In the early 1900s, new technology took more than 50 years to reach most countries; today it takes about 16 years. But technology tends to spread slowly within countries because many developing countries lack the technical skills necessary to master new, or even older, technologies.

Although better macroeconomic and educational policies, as well as the spread of older enabling technologies – such as electrical networks, road infrastructure, telephone land lines, and sanitation networks – have advanced the spread of technology in developing countries, progress has been slow and the capacity to absorb new ideas and techniques remains weak.

Closing the gap

To continue catching up with high-income countries, developing countries need to:

- Maintain exposure to foreign technologies through trade openness, foreign direct investment, and the participation of migrant populations.
- Further improve the investment climate to allow innovative firms to grow.
- Invest in enabling technologies and basic infrastructure, such as roads, electricity and telephones.
- Improve the quality and increase the quantity of education throughout the economy – not just in major centres.
- Emphasize technology diffusion by reinforcing dissemination systems and the market orientation of R&D programmes.

Source: Burns, 2008.

Techniques of production

If labour is more abundant and capital is scarcer in developing countries than in developed countries, we might expect to observe the use of more labour-intensive techniques of production in the industrial sector of developing countries, reflecting a lower price of labour relative to capital. Figure 6.4 shows this. Assuming the same production function in the two sets of countries, labelled '1', and holding everything else constant, the lower relative price of labour in the developing country, given by the price line (or isocost curve), *cb*, gives a more labour-intensive choice of technique than in the developed country, where the relative price of labour is given by the steeper line *ad*.

In the developed country, the capital–labour ratio is given by the ray from the origin, *DC*, while in the less-developed country, the capital–labour ratio is given by the ray *LDC*; both rays pass through the point of tangency between the price line and production function – *A* and *B*, respectively.

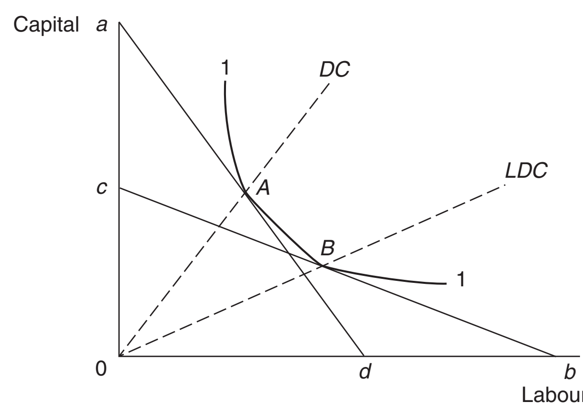
In practice, however, it is often the case that for the same outputs produced, the capital intensity of techniques is not very different between the two sets of countries, and that the capital–labour ratio differs between developed and developing countries in the aggregate only to the extent that the composition of output differs; that is, because there are large sectors in developing countries' economies where very little capital is employed at all, as in subsistence farming and petty service activities. In the modern sectors of developing countries, however, techniques are much more capital-intensive than would be predicted on the basis of knowledge of factor endowments. Given the supply of labour available, and given the rate of investment, the more capital-intensive the techniques, the less employment and the more unemployment there will be.

Unemployment and underemployment are major preoccupations in developing countries, and are one reason why the prevailing techniques of production might be regarded as 'inappropriate'.

But what accounts for this relative capital intensity of modern sector techniques, and would developing countries be better off using more labour-intensive techniques? There are a number of reasons why technological choice sometimes appears to be little different in developing countries than in technologically advanced societies.

First, for a large number of commodities, there may not be a spectrum of techniques to choose from; that is, in practice, the production function in Figure 6.4 may not be smooth, and a country cannot move from point *A* to *B* in accordance with differences in relative factor endowments and

Figure 6.4 Optimal choice of technique

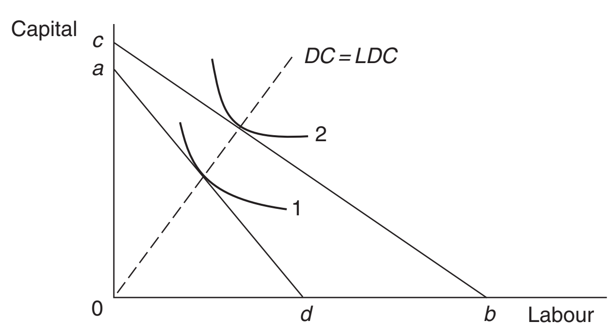


relative factor prices. We are talking here, of course, about techniques that are profitable. There may always be more labour-intensive techniques using more labour and capital, but then the output would not be competitively saleable. If there is not a spectrum of profitable techniques of production, and the coefficients of production are fixed, the production function is L-shaped (sometimes called a **Leontief production function**, after Wassily Leontief, the 'father' of input–output analysis, which assumes no substitutability between capital and labour). Whether technology is such that there is only one profitable technique, or whether there are many but developing countries do not have access to them, is an empirical question we shall consider later in the chapter.

A second reason for the relative capital intensity of production in developing countries is that the market prices of factors of production frequently do not reflect relative abundance or scarcity. This tendency is often exacerbated by developing countries themselves, which give generous subsidies to scarce capital and encourage high wages in the modern manufacturing sector by the government paying high wages to its own employees. The old justification for using capital-intensive techniques, which governments used to believe in and still do to some extent, was that they are necessary to maximize output and saving, and that more labour-intensive techniques would reduce the level of output and saving because of their relative inefficiency and higher wage bills. Later in the chapter, we shall examine these contentions; but, clearly, the cheaper that capital is made by subsidies, and the higher wages are above their 'shadow' price, the more capital-intensive the techniques will tend to be.

A third factor to bear in mind is that although labour may be abundant and the money wage may be lower than in developed countries, it is not necessarily 'cheaper' or less 'costly' to employ, because its productivity may be lower. In other words, the so-called **efficiency wage** (that is, the wage rate divided by the productivity of labour), or wage costs per unit of output, may differ very little between developing and developed countries. This means that the production function for the developing country in Figure 6.4 above will lie outside the production function for the developed country in such a way that even if the relative money wage of labour is lower in the developing country, it is profitable to choose a relatively capital-intensive technique. Figure 6.5 shows this. The production function for the developing country is labelled '2'. Even though labour is cheaper relative to capital in the developing country (slope of $cb <$ slope of ad), nonetheless the most profitable capital–labour ratio will be the same in both countries (given by the ray from the origin, $DC = LDC$). It is probably because abundant labour is not necessarily 'cheap', in a cost per unit of output sense, that accounts for the observation that, in trade, developing countries' exports are sometimes as capital-intensive as in developed countries, contrary to the prediction of certain trade theories. This apparent paradox (sometimes called the **Leontief paradox**) can be explained

Figure 6.5 Different wages: same technique



by the fact that it is the 'efficiency' wage that matters, not the money wage, and while the money wage may be low in developing countries, the 'efficiency' wage is relatively high.

Fourth, in certain instances, capital intensity may be explained by a skill constraint. Typically, labour-intensive techniques require a great deal of skilled labour, compared with capital-intensive techniques which mainly require a preponderance of semi-skilled labour to undertake routine tasks. In developing countries that are short of skilled manpower, capital may substitute for skills and constitute a rational response on the part of decision-makers, whoever they may be.

But perhaps the overriding factor that accounts for the relative capital intensity of the modern sector of developing countries is that many, if not most, of the techniques of production are imported from abroad, with a heavy bias in the labour-saving direction. The techniques may either be employed by indigenous firms or, as increasingly seems to be the case, by large foreign-owned **multinational corporations**, which invest in the country and bring their technology with them. In this case, the technology may be 'inappropriate' not because there is not a spectrum of techniques to choose from or an inappropriate selection is made, but because the technology available is circumscribed by the global profit-maximizing motives of the companies investing in the developing country concerned. The labour-saving bias of the technology is to be explained by the labour-saving bias of technical progress in advanced countries where labour is relatively scarce and expensive. As we saw earlier (Figure 6.2), labour-saving bias on a production function diagram is represented by a non-uniform inward shift in the production function, causing capital to be substituted for labour at the same ratio of relative factor prices.

If developed countries have designed labour-saving technologies that, through the process of international investment, are now being widely used in developing countries, it might well be asked: Why have developing countries not invented capital-saving technologies to economize on scarce capital? The answer is that if a country is to develop technology to save capital, it must have a capital goods industry, but typically the capital goods sector of developing countries is rudimentary or non-existent. With a large fraction of investment goods coming from abroad, coupled with a lack of domestic knowhow, there has been very little incentive for developing countries to establish their own capital goods industries.

Capital goods production is characterized by the ability to specialize, but to do this economically requires a large market – a much larger market than for homogeneous consumer products that can reap economies of scale. Capital saving also comes from improvement in the efficiency of capital goods production itself, but without a capital goods sector there cannot be innovations, and an important source of capital saving and technical progress in the economy as a whole is lost. It is widely recognized that a capital goods sector is essential for innovatory activity in the economy as a whole, and if developing countries are to reduce their dependence on imported technology, priority must be given to the establishment and nurture of an indigenous capital goods sector (for a lucid discussion of these issues, see Stewart, 1977, especially Chapter 6).

The empirical evidence on multinational corporations and the choice of techniques is mixed. Lall (1978) distinguishes three separate issues:

1. Whether the technologies used by multinationals are adaptable to abundant labour and low wage conditions in developing countries.
2. Whether multinationals do adapt the technologies they transfer.
3. Whether multinationals adapt better or worse than local firms.

Regarding the first question, the technologies used by multinationals are unlikely to be very flexible because the companies tend to predominate in modern industries where processes are complex, continuous and, by their very nature, capital-intensive. Outside processing, however, ancillary activities, such as the handling of materials and packaging, may be amenable to substitution. On the second issue, it is unlikely that multinationals will undertake major, expensive alterations to technology simply to suit local conditions, and there is not much evidence that they do so.

With regard to the third matter, however, in comparison with local firms, the experience of the multinationals seems to be mixed. The problem here is that when making comparisons, like must be compared with like; that is, local and foreign firms must be compared in the same market, producing similar products with equal access to technology. Studies must therefore be treated with caution. It is easy to reach the conclusion that multinationals are more capital-intensive than local firms if they operate in different industries producing different products. This is, in fact, often the case, as they tend to be concentrated in activities that are intrinsically more capital-intensive such as heavy industries and extractive industries. We shall say more about the empirical evidence below, and more about multinational corporations in Chapter 14, where we consider the role of FDI in the development process.

We turn now to the potential conflict between moving towards the use of more labour-intensive techniques of production and output on the one hand, and saving on the other.

The conflict between employment and output and employment and saving in the choice of techniques

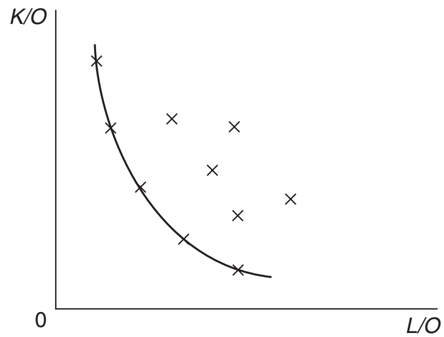
Developing countries have three broad objectives: to raise the level of *present* consumption, to raise the level of *future* consumption (by saving now), and to raise the level of *employment*. In the choice of *new* techniques, a conflict between objectives may arise. First, a technique that maximizes employment may involve a sacrifice of output. Second, a technique that maximizes employment may involve a sacrifice of saving. As we have mentioned already, certainly one of the justifications for the use of modern capital-intensive technology used to be that labour-intensive techniques would reduce output and the investible surplus. We need to look at this matter theoretically and empirically. We shall argue that while, in theory, there may be a conflict, the assumptions on which a potential conflict is based are either invalid or too extreme, and that, in practice, developing countries could move towards the use of more labour-intensive techniques without sacrificing the level of present or future consumption. Some of the empirical evidence would seem to bear this out.

Employment versus output

A potential conflict between employment and output exists in the choice of new techniques because methods that employ high labour–capital ratios may involve high capital–output ratios because labour productivity is lower.[1] Assume that a fixed amount of capital, £1,000, is to be invested. Technique I employs 100 persons with an incremental capital–output ratio of 5, giving an annual flow of output of £200. Technique II employs 50 persons with an incremental capital–output ratio of 4, giving an annual flow of output of £250. Therefore the technique that maximizes employment has a lower flow of current output.

It should be said straight away that there is very little evidence, if any, to support the view that labour-intensive techniques have higher capital–output ratios than capital-intensive techniques. On the contrary, there is growing evidence that labour can be substituted for capital, provided cooperating factors are available, without the level of output being impaired. One interesting pioneer study is that by Pack (1974), using UN data on capital per unit of output (K/O) and labour

Figure 6.6 Efficiency frontier



per unit of output (L/O) for 6 commodities in 16 firms across 10 countries. Pack plots the observations of (K/O) and (L/O) (as in Figure 6.6) for each commodity from the cross-section data, and then defines the efficiency frontier to estimate the elasticity of substitution along it.

Each scatter point in Figure 6.6 represents country observations for one industry, say cotton textiles, of the relative amounts of capital and labour employed per unit of output. The **efficiency frontier** (or unit isoquant) is drawn through the points closest to the origin and the elasticity of substitution is calculated as:

$$\frac{(K/L)_i}{(K/L)_j} = \left[\frac{(w/r)_i}{(w/r)_j}\right]^{\sigma}$$

where w/r is the wage-rental ratio, i and j are the two observations closest to the origin, and σ is the elasticity of substitution. For five of the six commodities, there is a large difference in the amount of capital per worker year used by countries on the efficiency frontier and a fairly high elasticity of substitution. The results are shown in Table 6.1.

Table 6.1 Capital–labour substitution possibilities

Industry	Countries on the efficiency frontier	Capital per worker year ($)	Elasticity of substitution (σ)
Bicycles	India	400	0.24
	Japan	520	
Grain milling	Japan	280	3.70
	Israel	6,410	
Paints	India	214	1.60
	Middle Europe	2,790	
Tyres	Iran	6,240	1.50
	Mexico	10,600	
Cotton textiles	India	1,100	2.00
	Mexico	8,240	
Woollen textiles	India	260	1.20
	Japan	4,600	

The results suggest that for countries using large amounts of capital per unit of labour, there are more labour-intensive techniques available (as used by other countries) that could be adopted without sacrificing output, unless the cooperating factors associated with the increased labour intensity are not available. One interesting observation from Pack's work is that India is invariably either on or close to the efficiency frontier, and hence is using labour-intensive techniques effectively.

Pack's study (1976) of 42 plants in Kenyan manufacturing also suggests that there appears to be considerable *ex ante* choice of capital intensity in most industries, particularly outside the processing sector in the auxiliary activities of material receiving, material handling among processes, packaging and storage of the finished products. In fact, many auxiliary activities are already very labour-intensive, and contrary to the conventional wisdom, it was found that foreign-owned firms generally used more labour-intensive techniques than indigenous firms. Pack ascribes this to the better managerial expertise and technical training of personnel in foreign firms. Forsyth and Solomon (1977), in a study of Ghana, also found scope for capital/labour substitution and could find no conclusive evidence that foreign firms are more capital-intensive than resident expatriate or private indigenous firms. The situation varies from industry to industry. Helleiner (1975) concludes his survey of multinational corporations and technological choice by saying:

> In particular industrial sectors, the multinational firm has often proven more responsive and adaptable in its factor and input use, especially in the ancillary activities associated with the basic production processes, than local firms, and so it perhaps should be with its wide range of experience on which to draw.

Even if more labour-intensive techniques can be used without a sacrifice of output, there is still the question of whether the investible surplus, and therefore future output, will be impaired. Pack's work suggests otherwise, but let us now consider in more detail the potential conflict between employment and saving, as the traditional argument has it.

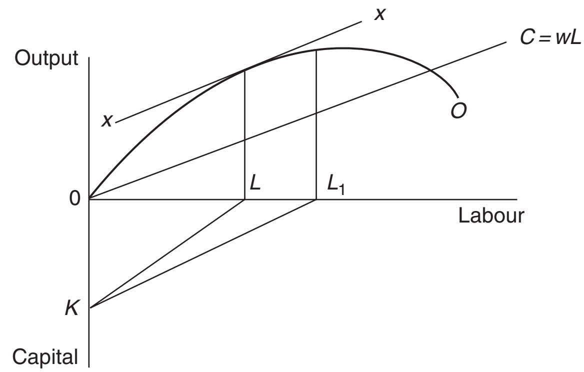
Employment versus saving

The potential conflict between employment and saving can be illustrated in its starkest form using a simple production function diagram, first used in this context by Dobb (1955) and Sen (1968).

Consider the use of a given amount of investible resources, K, and the possibility of employing those resources with varying amounts of labour to produce output. In Figure 6.7, $0O$ is the production function in the consumption sector, exhibiting diminishing returns to labour. Now take the standard traditional (although not necessarily correct) assumption that in the industrial sector, labour is paid a fixed wage that is all consumed, so that a ray from the origin ($0C$) with a constant slope (w) shows the level of the wage bill and consumption at each level of employment. The difference between $0O$ and $0C$ is profit, and if all profits are saved, the difference also shows the level of saving at each capital–labour ratio. Saving is maximized where a line drawn parallel to $0C$ is tangential to the production function – at employment level L in Figure 6.7. Beyond this point, further employment generation would diminish the level of saving and investible surplus.

The potential clash between increasing employment and maximizing saving can be seen, however, to be based on several assumptions, the validity of which may be questioned:

Figure 6.7 Employment versus saving



- The wage rate is given and invariant with respect to the technique of production. This assumption would seem to be a hangover from Lewis's influential model of the development process (discussed in Chapter 5), which assumes an elastic supply of labour to the industrial sector at a *constant* wage. If this wage is above the minimum necessary, several other implications ensue.
- All profits are saved and all wages are consumed.
- Unemployment resulting from the use of capital-intensive techniques does not reduce community saving by at least as much as with more employment and a higher wage bill.
- Consumption is not productive (that is, it has no investment component), or that present consumption is no more productive than future consumption.
- Governments lack the ability to tax and to subsidize labour to reconcile the potential conflict.

Let us relax these assumptions and see what difference is made.

Wages and the capital intensity of production

Let us first relax the assumption that the wage rate is given and the same for all techniques, regardless of capital intensity. There are two fundamental points to be made here in the context of a developing country. The first is that a great deal of the technology, at least in the modern industrial sector, is not indigenous but imported. In this case, the wage structure is set by the *skill mix* demanded by the technology and the need to keep the labour force well nourished and contented if the capital equipment is to be worked productively and profitably. By and large it may be expected that the greater the degree of capital intensity, the higher the average wage paid.

The second point is that with large amounts of disguised and open unemployment in the urban sector of developing countries, there is likely to be a big difference between the wage that is being paid with the use of existing technology (imported or indigenous) and the wage at which labour would be willing to work, given the opportunity, with the use of more labour-intensive technology. If more labour-intensive technology could be developed and applied, there is no reason why the wage rate should not be lower with the use of these techniques, unless there is strong trade union resistance in certain sectors.

If the wage is not assumed to be given, but may vary with the technique of production for the reasons outlined above, the conclusion of a conflict between employment and saving in the choice of new techniques is affected considerably. Indeed, if the marginal product of labour declines with the labour intensity of production, and the wage is equal to the marginal product, the conflict disappears entirely. The surplus increases in line with increases in the amount of employment because the surplus on *intra-marginal* units of labour increases.

Wages cannot fall to zero, however – there must be some minimum below which wages cannot fall. This gives the conclusion that there is no necessary conflict between employment and saving up to the point where the marginal product equals the *minimum* wage. Beyond that point there will be a conflict.

Different classes' propensity to consume

The alleged conflict between employment and saving also depends on the assumption that the propensity to save out of profits is higher than the propensity to save out of wages. In Figure 6.7 above, the difference between employment levels L (which maximizes saving) and L_1 (which maximizes employment) depends on the extreme assumption that all profits are saved and all wages are spent. No one would dispute that the propensity to save out of profits (s_p) is higher than the propensity to save out of wages (s_w) (indeed, there is plenty of empirical evidence to support the assertion), but it would be unrealistic to argue that there is no saving out of wages and no consumption out of profits. Both consumption out of profits and saving out of wages will reduce the conflict between employment and saving and move the point of maximum surplus away from L towards L_1.

The narrower the difference between s_w and s_p, the higher the level of employment before a conflict sets in, until at the limit, if $s_w = s_p$, there is no conflict at all. The distribution of income between wages and profits will not affect the aggregate level of saving.

Support of the unemployed

If a particular choice of technology, which is designed to maximize the reinvestible surplus, causes unemployment and the unemployed make claims on society's investible resources, the surplus may ultimately be less than if more labour-intensive techniques had been chosen. There are three main ways in which the unemployed may reduce the investible surplus:

- If the unemployed remain in the agricultural sector, they may depress average product and consume more than they produce, thus reducing the agricultural surplus.
- If the unemployed remain in the industrial sector, they will absorb family savings to support themselves.
- There may be public support for the unemployed through unemployment insurance programmes, in which case, public saving will be reduced below what it otherwise might be.

If 'compensation' to the unemployed in any of the forms outlined above exceeds the difference between the industrial wage and the marginal product using more labour-intensive techniques, it would pay to create extra employment because the difference between consumption and production as a result of expanding employment would be less than the reduction in saving caused by the unemployment. At the limit, of course, if the unemployed 'consumed' resources equal to the value of the industrial wage, it would make no difference if labour was employed up to the point where the marginal product of labour is zero. There is clearly no difference from the point of view of saving between an unemployed person consuming the equivalent of an industrial wage and an employed man with zero marginal product receiving an industrial wage. As long as unemployment absorbs saving, therefore, in whatever form, employment can be higher without reducing the investible surplus to below what it would otherwise have been. Thus, as a general proposition, it may be said that the extent of the conflict between employment and saving will also depend on the amount of compensation to the unemployed out of the total investible surplus.

Are consumption and investment distinct?

The alleged conflict between employment and saving also assumes either that consumption has no investment component or that present and future consumption are equally productive. Those who argue for techniques to maximize the investible surplus at the expense of employment place no value on present consumption at the margin, and those who argue for techniques to maximize employment are indifferent at the margin between an extra unit of consumption and saving (investment). It can be shown, however, that if consumption has an investment content, and the productivity of consumption falls as the level of consumption increases, the relative valuation of present consumption increases, favouring more labour-intensive techniques (Thirlwall, 1977). 'Productive' consumption refers to consumption that improves the efficiency of labour, thereby raising the level of income in the same way as normal additions to the capital stock. As long as consumption is productive, therefore, an increase in employment and consumption need not be at the expense of 'investment' for future output.

All too little is known about the precise extent to which low levels of consumption, and particularly food intake, impair working efficiency and productivity. But we do know that the food requirements considered by nutritionists to be necessary for efficient working and healthy living are far greater than the levels achieved by a large minority of the population in developing countries (see Dasgupta, 1993). Calorie deficiency causes loss of body weight, tiredness, listlessness and a deterioration of mental faculties. Protein deficiency causes such conditions as kwashiorkor, and may cause death in children. Vitamin A deficiency causes blindness, and iodine deficiency is a cause of goitre, which leads to cretinism and deaf-mutism. Altogether, it has been estimated by the UN Food and Agriculture Organization that at least 1 billion people in the world suffer from various degrees of malnutrition. To the extent that this impairs efficiency and output, and is caused by a lack of consumption, an increase in employment and present consumption may be as valuable at the margin as an extra unit of saving from the point of view of future welfare. The more equal the relative valuation of consumption and saving at the margin, the less the conflict between employment generation in the present and the level of future output.

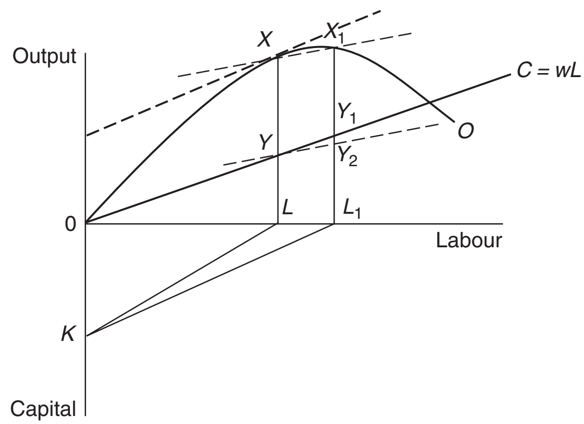
Taxes and subsidies

It has been assumed so far that savings and employment depend exclusively on the choice of technique. In practice, of course, governments can tax and subsidize to achieve desired ends, and this they can do to reconcile the conflict between employment and saving. As Sen (1969) has remarked:

> the total amount of income to be saved can be determined by the planner in any way he likes . . . If this is true then the link snaps between the choice of techniques and the proportion of income saved. The technical choice may be made with the main purpose of maximising the amount of output, and the proportion of the output to be invested can be decided at a separate stage.

Consider again Figure 6.7, which is redrawn here as Figure 6.8. By the choice of techniques alone, maximization of the surplus XY means a sacrifice of employment L_1L. Or employment L_1 means a sacrifice of savings equal to Y_1Y_2. Now suppose that the government possesses the power to tax and subsidize. To employ L_1 requires a shadow wage of zero: that is, a subsidy to employers equal to the full value of the wage. The employers' surplus will now be X_1L_1, but since workers receive the market wage and all wages are consumed, consumption will still be Y_1L_1, and the investible surplus, X_1Y_1. The question is: Can tax policy in the new situation preserve the level of the surplus XY generated by the more capital-intensive technology? The answer must be yes, provided the

Figure 6.8 Preserving the level of saving through taxation



propensity to consume is greater than zero. The total wage bill is Y_1L_1 and it is desired to reduce consumption out of the wage bill by Y_1Y_2. Consumption will fall by the amount of tax times the propensity to consume (c). Hence, the level of tax raised must be $T = (Y_1Y_2)/c$. If the wage bill is, say, £1,000, Y_1Y_2 is £100 and c is 0.8, then the tax raised must be £100/0.8 = £125.

In this example, the preservation of the level of saving is quite easily accomplished while moving from the more capital-intensive to labour-intensive techniques. If, of course, a fairly high level of taxation already exists, and there is no scope for further taxation, subsidization and taxation will not be a feasible means of reconciliation. In practice, however, the presumption must be that developing countries are not yet at their taxable capacity, and that the subsidization of labour, coupled with appropriate tax policy, is a possible policy.

Some care must be taken, however, over the form of taxation. For example, if the wage is fixed in real terms, then indirect taxes that raise prices will reduce the real wage, and the money wage will have to rise to compensate. Since the money wage is the cost to the employer, subsidies will then have to be increased. The imposition of indirect taxes to finance subsidies may lead to a spiral of increased taxation, inflation and subsidization. Direct taxes on workers' incomes may also be counterproductive if workers bid for money wage increases to maintain disposable income. The only feasible taxes to finance subsidies may be on exports or luxury consumption goods, which will not affect the real income of the broad mass of the population. While theoretically, therefore, a policy of labour subsidization financed by taxation may reconcile the conflict between employment and saving, it may run into a number of practical difficulties.

All the factors that may lead to an increase in the labour intensity of production without impairing the investible surplus may either be thought of as additive, or any one of them by itself may be powerful enough to push employment close to L_1 in Figure 6.7 above without loss of saving or its benefits.

Future policy

It has become part of conventional wisdom, and there may be a good deal of truth in the assertion, that a major cause of the growth of urban unemployment in developing countries lies in the application of 'inappropriate' production techniques because of the limited choice of techniques available, from within the countries and from outside. The choice is limited from within owing to the absence of a domestic capital goods sector, and it is limited from without because the techniques imported reflect the labour-saving bias of technical progress in the developed countries from which they come. The application of 'inappropriate' technology not only exacerbates unemployment, but perpetuates the dualistic structure of developing countries, increases income inequality, may worsen the foreign exchange position, and, in general, produces a distorted economy, while increasing the dependence of developing countries on developed countries.

There is now a strong movement throughout the developing countries in support of the creation of an **intermediate technology** using more labour per unit of capital and fewer foreign inputs. What is required is a whole spectrum of techniques to suit different circumstances, from which developing countries can choose. For this to happen, developing countries need to encourage the establishment of their own capital goods industries, and more R&D is required both within, and on behalf of, poor countries. An **international technology bank** would be a useful starting point, giving countries access to technological blueprints from different sources.

The capital intensity of production is also a function of the composition of output. There are often many ways of meeting a given need, some of which may be more labour-intensive than others. Where this is so, such as in transport, nutrition, housing and so on, serious consideration should be given to the most labour-intensive way of meeting such needs, consistent with other objectives.

Finally, the location of activity needs to be considered. Whatever technology is applied in the modern sector, it will have implications for the rural sector that will rebound on the modern sector. We saw in Chapter 5 that the creation of more modern sector jobs may encourage more migrants than the number of jobs created, thus increasing urban unemployment. This would seem to call for the location of new labour-intensive industries in the rural sector, to curb the flow of migrants and ease urban unemployment.

To conclude our analysis, we have seen that there are many reasons for believing that the potential conflicts inherent in the choice of new techniques between employment and saving on the one hand and between employment and output on the other have been exaggerated, and that techniques can be more labour-intensive without impairing the level of the investible surplus or the level of output. **It is in the direction of more rural-based, labour-intensive projects that development strategy ought to move for the maximization of general welfare.**

Summary

- There can be no economic growth unless economies invest a proportion of their output. The amount of capital per worker in developing countries is much lower than in developed countries, which partly accounts for the lower productivity of labour in developing countries.
- There are many different types of capital: physical plant and machinery, infrastructure, human capital and social capital, including health expenditure, which makes labour more productive (see Chapter 7).
- The productivity of capital depends to a large extent on the amount of technical progress embodied in it.
- The pace of technical progress depends on the willingness and capacity of societies to be inventive, to innovate, and to devote resources to human capital formation, skills training and R&D expenditure.
- There is a huge technological divide between rich and poor countries, which will take time and effort to bridge.

- The choice of techniques of production is an important issue in developing countries – whether to choose relatively labour-intensive techniques to create more employment, or relatively capital-intensive techniques, which embody more technology.
- Theory and evidence suggests that developing countries can move towards the use of more labour-intensive technologies without sacrificing future growth.

Chapter 6 **Discussion questions**

1. What is meant by the process of capital accumulation?
2. Distinguish between the various forms of investment and capital accumulation that can raise per capita income.
3. Why do developing countries, and many development economists, lay great stress on the role of capital accumulation in the development process?
4. What is meant by the following terms: neutral, capital-saving, and labour-saving technical progress?
5. What are the main means by which societies progress technologically?
6. What is 'learning by doing'?
7. In what sense is infrastructure investment complementary to investment in plant and machinery, and does it have to be provided publicly?
8. What are the major factors that dictate the choice of techniques in the industrial sector in developing countries?
9. Why did early development theory tend to stress the importance of capital-intensive techniques for rapid economic development?
10. Would the use of more labour-intensive techniques necessarily reduce the size of the investible surplus?
11. What do you understand by the 'efficiency wage' of labour, and how does this concept help to explain the relative capital intensity of production and goods traded?

Note

1. The capital–output ratio (K/O) may be expressed as the product of the capital–labour ratio and labour requirements per unit of output, that is, $K/O = (K/L)(L/O)$. Techniques with a low K/L may nonetheless have a high K/O because L/O is high – that is, the productivity of labour is low.

Websites on technology and investment

Economic Growth Resources run by Jon Temple, Bristol University, UK www.bristol.ac.uk/efm/people/jon-r-temple/overview.html
International Institute for Communication www.iicd.org
World Intellectual Property Organization www.wipo.int
United Nations Industrial Development Organization www.unido.org